Noise considerations for designing Skyport networks

Danielle Rinsler, Head of Aviation Policy
Rohit Goyal, Ops Planning Strategic Lead
David Josephson, Consultant

April 29, 2020

Uber Elevate
Agenda

01 Uber Elevate Overview
02 Environmental Review and Permitting
03 Land Use compatibility
04 Change in Aviation Noise
05 Change in Ambient Noise
06 Quantification of UAM Operational noise
We ignite opportunity by setting the world in motion
Elevate Vision

We are weaving everyday flight of people and things into the Uber Platform.

We do this through 5 major pillars.
Elevate Pillars

Multimodal Aerial Ridesharing

Electric Aircraft

Industry Ecosystem

Automation Platform

Connected Skyports
Network Strategy Informs System Requirements

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Value</th>
<th>Description</th>
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<tr>
<td>Speed</td>
<td>150</td>
<td>Miles per hour at cruise</td>
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<tr>
<td>Payload</td>
<td>1+4</td>
<td>Pilot + Passengers</td>
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<tr>
<td>Range</td>
<td>60</td>
<td>Miles of max flight range</td>
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<tr>
<td>Quiet</td>
<td>-15 dB</td>
<td>Noise improvement over helicopters</td>
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<tr>
<td>Electric</td>
<td>3.5x</td>
<td>Efficient over traditional turbines</td>
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<tr>
<td>Reliability</td>
<td>2k</td>
<td>Flight hours per year</td>
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To do this, we must understand human response to noise and design our aviation products accordingly.
Noise can be categorized three ways:

**Ambient Noise**
This is the noise that exists in the absence of new urban aviation modes (aerial ridesharing, food/cargo delivery by air).

Different approaches to modeling this have been undertaken by VOLPE with:

- U.S. Department of Transportation’s Bureau of Transportation Statistics (BTS)
- U.S. National Park Service (NPS)

**Operational Noise Impacts**
This is the noise that results from the new urban aviation modes. Typically aircraft noise signatures are summarized and converted into appropriate metrics for use by tools like AEDT. Their impacts may be predicted in a few ways:

- **Existing land use compatibility guidelines**
- **Deltas from ambient**

**Perception**
Ultimately, the ambient noise and operational noise impacts should be combined so that the perception by observers can be understood for community acceptance.

In the case of drones, eVTOL, and electric general aviation, this has not been explored deeply.
Existing and past guidance suggests path to evaluate noise impact of Uber Air operations

**FAA Order 1050.1**
The FAA issued Order 1050.1F Environmental Impacts: Policies and Procedures on July 16, 2015. This order serves as the FAA’s policy and procedures for compliance with the National Environmental Policy Act (NEPA) and implementing regulations issued by the Council on Environmental Quality (CEQ).

**AC 150/5020 - 2 (1983)**
This AC (now canceled) provided guidance to private sector and local authorities, for new heliports, on standardized methods for preliminary evaluation of potential sites for new private or municipal vertiports, to facilitate development of infrastructure to support helicopter operations, even if no federal actions are included.

**Existing Metrics**
- **Day Night Level (DNL):** average noise level from airport operations delivered to a community, independent of background noise
- **LAmax:** maximum instantaneous sound pressure level
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As early as the 1950s, helicopters were emerging as a short-haul transport mode for air mail and other uses, and planners recognized the need to consider the implications of these “strange craft”.

Transportation by Helicopter, 1955–1975 predicted air cabs (airport helicopter shuttles) would be commonplace by the mid-1960s.
It is important to plan facilities and routes with the goal of minimizing additive community noise and ensuring land use compatibility.

At the same time...
Noise is only one factor contributing to community annoyance. Annoyance is also influenced by what you see, feel and believe. Many of the UAM vehicles in development will have significantly lower noise profiles than conventional aircraft - so addressing non-acoustical concerns will be critical to successful launch.
Past research on helicopter noise will continue to inform; and new research on eVTOL aircraft will guide future UAM facility planning and community engagement.
Ultimately, to gain community acceptance, cities and operators need to plan together. Systematically plan for urban air mobility services by:

- Developing policies that enable UAM while protecting for land use compatibility
- Integrating planning for UAM into city plans (comprehensive plans, municipal zoning, land use plans) and building and fire codes, regional transportation plans and airport system plans
- Conducting market analyses to identify areas of high demand
- Investing in existing aviation facilities to sustain and improve the airport system, adding new facilities only where feasible and with community input
- Preserving and protecting existing aviation assets and associated airspace from encroachment through effective zoning and other land use controls

