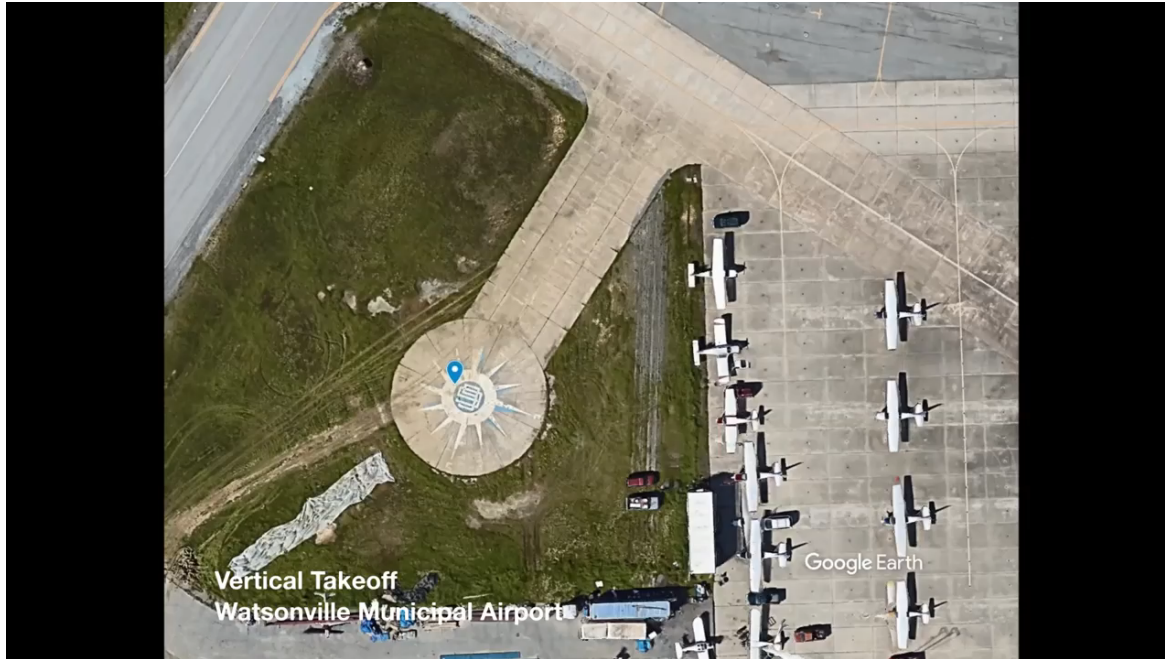




UAM Variable Separation

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Trip to SFO (Video)





Overview

- Given vehicle design and operating conditions, air taxis (ATs) may need to change separation minima during their flights
- For Part 121 operations, separation changes between en route (1,000 feet vertical and 5 miles lateral) and terminal (1,000 feet vertical and 3 miles lateral)
 - Remains static in given flight domain
- ATs could dynamically vary their separation from other aircraft
- This would make more efficient use of the airspace compared to creating permanent, conservative separation minima
- Made list of factors that could affect separation
- Examples assume minimum separation of 500 feet vertical and 1,500 feet lateral with buffers added as needed
- Assumes on board self-separation reverting to ground in heavy traffic



Separation Factors

Factor	Description
Low Altitude Operations	At low altitudes, there may be non-cooperative objects such as para-gliders, remote control hobby aircraft, balloons, and flocks of birds. Air taxis must be separated from these objects, which may move erratically. There will also be no-fly, curfew, and other zones where flight is not permitted. Separation may need to be varied depending upon these conditions.
Automation	The amount of separation will be dependent on the quality of automation and user interface. Separation may need to be adjusted for level of operator training and the capabilities of automation. Poor training and deficient automation may dictate larger separation minima.
Community Acceptance	The aircraft density needed for profit by air taxi companies may exceed acceptable limits by communities. Aircraft spacing may have a large impact on that acceptance. Aircraft may need to be spaced or separated by wider margins over populated areas to reduce the noise and visual pollution footprints.



Separation Factors

Factor	Description
Surveillance	The accuracy of vehicle tracking plays a critical role in determining separation requirements. For example, GPS may not be effective at low altitudes and among buildings. If location accuracy is degraded, larger separation minima will be needed.
Equipage	The minimum level of vehicle equipage necessary to achieve needed spacing, throughput of traffic, and customer safety are items that need research. Less equipped aircraft may not be able to maintain consistent speed, altitude, or position requiring larger separation criteria.
Communications	Voice and data communications with low-flying air taxis may be challenging. If separation assurance services are provided from the ground, communication delays or disruptions could lead to losses of separation. Separation minima may have to be altered based on quality of communications.



Separation Factors

Factor	Description
Infrastructure	The structure and location of vertiports may affect separation by imposing flight path restrictions on air taxis. For example, arrival and departure routes may be established that provide lateral separation. Aircraft may be sequenced by time or distance to maintain in trail separation. In such cases, other separation criteria will be suspended. There will need to be a smooth transition between an arrival or departure phase of flight and en route flight where other separation rules will apply.
Handling Qualities	Handling characteristics will vary between aircraft types. This includes acceleration, deceleration, climbing, descending, and turning. If an aircraft type has limited maneuverability, it may need to maintain larger separation minima from other aircraft.
Headwinds and Tailwinds	Headwinds and tailwinds will affect the relatively light air taxi aircraft in different ways depending upon aerodynamics. Engine power and battery capacity will influence how well the aircraft can deal with headwinds. These winds may create unexpected changes in vehicle position and require larger separation distances.



