Recommended Community Noise Model Enhancements to Improve Prediction of Helicopter Activity Impacts

DETAILS

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RECOMMENDED COMMUNITY NOISE MODEL ENHANCEMENTS TO IMPROVE PREDICTION OF HELICOPTER ACTIVITY IMPACTS

This digest summarizes the findings of ACRP Project 02-44, "Guidance for Helicopter Community Noise Prediction." The research team was led by Wyle Laboratories and included the Volpe National Transportation Systems Center, Netherlands Aerospace Centre (NLR), and KB Environmental Sciences.

SUMMARY

Predicting noise impacts from aircraft activity typically involves a complex modeling process, and accounting for helicopter and tiltrotor aircraft remains a particularly challenging aspect of aircraft noise modeling. This digest provides an overview of research conducted to identify improvements to the most common methods for predicting helicopter community noise, including the research tasks, findings, final conclusions, and next steps. While the research did not attempt to identify which noise metric best predicts annoyance, it offers a computational methodology from which suggested metrics may be accurately determined.

BACKGROUND

Historically, the study of noise impacts from aviation has been focused on fixed-wing aircraft, while noise impacts from helicopter and new-technology rotary-wing aircraft have received less attention due to their greater complexity. The FAA Aviation Environmental Design Tool (AEDT) is currently the agency's required tool for NEPA-related studies and FAR Part 150 studies. The fixed-wing aircraft noise prediction techniques used in AEDT rely on the widely accepted methodologies described in documents such as SAE International's SAE-AIR-1845 and the European Civil Aviation Conference's Document 29. However, there has been no peer-reviewed guidance document describing an integrated modeling technique for the prediction of noise from rotary-wing aircraft. While higher fidelity rotorcraft noise models exist, and advancements to the state of the art continue, the industry recognized the need to conduct research focused on enhancing typical community noise modeling practice, level of effort, and input data constraints.

The objective of the research was to review, evaluate, and document current helicopter noise models and identify potential improvements to AEDT to better capture the unique complexity of helicopter operations.

The review and evaluation of current models began with an examination of each method's input requirements, assumptions, algorithms, database coverage, outputs, and validation history. An assessment was made as to their ability to capture the unique noise characteristics of helicopter operations, including takeoffs and landings, overflights, hovering, and orbiting. The review also critiqued each method's

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strengths and weaknesses from a user experience perspective, including database availability and accuracy, user interface, runtime, and output. Based on this review, potential technical refinements to AEDT, specifically designed to improve the model's prediction of helicopter activity, were developed. Next, an outreach effort was conducted within the international rotorcraft noise community to solicit feedback. Input was received from more than 150 practitioners from several countries, representing manufacturers, noise modeling researchers, airport and heliport operators, and agencies and associations involved with helicopter operations, research, regulation, and oversight.

Based on the research and industry feedback, the research team prepared a final list of conclusions and a draft supplemental document for calculating helicopter noise levels using AEDT. This supplemental document has been structured and written in the style of the AEDT Technical Reference so that it outlines in mathematical and algorithmic format the conclusions of this project. It was created to serve as a starting point for a future international standards review process.

FINDINGS

The framework for AEDT modeling is well established for fixed-wing aircraft. The historical integrated Heliport Noise Model forms the basis of the AEDT rotorcraft core. As with most noise models, these key elements must be included:

- Source noise characteristics (level, directivity, spectra/metrics, conventional/tiltrotors).
- Operational capabilities (takeoff, landing, hover in/out of ground effect, orbiting, tiltrotor-specific modes).
- Propagation modeling (atmospheric models, natural and urban terrain, spectral domain, range).
- Community Noise Metrics (single and multiple operation contours, standard and supplemental metrics).

The research revealed that the primary focus for improving AEDT capabilities with regard to predicting helicopter noise impacts should be on source modeling, including spectral content, lateral directivity, and operational sensitivity. Following is a prioritized list of seven key conclusions:

1. AEDT should be capable of computing the following metrics: Maximum Sound Level (L_{max}), Sound Exposure Level (SEL), Day-Night Average Sound Level (DNL or Ldn), Community Noise Equivalent Level (CNEL), Perceived Noise Level (PNL), Tone-Corrected Perceived Noise Level (PNLT), Effective Perceived Noise Level (EPNL), Weighted Equivalent Continuous Perceived Noise Level (WECPNL), Maximum C-weighted Sound Level (L_{maxC}), C-weighted Sound Exposure Level (CSEL), d-Prime Audibility (DPRIME), Number-of-events Above (NA), and Time Above a Specified Level (TAL).
2. AEDT should model lateral source characteristics with sufficient (a) angular fidelity to capture directional Blade Vortex Interaction (BVI) noise and (b) lateral extent to account for changes in vehicle roll angle. Under vehicle-specific approach flight conditions the rotor-wake interaction can cause significant increases in noise source emission over highly directive regions. Modeling of rotorcraft in regions with urban and natural terrain and inclusion of bank angle in the noise analysis can require vehicle source characteristics to be defined well outside the current 45° extent defined in AEDT/INM.
3. The model's spectral content should include one-third octave bands down to 10 Hz. The low-frequency trade study demonstrated a strong sensitivity to inclusion of low-frequency effects below 50 Hz for helicopters over the range of distances (0–25,000 ft) included in the AEDT/INM NPD database for C-weighted metrics and for the supplemental metric d-Prime. Researchers found that variations due to incorporation of the low-frequency content exceed the established criteria for AEDT/INM spectral class selection for C-weighted metrics; therefore, the rotorcraft should be modeled down to 10 Hz.
4. The model should include the effects of approach flight path angle on source noise characteristics. Significant changes to the source noise emissions can occur when flight path angle (FPA) is adjusted. During BVI the blade and wake are in close proximity to one another. Changes of FPA by a few degrees can enter BVI condition and cause large