Collaboration is Key
Integration of eVTOLs may require a phased approach

**Early Stage**
In the early stages of Uber Air, with a pilot in the cockpit,

- Aircraft and operator certification processes and airspace management will look similar
- Adapt existing aviation infrastructure to support electric vehicle charging and associated storage and safety requirements, and new eVTOL-specific layouts
- Environmental review will rely on existing methodologies
- Local approaches to permitting of infrastructure will facilitate compatibility and aid community acceptance

**Scaled Operations**
As scale of activity increases, and as technology, regulations and policy mature to enable full autonomy, new approaches will be necessary - from air traffic management and airspace design to noise analysis techniques

- NASA, FAA, ICAO, standards developing organizations (ASTM, SAE) and other industry-led research and engagement will guide this evolution.
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Environmental Review Process - Noise and Compatible Land Use

Under Federal and some State regulations, agencies are asked to consider:

- Does the proposed action produce increase noise exposure over incompatible land use areas?
- Further from the airport/skyport, does the proposed action result in increases in aviation noise exposure beyond certain thresholds?
- If so, can significant impacts be mitigated?
FAA Advisory Circular 150/5020-1
Appendix 1 (based on 14 CFR Part 150, Appendix A)

Land Uses Normally Compatible With Various Noise Levels

<table>
<thead>
<tr>
<th>Land Use Category</th>
<th>Normally Compatible (DNL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential - Low Density Single Family, Duplex, Mobile Homes</td>
<td>65</td>
</tr>
<tr>
<td>Residential - Multi Family</td>
<td>65</td>
</tr>
<tr>
<td>Transient Lodging - Motels, Hotels</td>
<td>70</td>
</tr>
<tr>
<td>Schools, Libraries Churches, Hospitals, Nursing Homes</td>
<td>75</td>
</tr>
<tr>
<td>Auditoriums, Concert Halls, Amphitheatres</td>
<td>70</td>
</tr>
<tr>
<td>Sports Arena, Outdoor Spectator Sports</td>
<td>70</td>
</tr>
<tr>
<td>Playgrounds, Neighborhood Parks</td>
<td>70</td>
</tr>
<tr>
<td>Golf Courses, Riding Stables, Water Recreation, Cemeteries</td>
<td>70</td>
</tr>
<tr>
<td>Office Buildings, Business Commercial and Professional</td>
<td>70</td>
</tr>
<tr>
<td>Industrial, Manufacturing Utilities, Agriculture</td>
<td>70</td>
</tr>
</tbody>
</table>

Airport Land Use Compatibility

“Airport land use compatibility is the reconciliation of how land development and airports function together”
- California Airport Land Use Planning Handbook

Tools and Techniques

- Municipal Planning and Zoning
- Airport/Heliport Planning and System Planning
- Airport and Heliport Layout Plans
- Noise Compatibility Planning (Part 150 studies) and noise mitigation approaches
- Airport Land Use Compatibility Plans
- State legislation
- Acquisition, easements and real estate disclosures
Other Land Use Compatibility

Resources

Compatible Land Use

Airports

The compatibility of airport land uses is important to both the local government and the airport. Ensuring this compatibility requires understanding how an airport functions and how it can impact or be impacted by the community that surrounds it. These resources help local governments and airports understand their roles and offer ideas for compatible development.

Guidance

- AC 150/5100-30: Guidance on the Extraction of Oil and Gas on Federally Obligated Airports (FAAIRW)
- Airport Noise Compatibility Planning Toolkit
- Land Use Compatibility and Airports, a Guide for Effective Land Use Planning (PDF)
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Change in Exposure/Aviation Noise

- Traditionally used for evaluation more distant than 65 DNL contours
- Use the same contour prediction method
- "Reportable" areas where exposure to aviation noise changes by
  - Greater than 65 DNL, 1.5 dB
  - 60-65 DNL, 3 dB
  - 45-60 DNL, 5 dB
- Only considers change in aviation noise
Change in Exposure/Ambient

- Consider **all noise sources**, not only aviation
- Historical guidance from AC 150/5020-2 (1983)
  - Measure 24-hour average ambient
  - New aircraft noise to not exceed ambient (would result in +3 dB)
- May find that 3 dB is too much
- Good start to characterize community exposure generated by UAM
- Under discussion in VFS and HAI working groups
- May need **hourly assessment**, not 24-hour average
Subject: NOISE ASSESSMENT GUIDELINES FOR NEW HELIPORTS

Date: 12/9/83

Initiated by: AEE-110

Ac No: 150/5020-2

Change:

FOREWORD

This circular provides technical guidance for local planners, other government agencies, and operators in calculating the acoustic environment near new heliports. It is intended to provide assistance in preliminary evaluation of the noise compatibility of sites for heliports where none exists. It is not intended for the evaluation of existing heliports or those areas where noise is not an issue.