Separation Factors

Factor	Description
Crosswinds	Crosswinds will be affected by terrain and buildings. They will impact air taxi types in different ways, depending upon weight and aerodynamics. Sudden changes in aircraft position and altitude could occur, necessitating large separation limits.
Updrafts and Downdrafts	As wind impinges on a building, updrafts and downdrafts occur. These winds will have impacts on air taxis, causing sudden changes in altitude or rapid pitch/roll excursions. Larger vertical separation boundaries may be needed.
Convective Weather	Electric VTOLs will be very susceptible to convective weather. Low altitude airspace may become very constrained if several aircraft need to deviate around weather. Buffeting winds in the area of the storm may abruptly change vehicle three-dimensional position and speed. Special separation boundaries may be needed for these weather events.



Separation Factors

Factor	Description
Rain, Fog, and Haze	Reductions in visibility will affect the vehicle pilot's ability to see and avoid other aircraft. Depending upon aircraft equipment and surveillance techniques, air taxi flights may not be able to operate in these conditions or will operate with larger separations.
Ability to Hover	Most air taxi vehicles will be able to hover and will do so at certain times during the flight. This completely changes the separation dynamics. For example, horizontal separation from aircraft that are in level flight at the same altitude will change when an aircraft hovers. There may need to be limited zones of airspace where hovering is permitted. Nevertheless, vehicles may choose to hover while en route for emergency or other reasons.
Flight Transition Phase	Air taxis will transition between vertical and horizontal flight. This results in different control characteristics. Vertical and horizontal separation from other vehicles may need to be varied for phase of flight.

