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## **Aviation Noise Prediction during Hybrid Aircraft Operations: Developing Scenarios**

*This paper presents a methodology for the development of operational scenarios for hybrid aircraft with a focus on noise prediction. The methodology provides three levels of research for overall analysis: aircraft level, airport level, and fleet level.*

### **Introduction**

Introducing hybrid aircraft offers new opportunities for sustainable aviation development [1]. To meet the ambitious emission reduction targets at European and global levels, developing novel types of aircraft – especially hybrid aircraft – could be the key to minimize aviation’s footprint [2]. Targeted at reducing emissions, new H&E aircraft must comply with the latest ICAO noise certification standards and follow the trend of lowering the noise of conventional aircraft. Even with reduced noise from single aircraft operations, increasing air traffic poses additional challenges for noise management, especially in populated areas around airports. This paper presents a methodology for developing operational scenarios for hybrid aircraft with a focus on noise prediction. The goal is to understand how new technologies and increasing traffic will impact the quality of life for people living around airports.

### **Methodology**

The goal is to understand how new technologies and increasing traffic will impact the quality of life for people living around airports. This goal could be achieved in a complex way only because of its range of input parameters and interdependencies. To assess the acoustic efficiency of the new hybrid aircraft, a three-level logic for scenario development is proposed (see Fig. 1):

- 1) the individual aircraft level (take-off and landing operations);
- 2) the airport level (analysis for a typical/generic airport scenario), and...
- 3) the contribution to global environmental impact reduction. For each of these levels, it is necessary to select evaluation criteria, define the level of detail of the input data, and assess potential interdependencies with aircraft engine emissions.

At this stage, work on developing the optimal hybrid aircraft continues. However, basic scenarios for noise pollution prediction have been completed.

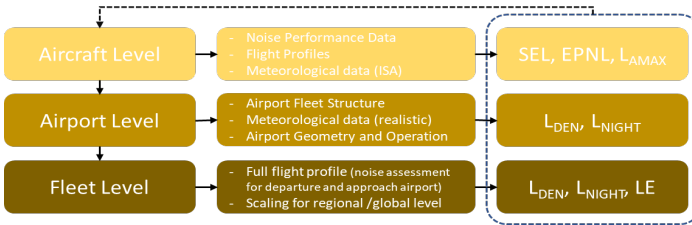


Fig. 1. Tree-level approach for noise forecasting of the novel aircraft

### Baseline scarious for aircraft level

At the aircraft level, modeling of a typical flight profile of a hybrid aircraft was performed, and a comparison was shown with a conventional aircraft using a flight profile generated according to the same algorithm. Additionally, a comparison was included with conventional aircraft and standard flight profiles from the ANP database. The ATR76 was selected as the representative aircraft type, as it is the closest in terms of flight performance characteristics to the hybrid aircraft being developed in the ECAFA project. To assess acoustic performance at the aircraft level, the following criteria were selected in addition to SEL and  $L_{AMAX}$ : EPNL noise levels and equal noise contours of EPNL (Fig.1). Thus, the following flight profiles were investigated: 1) Standard ANP Approach and Departure (STANDARD), 2) User Conventional Aircraft Approach and Departure (UCON), and 3) User Hybrid Aircraft Approach and Departure (UHYBRID).

The approach for modeling user profiles was implemented as described in the paper [3]. The calculated profiles with a 1-second time step were filtered using the Douglas-Peucker algorithm with altitude and thrust filters for more complex segments (fig.2). The differences among the main profiles are illustrated in figure 3: (a) for departure and (b) for approach.