John E. Wesler
Director of Environment and Energy
b. Methodology. A process similar to that used in the simplified method is used here, except that the appropriate formula from 17(a) is used to compute the average equivalent sound level (EQL). This value of EQL is then compared against the normally compatible sound levels in Table 1. Again, it is **recommended that the helicopter average equivalent sound level not exceed the community EQL.** An example calculation using the detailed method is shown in Appendix 1.
Ambient Noise Measurement

Establish a baseline

- Human exposure indoors and out
- Guidance from ARP4721-1 (intended for validating DNL prediction, repurposed here)
- Need finer detail on estimation of building transmission loss
- Guidance from other protocols such as ANSI/ASA S12.9
- Realtime area-wide prediction
Project Symphony

Fixed Sensors

Movable Sensors
125+ Acoustically different sites for Data Collection
Single-Event Noise, Impulsivity, Loudness

- Guidance from Federal Interagency Committee on Aviation Noise (FICAN) to estimate maximum Single Event Noise Exposure Level (SENEL) to predict nighttime awakening also useful to capture transients
- Consider additional noise penalty from rapid shifts in noise level
- Refine route planning for single-event noise as well as exposure
- Loudness and masking, auditory scene analysis
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UAM operational noise impact can be evaluated using different approaches

**Land Use Compatibility**
Max. number of arrivals and departures is defined as that level of operation that causes the first occurrence of vertiport DNL above the “normally compatible” DNL level for the affected land use.

**Reportable ΔAmbient**
Max. number of arrivals and departures is defined as that level of operation that causes the first instance of a “reportable” change in ambient DNL based on:
- For DNL 65 dB and higher, 1.5 dB
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Max. number of arrivals and departures is defined as that level of operation that causes the first instance of a “reportable” change in ambient DNL based on:
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Max. number of arrivals and departures is defined as that level of operation that causes the first instance of a “reportable” change in ambient hourly LAeq based on Approach 2 and Approach 3 “reportable change” steps.

Reportable ΔAmbient

UAM operational noise impact can be evaluated using different approaches

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Reportable ΔAmbient
FAA’s AEDT is used to model Aircraft noise impacts

- AEDT is a software system that models aircraft performance in space and time to estimate
  - fuel consumption,
  - emissions,
  - noise and,
  - air quality consequences.

- AEDT facilitates environmental review activities required under NEPA by consolidating the modeling of these environmental impacts in a single tool.

Source: https://aedt.faa.gov/
Sample AEDT Output

Noise Contours for levels of Daily Arrival Operations

Noise Contours for levels of Daily Departure Operations
Land Use Compatibility
Land Use compatibility requirements limits daily ops

Number of arrival and departures without zoning and land use consideration = x

Number of arrival and departures on application of Approach 1 = <<x
Reportable ΔAmbient
Evaluating BTS and NPS ambient noise maps

**BTS:** 24-hour equivalent sound level (LAEQ) is the (logarithmic) average of sound energy over a 24 hour period for transportation noise (no other ambient noise sources).

**NPS:** Georeferenced maps of the expected existing, natural, and impact A-weighted hourly L50 sound pressure level dB re 20 uPa on a typical summer day across the contiguous United States, Alaska, and Hawaii regions at resolutions of 270 m, 250 m, and 270 m respectively.
Prediction of Standard Metrics

And supplementing with DFW measurements

- Sensors collect data at each site every second, which is converted into A-weighted hourly L90 sound pressure level dB
- 24-hour equivalent sound levels is calculated by taking an average of hourly L90 sound pressure level
- Difference (in dB) from the nearest sensor is calculated for each hour that is applied to 24 hour equivalent sound levels from BTS to generate hourly LAeq
- Median difference (in dB) from all the sensors are applied to certain locations in BTS that do not have a sensor nearby (i.e. less than 0.5 miles)
To quantify reportable Δambient approaches

Number of daily ops without ambient noise consideration = x

Number of daily ops on application of Approach 2 = <x
Evaluating impacts across cities & communities

Sample Results

### Airport

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- Number of Daily Arrivals and Departures

### Commercial Hub

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- Number of Daily Arrivals and Departures

### Residential

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Perception of aircraft noise is key to understanding community annoyance

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