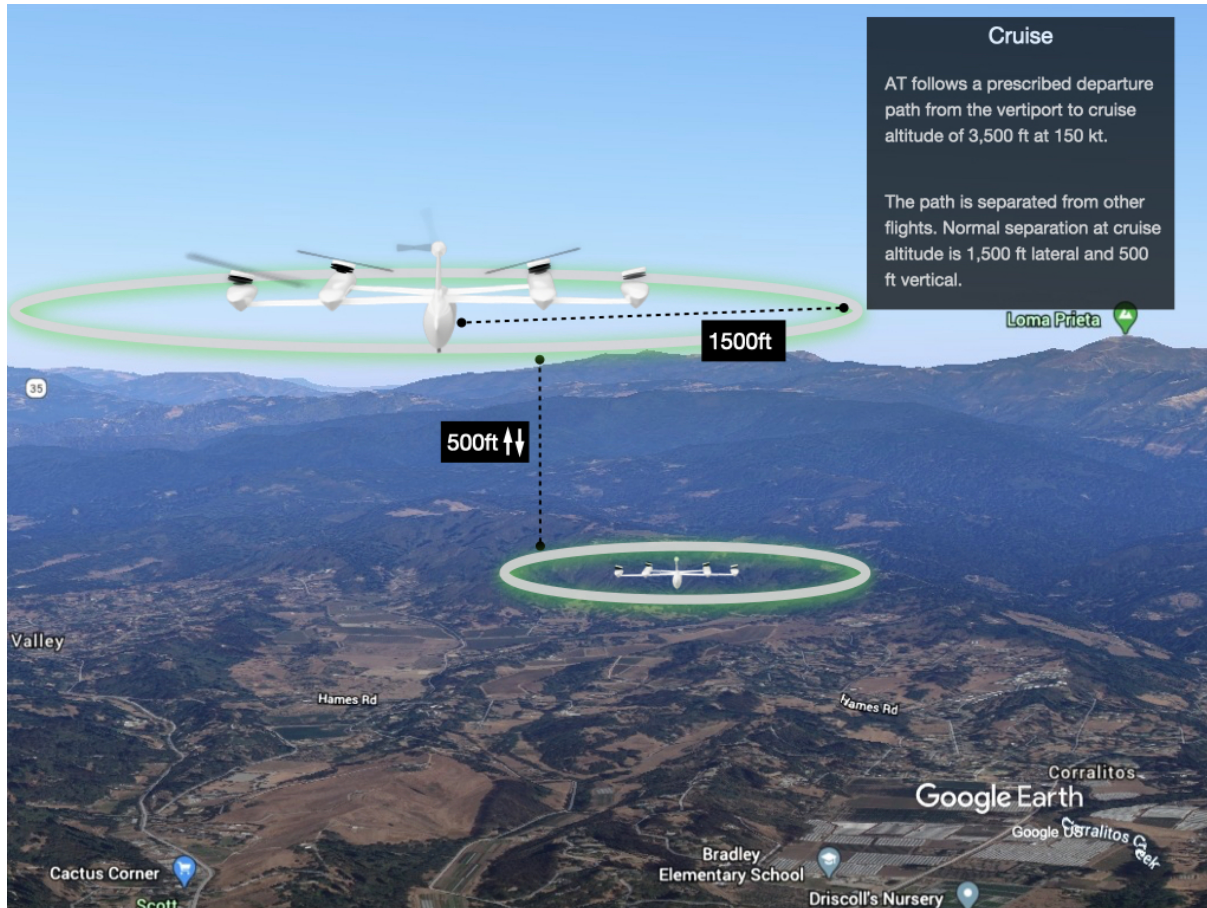


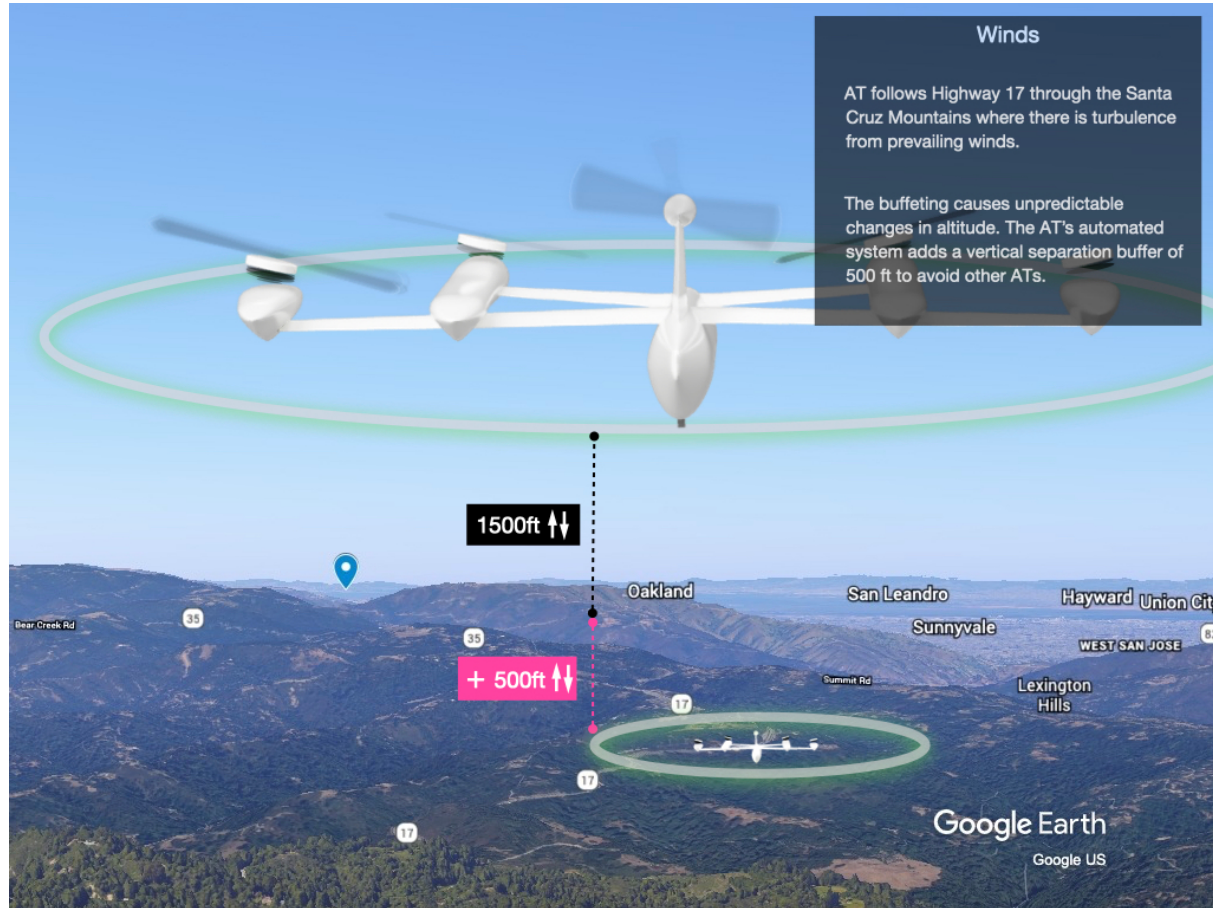
Separation Factors

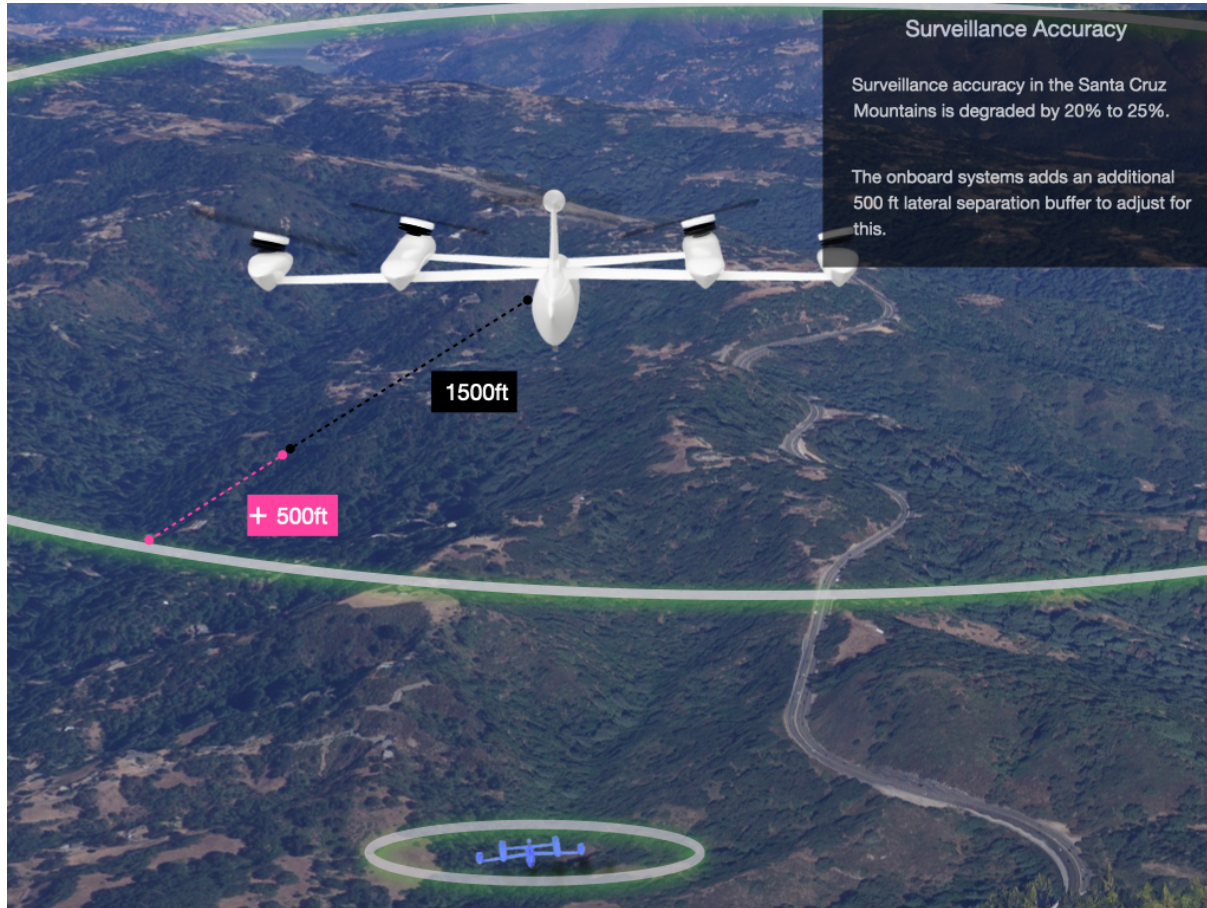
Factor	Description
Emergency Maneuvering	Sometimes, an emergency maneuver may be needed to avoid other traffic, terrain, or other hazards. Extra space is required for this.
Comfort	Passenger comfort may dictate vehicle spacing. A view out the window of nearby traffic may cause concerns.
Differences Between Service Suppliers	It is anticipated that separation, flow control, and other services will be provided by the private sector. The automation capabilities of these vendors may vary and not interface perfectly with each other. Separation may have to be adjusted to anticipate transitory or permanent automation limitations.