changes in noise, exceeding 10 dBA and must be considered.

5. The model should include the changes in noise source characteristics from maneuvering flight if: (a) one needs to model or optimize low-noise rotorcraft profiles or take into account approach drag devices for BVI-avoidance, or (b) L_{max} and other maximum non-integrated metric values are to be predicted on a high-fidelity spatial mesh in the vicinity of flight maneuvers, or (c) time above metrics are to be computed from flights whose maneuver time durations are significant. Maneuvering flight is an active area of research, and helicopter performance modeling capabilities are currently under development for AEDT and other noise models. Funded Advanced Acoustic Model (AAM)[i] [Page et al. 2010] maneuvering flight implementation project also suggests that simplified source equivalences based on gross kinematic parameters will be available in the near future.
6. The model should account for the effect of tiltrotor transition between airplane and helicopter modes. Flexible profile modeling is needed to capture all possible operational procedures. Consideration should be given to the inclusion of source fidelity to capture the relative wing/rotor loading during transition mode. Changes should be made to the model including the capability to handle tiltrotor movements and transition noise source emission (NPD and Spectral Class).
7. The method described and proposed in the report entitled “Detailed Weather and Terrain Analysis for Aircraft Noise Modeling”[ii] for inclusion of higher fidelity atmospheric and terrain modeling in AEDT is suggested. It was found that the propagation algorithms in AEDT are sufficient, and only specific airport considerations will necessitate the inclusion of terrain, shielding, and/or variable ground impedance. Therefore no conclusion to always or never include such effects can be made; however, the AEDT/INM model should be capable of higher fidelity modeling.

NEXT STEPS

Several process and technical steps are needed to incorporate the research conclusions into community noise models.

From a process standpoint, the modeling conclusions and supplemental document are intended to help guide development of a draft helicopter and tiltrotor noise modeling standards document under the aus-pices of the SAE A-21 Aviation Noise and Emis-sions Committee in the United States, and possibly also the International Civil Aviation Organization (ICAO) and the European Civil Aviation Conference (ECAC) AIRMOD Group.

From a technical standpoint, the following steps would need to be taken:

1. Determine a suitable methodology for development of a comprehensive AEDT helicopter and tiltrotor database. Examine existing rotorcraft noise databases and research and develop specific processes for creation of an AEDT noise database that includes the expanded data itemized in the project recommendations (spectra, NPD mode data, and directivity information) for existing and retired vehicles. The methodology should be flexible and applicable to a variety of cases for which limited and extensive acoustic empirical data are available. The process should be tested using select rotorcraft and validated with measurement data. Develop specific AEDT input data requirements (empirical and analytical). The process should be peer reviewed and reflect stakeholder input.
2. Exercise the process for an expanded AEDT helicopter and tiltrotor fleet. Document and provide tools that can be used in the future to create additional database parameters for new and derivative rotorcraft.
3. Perform the necessary AEDT software modeling updates which implement the modeling recommendations and take advantage of

[i]Page, Juliet A., Wilmer, C., Schultz, T., Plotkin, K. J., Czech, J., 2010. “Advanced Acoustic Model Technical Reference and User Manual,” Department of Defense, SERDP Project WP-1304. Available from https://www.serdp-estcp.org/Program-Areas/Weapons-Systems-and-Platforms/Noise-and-Emissions/Noise/WP-1304/%28language%29/eng-US

[ii]Plotkin, K. J., Page, J. A., Gurovich, Y., Hobbs, C. M. In *Advanced Acoustic Model Technical Reference and User Manual*, DOT-VNTSC-FAA-14-08, April 2014.

the expanded database. AEDT code updatesshould be conducted after development of the methodology but in concert with cre-ation of the full helicopter and tiltrotor noise database and aligned with the final approved standard.

This important research has shown that significant advances are possible for improvement of rotorcraft community noise. Development of a comprehensive database and incorporation of the modeling improvements in AEDT in conjunction with an approved standard are critical next steps.

FOR FURTHER INFORMATION

For further information, or to obtain a copy of the contractor's final report or supplemental document, please contact Joseph Navarrete, Senior Program Officer at jnavarrete@nas.edu.

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