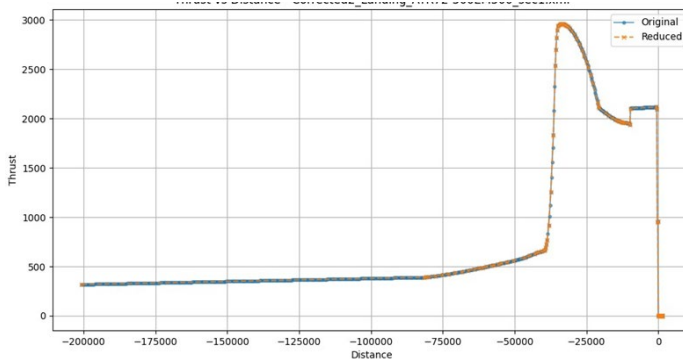
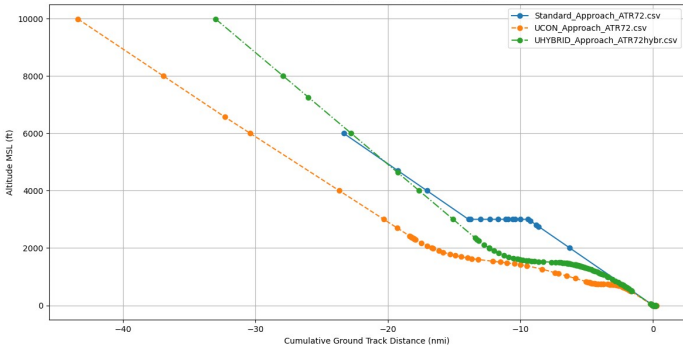
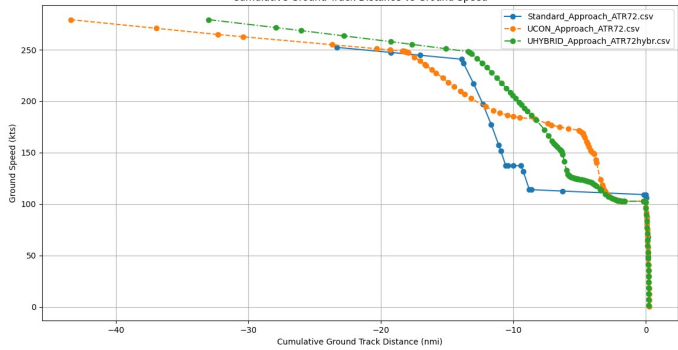


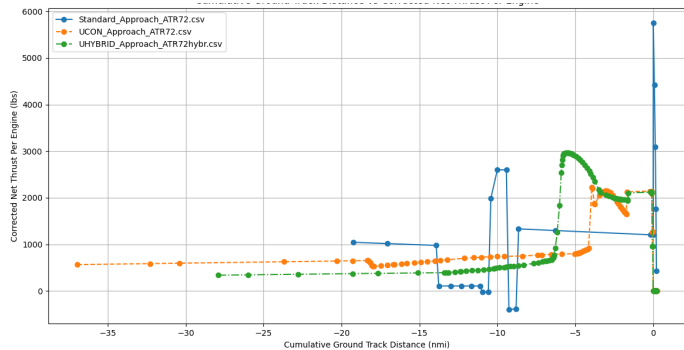
Fig. 2. Comparison of filtered (orange) and non-filtered (blue) flight profile data: Thrust vs Distance for user profile (UCON)



a)



b)



c)

Fig. 3. Comparison of Approach Profiles: a) altitude; b) ground speed; c) corrected net thrust per engine: STANDARD (blue); UCON (orange) and UHYBRID (green)

The results of noise modeling obtained using the AEDT 3e model for EPNL noise contours are shown in Fig. 4: (a) comparison of noise contours for the Standard Approach and UCON profile, (b) comparison for the Standard Approach and UHYBRID profile. The noise modeling results for EPNL noise contours during the departure phase are presented in Fig. 5: (a) shows the comparison of noise contours between the Standard Departure and UCON profile, and (b) illustrates the comparison between the Standard Departure and UHYBRID profile.

