San Francisco International Airport/Community Noise Roundtable

Ground-Based Noise (GBN) Ad-Hoc Subcommittee

March 19, 2019

Overview

- Reviewed the following approved scope of work items flagged "HMMH"
  - Item #2(c) (Metrics - Data and studies on GBN from other airports/communities – what are the most relevant takeaways for SFO?)
  - Item #2(d) (Metrics – Equipment/measuring tools that may be needed in future)
  - Item #3(a-c) (Mitigation Options)

Item #2(c) (Metrics - Data and studies on GBN from other airports/communities – what are the most relevant takeaways for SFO

- Five studies were reviewed and the following is a summary of the research:
  - Objective to quantify resident's judgement of start of takeoff sound levels and measure propagation rate into community
  - Goal of correlating aircraft noise levels with human perception of events
  - Homeowner instructed to use a scale of 0 to 100 for rating events, generally in multiples of 10
  - Outdoor C-weighted LMax was identified as the preferred metric
  - Low frequency sound energy important in determining how a person may react to the noise

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Item #2(c) Continued

- Objective was to review back blast noise – how it's generated, how it propagates, how it can be mitigated, and future study efforts and projects that should be directed
- Most sound energy generated by back blast noise is below 200 Hz and at these levels noise propagates over longer distances, travels more freely through structures, and can cause structures to vibrate
- A-weighting network does not adequately represent the noise; C-weighting works well

Item #2(c) Continued

- Important to understand 4 mechanisms of propagation of sound over flat ground with no obstacles:
  - Geometrical spreading – in open air, at distances greater than a few hundred feet, noise level decreases at a rate of 6 dB per doubling of distance regardless of frequency content
  - Air absorption – at low frequencies, it can be ignored for back blast because maximum attenuation at any reasonable combination is less than 1 dB per kilometer
  - Ground absorption – not significant factor in low frequency propagation under most conditions
  - Meteorological effects – temperature inversions and wind gradients can play a large role in noise increases to back blast noise (HMMH: recently completed study (2018) for LAX)

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Item #2(c) Continued

- As an aircraft departs there are two noise peaks – first when thrust is increased near maximum levels at start of takeoff roll and second when aircraft rotates and climbs from the runway
- As the aircraft orientation changes to vertical direction, the rear lobe of directivity is pointed more towards he ground which causes a sudden increase in noise level

Item #2(c) Continued

- Back blast noise mitigation: noise control at the source, barriers and buildings, trees and shrubs, sound insulation, vibration and rattle, and noise cancellation
- Noise control at source:
  - Persuade airlines for quieter aircraft (HMMH: now would be Stage 4 and 5)
  - Create procedure to lower climb rate to reduce second peak noise (HMMH: consider tradeoffs)
- Barriers and buildings:
  - Barriers effective only if placed close to receiver – minimal attenuation would mean a barrier at least 15 feet tall located within 50 to 100 feet of residence (HMMH: barrier could also create reflections)

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Item #2(c) Continued

- Tress and shrubs:
  - Provide minimal reductions to noise levels
  - Many people believe that it reduces noise, which can be due to the look and feel as they block the view
- Sound insulation:
  - While RSIP are successful for overflight noise, insulation for back blast is harder to achieve because of low frequency penetration
  - BWI pilot program with low frequency treatments achieved average increase in C-weighted noise reduction of 4 dB. Extent of treatments was considerable with major wall modifications and windows with an overall thickness of over 12 inches. Cost of treatment was 40% increase over standard RSIP treatments

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Item #2(c) Continued

- Vibration and rattle:
  - There are simple and cost effective solutions to minimize rattle of windows, doors and other household items. Some include using gasket materials to fill in gaps and soften contact points, vibration isolation pads and washer added to cushion impact
  - In Millbrae, additional treatment was applied to reduce low-frequency vibration in rooms facing runway. A secondary interior wall was added and higher STC windows. There was no measured data documenting improvement, but 38 out of 41 homeowners judged the treatments to be effective
  - In Minneapolis, majority of homeowners complained about rattling of windows and number dropped by 40% after standard treatment
  - Isolation of household items from tabletops, walls, and shelves with felt or rubber pads seems to eliminate audible rattle

Item #2(c) Continued

- Noise cancellation:
  - Initial demonstration of active noise control systems to reduce back blast were successful – noise reductions of up to 10 dB were achieved over the frequency range of importance for vibration and rattle

NOTE: HMMH has just submitted a FY2020 ACRP problem statement entitled, "Determining Feasibility of Applying Active Noise Reduction/Cancellation to Jet Aircraft Departures"

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Item #2(c) Continued

- Source spectra of departing aircraft contain greater amounts of low-frequency energy at points closer to start of takeoff roll than points further away from start of takeoff roll
- Addition of even small amounts of rattle increased its judged annoyance by 5 dB
- Field measurements found low frequency noise reduction of acoustical treated and untreated residences identical
- Low frequency noise reduction by residences of around 5 dB can be achieved by adding a heavy layer to outside or inside (e.g. 1" heavy weight plaster/stucco/interior wall). Around 10 dB would require complex structures (e.g. brick wall with minimal openings towards sources, and/or insulated cavity wall with separate support interior and exterior cladding)
- Treating rattle/vibration in residences affected by high annoyance of low frequency noise should be highest priority

Item #2(d) (Metrics – Equipment/measuring tools that may be needed in future)

- Portable noise and vibration monitoring systems for short term monitoring that can automatically integrate the data into SFO's Noise and Operations Management System (NOMS) are recommended for any additional study
- These portable systems have wireless communication and can be placed outdoors or indoors for continuous streaming of data
- The sound level meters should be capable of recording unweighted, A, and C weighted one-second noise values
- The noise and vibration equipment would not have established thresholds, but would send all one-second data back to the server for post processing
- It is recommended that each homeowner be provided with a log where they can record specific concerns at the time that each occurred

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Item #3(a-c) (Mitigation Options)

- Upgrades to residences to reduce low-frequency noise have limited options and are often very expensive compared to traditional sound isolation upgrades for medium to high frequency noise
- Active noise cancellation within the communities itself seems promising; however further study is required for scale
- Most complaints come from rattling/vibrations as opposed to the actual low-frequency noise, using affordable products to strap down and dampen objects that move can improve human perception of the annoyance (HMMH: Vibrations can occur without audible noise events present or ahead of and after actual noise events. This effect causes longer periods of aggravation
- Fixing older windows/doors can also reduce rattling effects which drive high annoyance levels:
  - Upgrading the edge seals around the window periphery using a tighter seal and more weather-resistant materials
  - Increasing the window thickness
  - Using double-pane construction with an airspace between each pane