Close Proximity Community Noise Acceptability

On-Demand Mobility and Emerging Aviation Technology
Roadmapping Workshop
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Why is ODM Noise Different?

<table>
<thead>
<tr>
<th>Where?</th>
<th>Conventional</th>
<th>ODM</th>
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<tbody>
<tr>
<td>How far?</td>
<td>&gt;10 km</td>
<td>&lt;1 km</td>
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<tr>
<td>What?</td>
<td>integrated airport noise dose (DNL)</td>
<td>individual vehicle events</td>
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<tr>
<td>Why?</td>
<td>acceptable level of annoyance</td>
<td>absence of disturbance</td>
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<tr>
<td>Design goals</td>
<td>not too noisy</td>
<td>quiet</td>
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Vehicle types

• CTOL
  – thin haul commuter fixed wing, conventional runway
  – scaling (down to GA, up to regional)
  – probably similar acoustic signature impact to existing quiet GA

• VTOL
  – urban air taxi 1-4 passenger autonomous
  – scaling
    • package delivery UAS (<55 lbs)
    • regional VTOL (>4 pax)
  – different acoustic frame of reference due to *proximity*
What can we measure?

• Quiet ≠ 1/noisy
• Sound pressure (hearing damage)
• Loudness (audibility)
• Annoyance (aversion)
Sound pressure dB (SPL)

- occupational exposure limits
- used to compute dose (hearing safety)
Loudness dB(A)

- sound pressure corrected for ear sensitivity
- rms (power) measurement, not perception
Annoyance

• 1950s “noy” scale (Stevens, Kryter)
• 1960s corrected for tones and duration (EPNL)
• developed to account for turbojet whine
• penalty concept for helicopter noise
Helicopter puzzle
Noticeability

- contrast sensitivity function (visual)
- crest factor (peak/average) of waveform
- rate of change in direction
- modulation (rate, depth)
Can we predict disturbance?

- counters
  - number of events
- integrators
  - cumulative dose
Figure of Merit

- CTOL – use existing noise certification metrics to integrate with existing airport noise profiles

- Urban VTOL – acoustic signature and CONOPS in FOM for smallest footprint
Urban VTOL

• design constraints – acoustics as driver
• quiet is perception-driven
• hypothesis: quiet \approx \text{low contrast/time}
Contrast $\frac{d\phi}{dt}$

- pitch
- amplitude
- direction
- spectrum
Measuring disturbance/contrast

- telephony (psophometer, T-REC-O.41)
- broadcasting (quasi-peak BBC standard)
- electromagnetic compatibility (BS.468-4)
- industrial processes (NT ACOU 112)
- automotive (NVH metrics)
- nonstationary loudness standards
- jury listening
Open rotor sUAS examples

- quadcopter
- modeled quadcopter
Urban VTOL design drivers

Per flight operation,
• How many people notice/are disturbed?

Enroute – minimum altitude for zero footprint

Terminal – size of notice/disturb footprints
YO-3A

<65 dB(A) at 250 ft
10' prop at 750 rpm
M(t) ~ 0.32 (360 fps)
If you can’t measure it, you can’t improve it

Be sure to measure what you want to improve