Project 40
Quantifying Uncertainties in Predicting Aircraft Noise in Real-world Situations

Motivation and Objectives

- Improving the understanding of uncertainties for predicting aircraft noise in the current FAA modeling tools.
- Need to account for uncertainties in modeling of the aircraft noise (source), meteorological conditions (propagation path) and ground impedance, terrain profile (receiver).

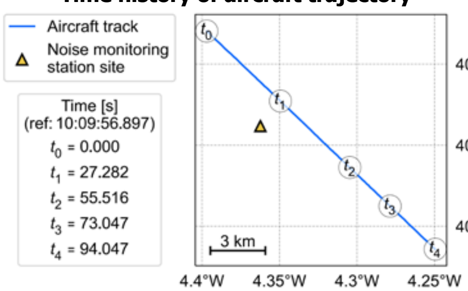
Approach

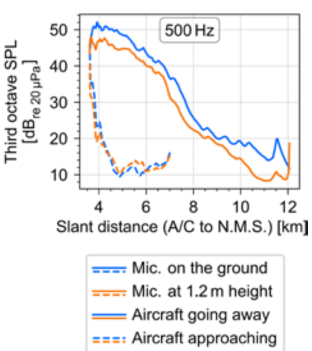
- Utilizing events from the BANOERAC ('Background noise level and noise levels from en-route aircraft') database to assess the role of aircraft directivity and uncertainties in the propagation path.
- Using acoustic data and atmospheric data in the DISCOVER-AQ acoustic data set to quantify the overall uncertainties during the propagation of aircraft noise.

An event from the BANOERAC dataset

After preliminary investigations, only 68 (out of ~1000) events have been determined to be useful for validating existing noise modeling capabilities and further analysis. Showing one such event involving Boeing 757-200 aircraft:

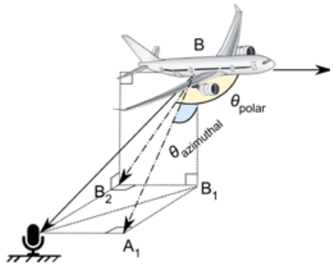
Time history of aircraft trajectory

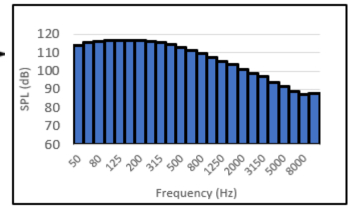


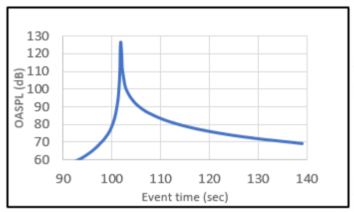


Aircraft noise level vs. slant distance: Aircraft noise received near the ground seems to be higher when the aircraft is approaching the receiver.

Schematic showing angles used for describing aircraft directivity



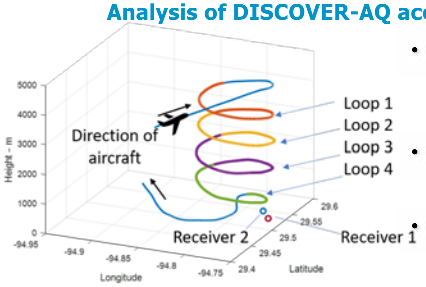




Noise prediction with ANOPP

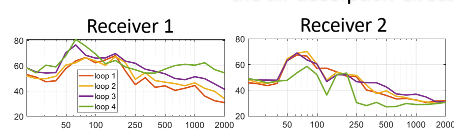
- ANOPP is used to predict 1/3 octave band spectra and OASPL using events from BANOERAC dataset.
- The figures above and to the left show a spectrum and time history, located 50 ft below the aircraft while at an altitude of 16800 ft.
- *These data provide the source information for propagation simulations through the uncertain atmosphere*

Analysis of DISCOVER-AQ acoustic data set

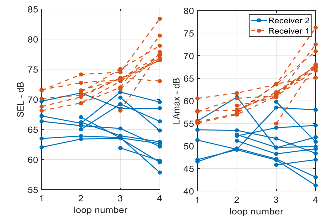


- 10 spiral events of P3-B Orion aircraft above Trinity bay near Houston are used in the analysis.
- 1/3 octave band on the ground and in the aircraft cabin were included
- Atmospheric data were available for prediction of the air absorption effect

Maximum level for 1/3 octave bands at the two receivers for loops 1 to 4.



Sound exposure level plotted against loop number



- The measured SEL (left) and L_{Amax} (right) are shown.
- Similar patterns can be observed in the plots for SEL and L_{Amax}.
- Attenuation is observed between loop 3 and loop 4 at Receiver 2 when aircraft moves closer to the receiver locations.

Results & Discussion

- The raw data from the BANOERAC dataset has been visualized to identify aircraft noise events useful for validating the existing noise modeling capabilities. The preliminary investigation has revealed the importance of correctly accounting for convective amplification, aircraft directivity and source levels to explain the difference in noise levels for a fixed slant distance but a different geometry (aircraft approaching vs. going away from the noise monitor). In collaboration with Georgia Tech, ANOPP input files have been created and predictions made for the noise source level and directivity close to the aircraft.
- The acoustic data of the loops are analyzed and selected for quantifying the uncertainties of received aircraft noise on the ground during the propagation.

Next Steps

1. Sound source spheres will be generated and then noise will be propagated to the ground with and without an uncertain atmosphere. Comparisons will be made with BANOERAC measurements. Source sphere changes for different altitudes and other flight cases will also be generated.
2. Using meteorological reanalysis data and the approach shown by Wilson et al. (2014)[2] to assess the role of uncertainty in meteorological conditions in predicting aircraft noise.
3. Level flight and the loop data will be investigated by using the method of subtraction for acoustic measurements at various receiver locations. This method helps to minimize the variations in acoustic power.

References

1. BANOERAC Project final report, Document ID PA074-5-0, ANOTEC Consulting S.L. (2009).
2. Wilson, D. Keith, et al., "Description and quantification of uncertainty in outdoor sound propagation calculations." The Journal of the Acoustical Society of America **136**(3) 1013-1028 (2014).
3. DISCOVER-AQ Acoustics Measurement and Data Report, U.S. Department of Transportation & Volpe National Transportation Systems Center. (2015).

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March 31, 2020

This work was funded by the US Federal Aviation Administration (FAA) Office of Environment and Energy as a part of ASCENT Project 40 under FAA Award Numbers: [13-C-AJFE-PSU Amendment 49, 13-C-AJFE-PU Amendment 31].