Close Proximity Community Noise Acceptability

On-Demand Mobility and Emerging Aviation Technology

Roadmapping Workshop

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Why is ODM Noise Different?

	Conventional	ODM
Where?	at edge	inside community
How far?	>10 km	<1 km
What?	integrated airport noise dose (DNL)	individual vehicle events
Why?	acceptable level of annoyance	absence of disturbance
Design goals	not too noisy	quiet

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?

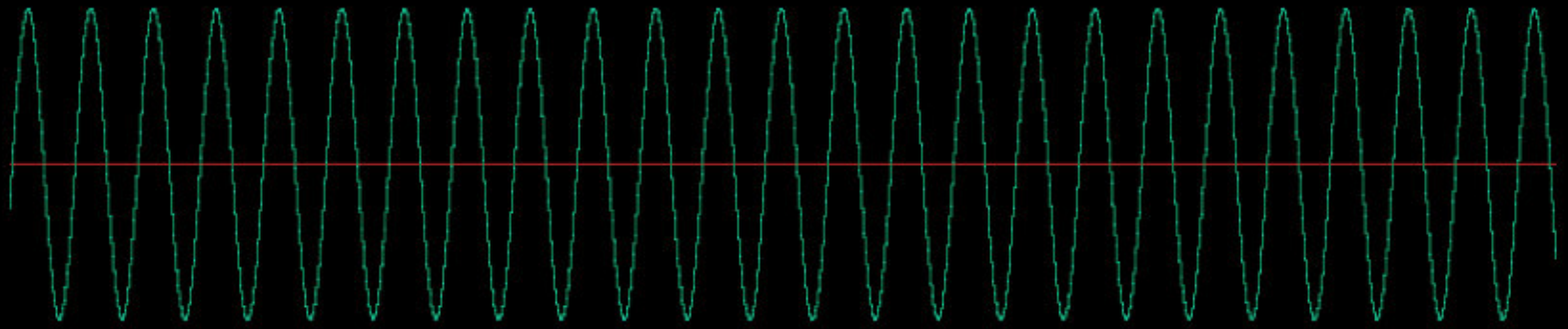
- Quiet ≠ 1/noisy
- Sound pressure (hearing damage)
- Loudness (audibility)
- Annoyance (aversion)

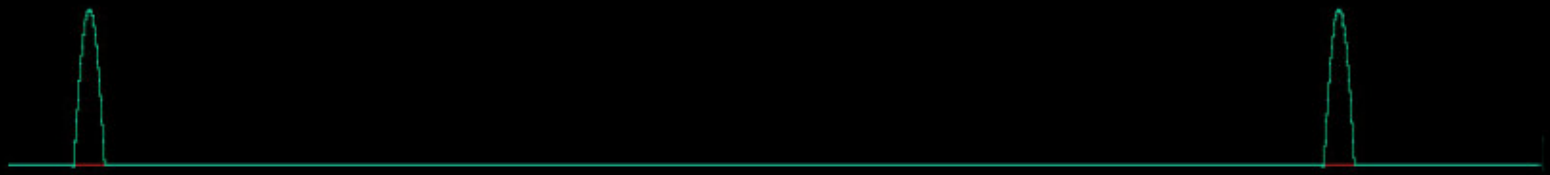
Sound pressure dB (SPL)

- 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 ≈ low contrast/time

Contrast d?/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

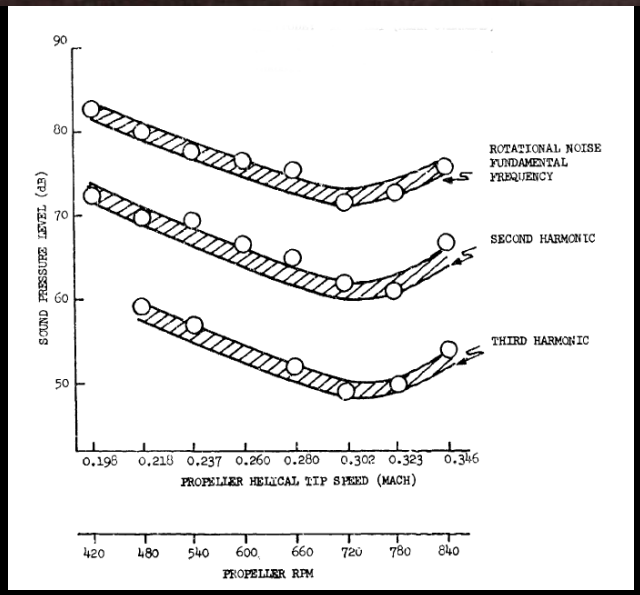
Per flight operation,

- 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