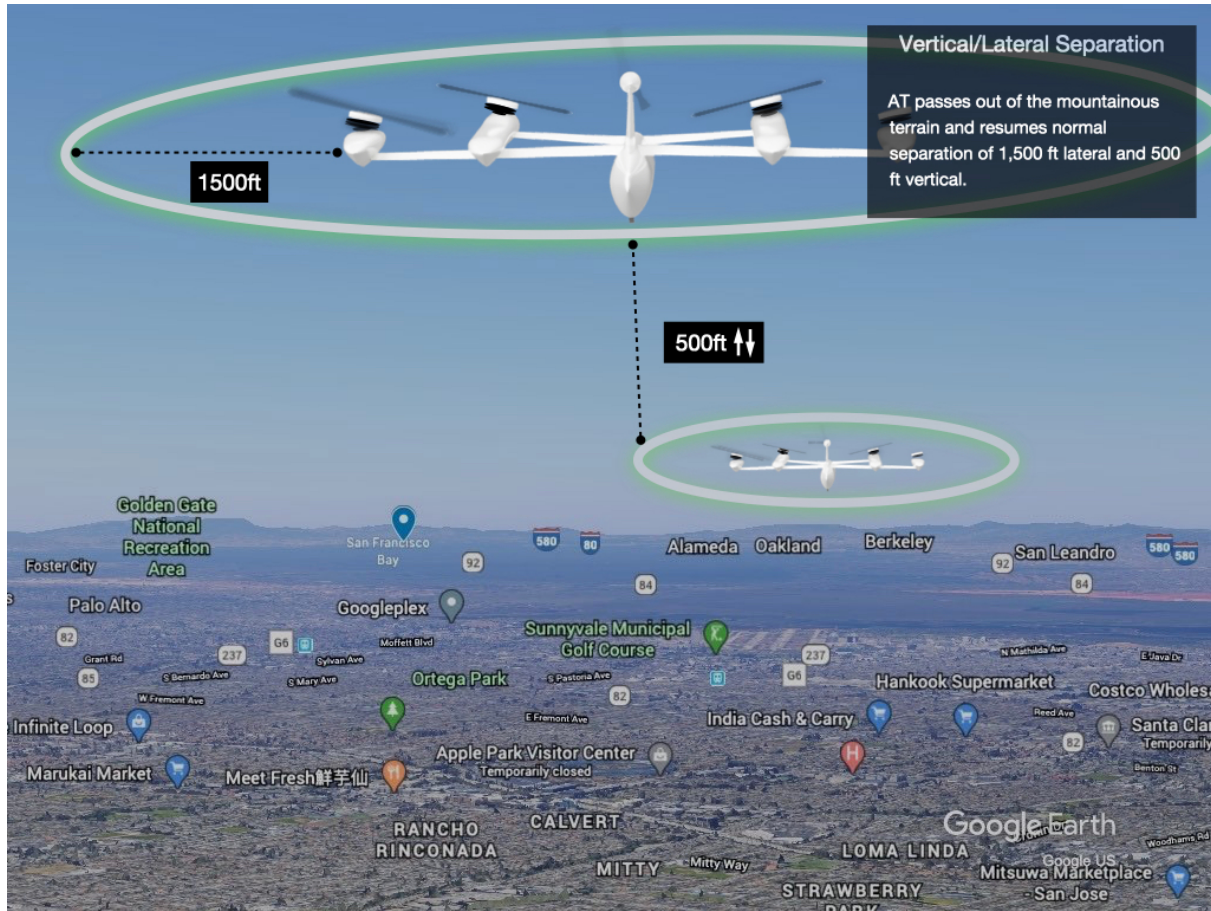
Flight Scenario

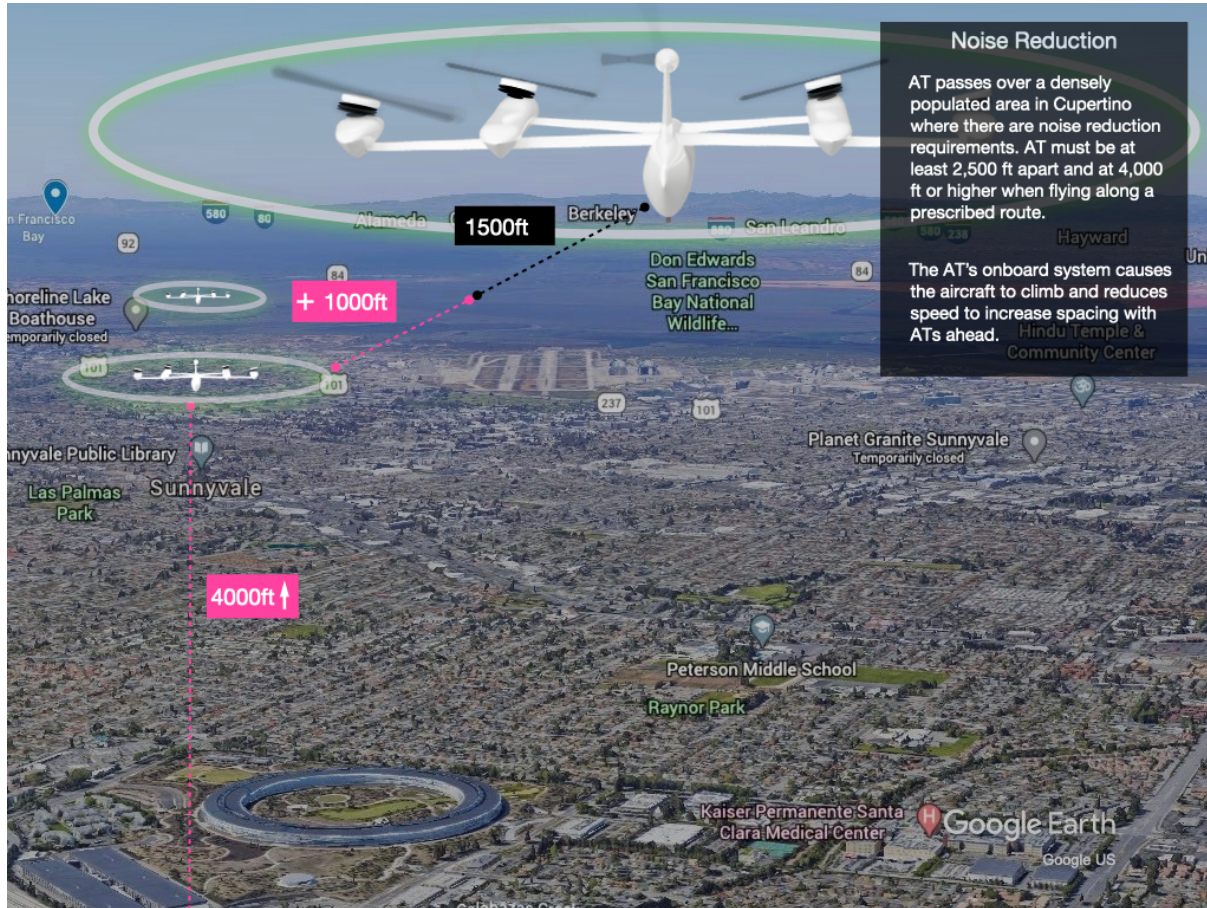


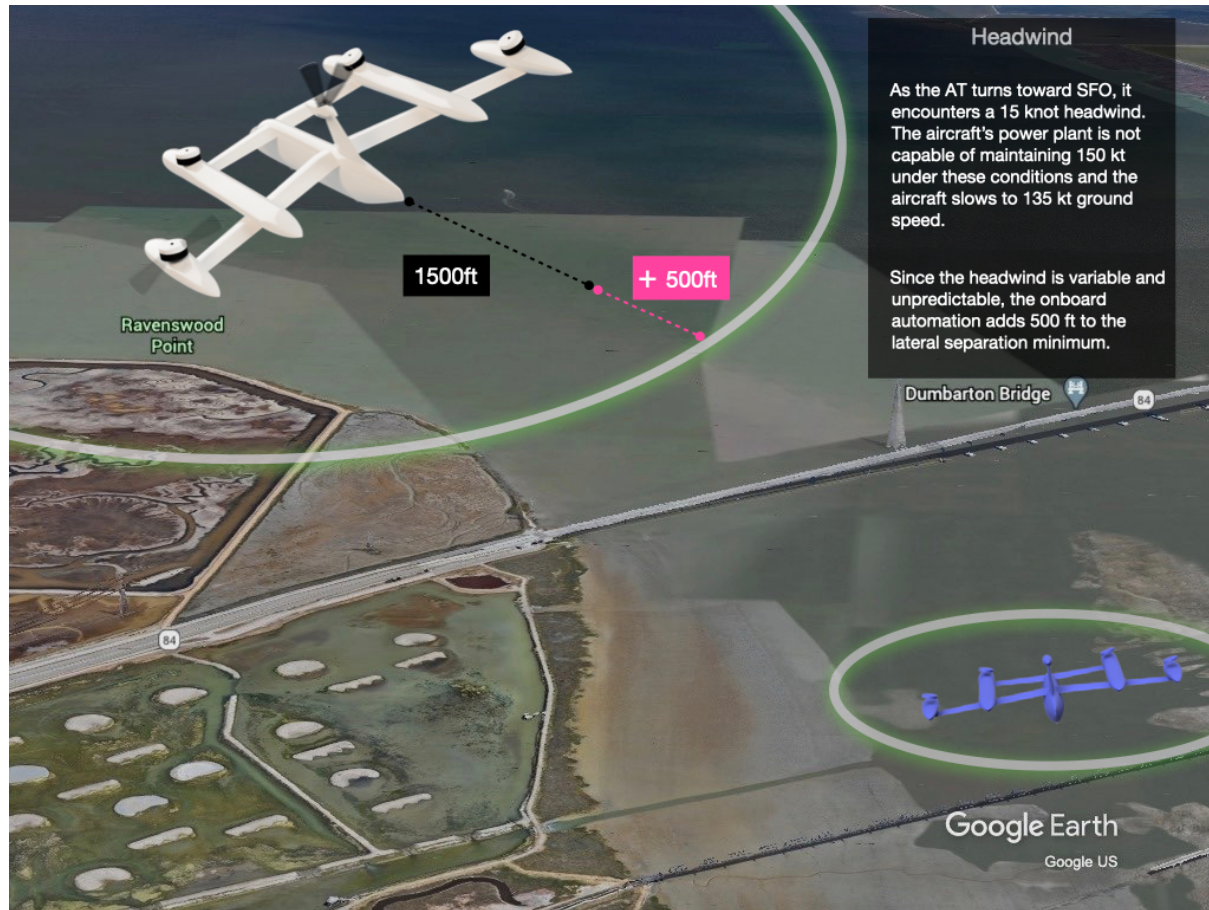


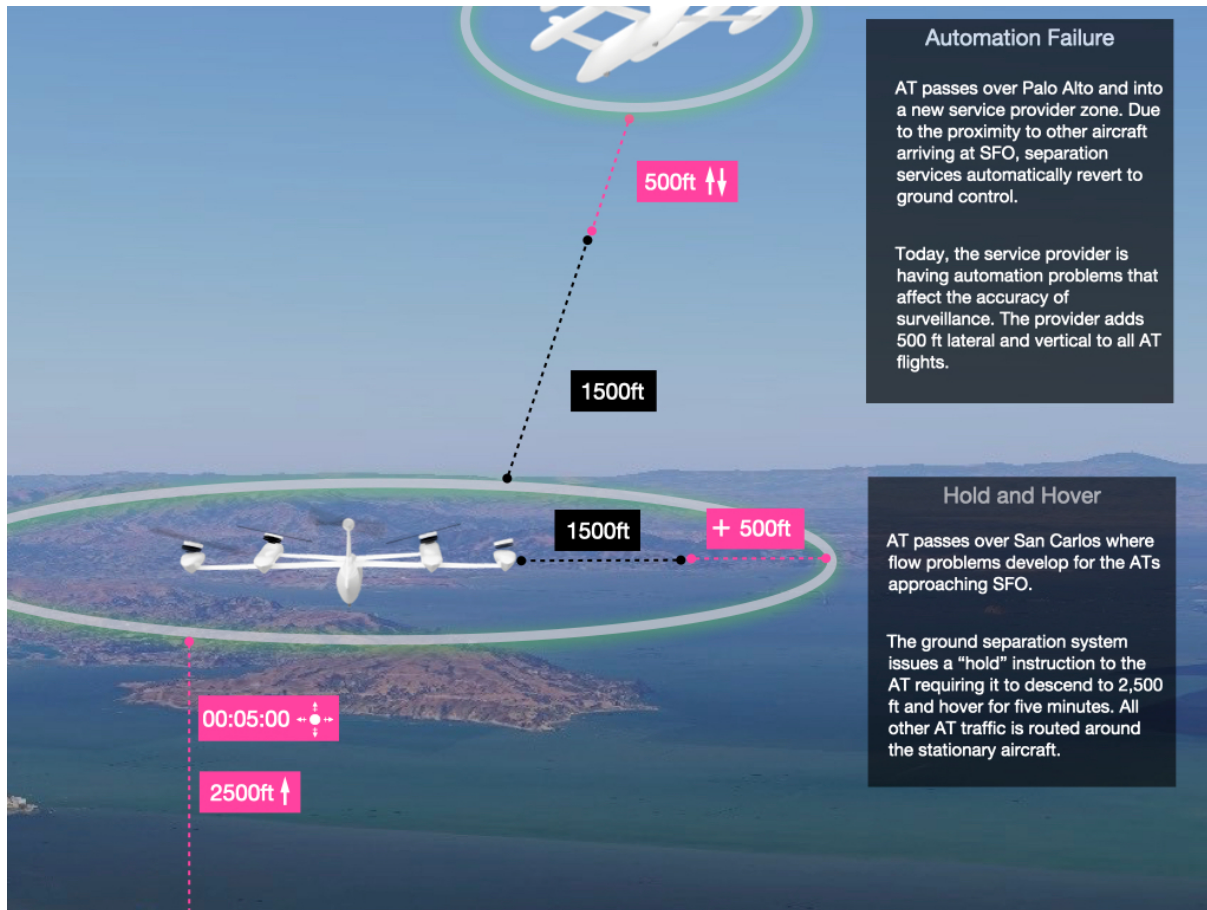


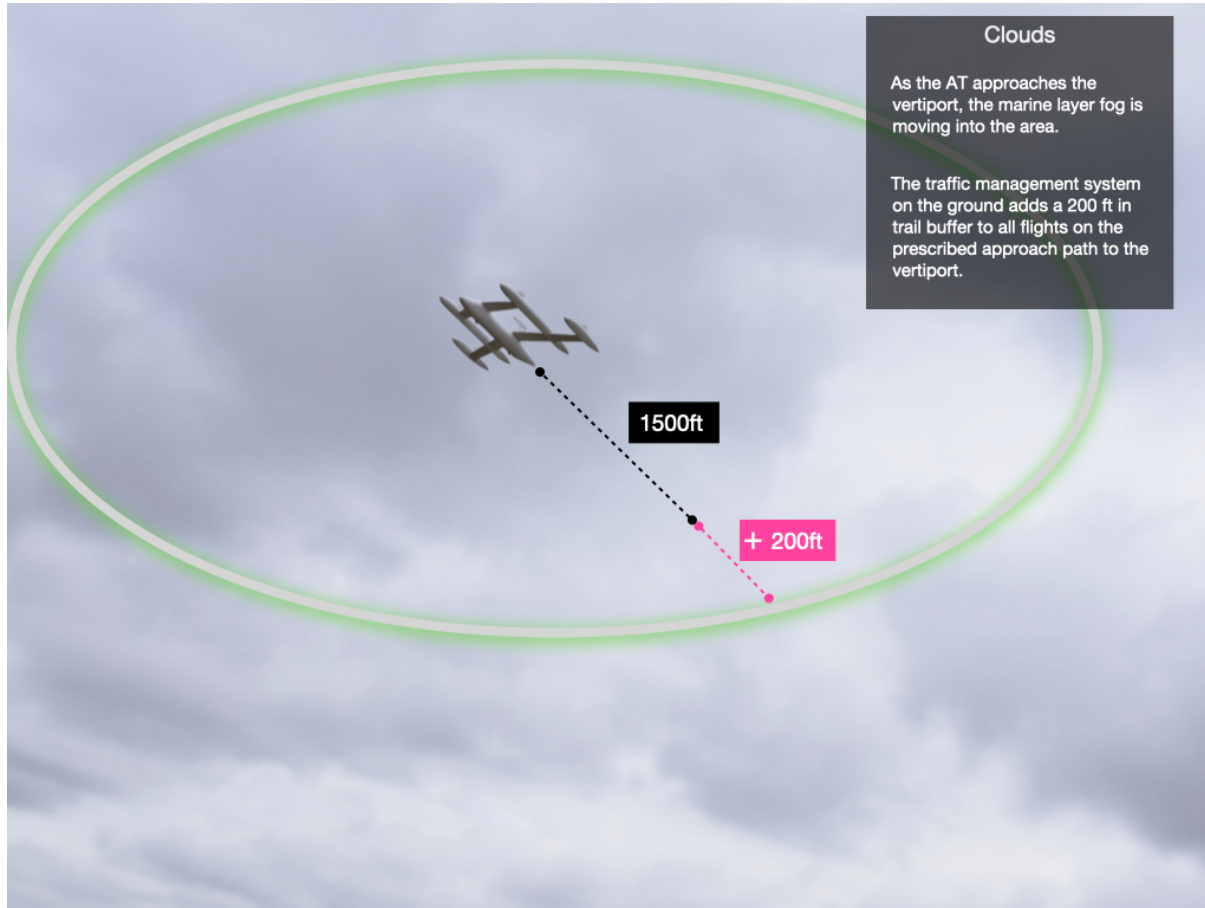


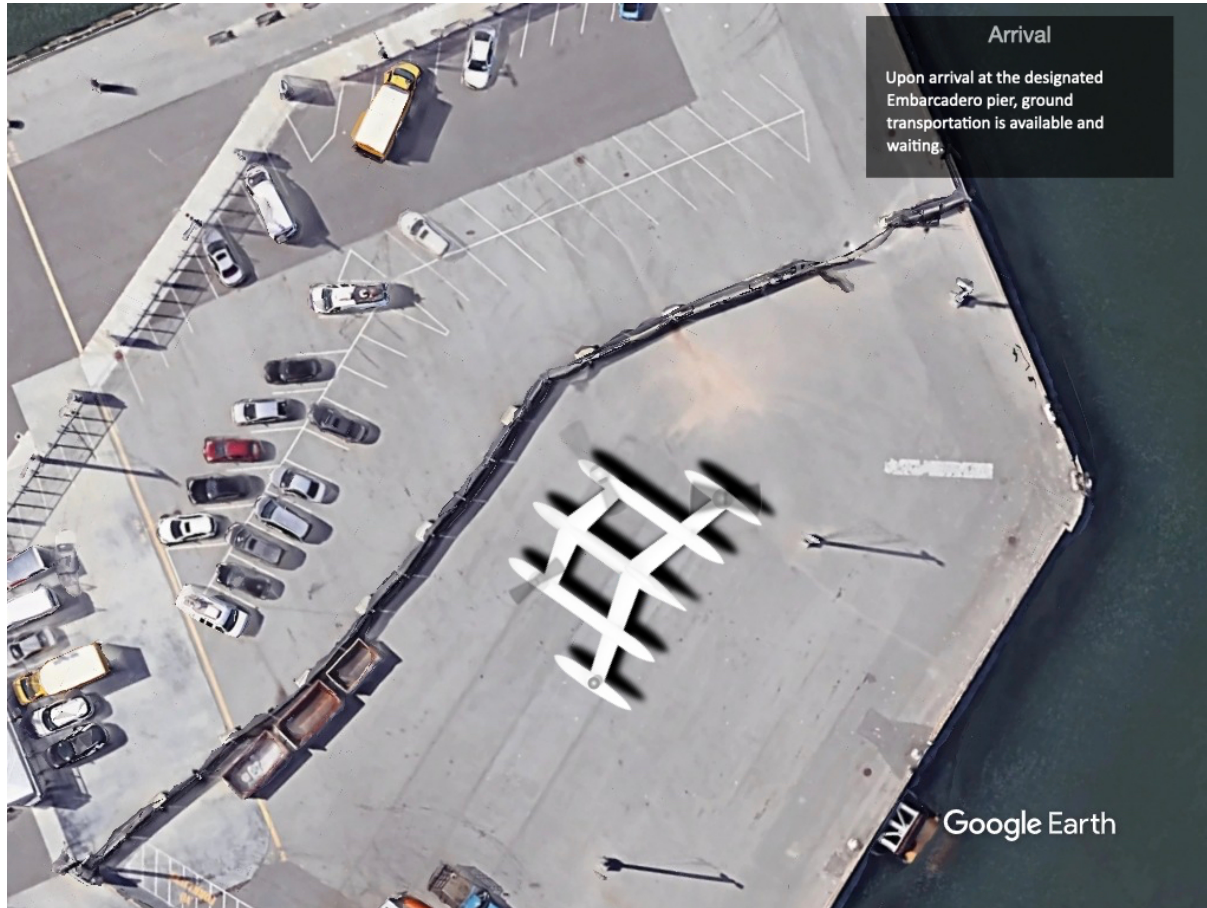












Arrival

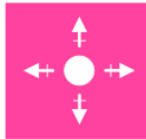
Upon arrival at the designated Embarcadero pier, ground transportation is available and waiting.

Google Earth

Hover Display

Hover Indicator

A search for a controller "hover indicator" icon failed. In lieu of an established icon, we created one from a combination of several instrument displays, such as the HoneyWell/Sikorsky vertical takeoff indicator.



Source: No Hover/Hover Indicator: Honeywell, Sikorsky
https://airandspace.si.edu/collection-objects/hover-indicator-honeywell-sikorsky/nasm_A20060098000



Summary

- UAM could conduct research on variable separation
 - Improves safety while maintaining efficient use of the airspace
 - How are aircraft affected by weather conditions?
 - Need data on handling qualities of aircraft
 - Could aircraft safely manage their separation from other aircraft?
 - What displays are needed to monitor separation?
- Would swapping separation management between air and ground improve traffic management?
 - Could be self-separation except in specific sectors, corridors, or areas where central control is safer
- Might include variable separation research in Phase 2



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