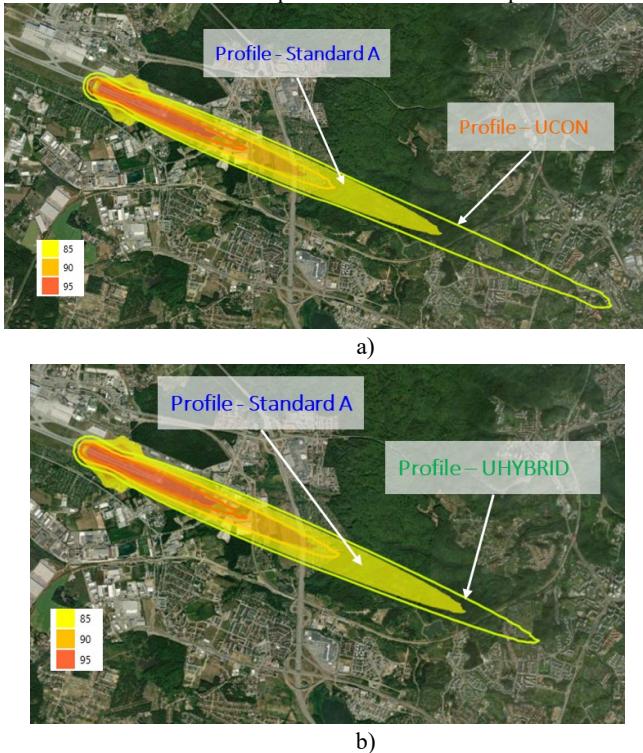


Fig. 4. Comparison of noise contours for a single approach: a) STANDARD and UCON approaches; b) STANDARD and UHYBRID approaches

### Conclusions

This study presents a comprehensive approach for evaluating the acoustic performance of hybrid aircraft through scenario-based noise prediction methodologies. By applying a three-level analysis—individual aircraft operations, airport level, and global environmental impact—the study highlights the acoustic characteristics of hybrid aircraft compared to conventional aircraft. At the aircraft level, noise modeling results indicate that hybrid aircraft perform favorably during takeoff compared to standard takeoff profiles of conventional aircraft, showing

reduced noise levels. However, the results for the landing phase are less clear-cut: the noise contours for hybrid aircraft in the 85-95 EPNLdB range are larger in area compared to those of conventional aircraft (both standard and user profiles). This suggests that while hybrid aircraft offer significant noise reduction benefits during takeoff, the landing stage requires further optimization to achieve comparable or better acoustic performance.

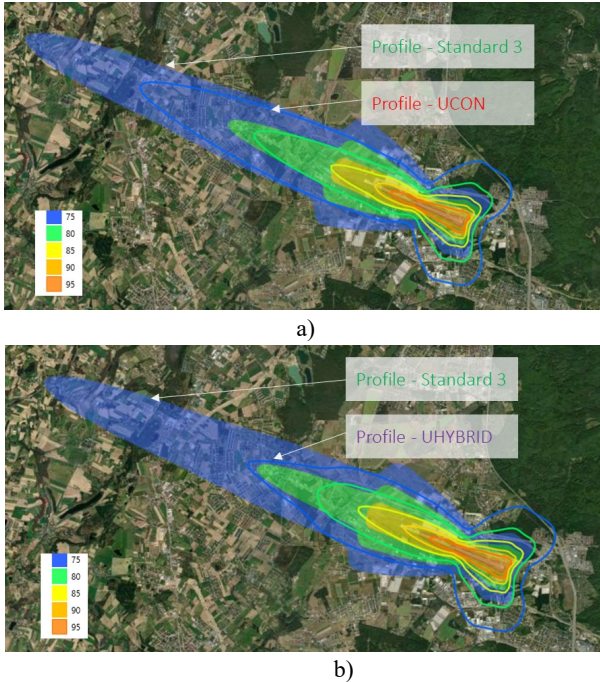


Fig. 5. Comparison of noise contours for a single departure: a) STANDARD and UCON departures; b) STANDARD and UHYBRID departures

## References

1. Pretto M., Giannattasio P., De Gennaro M., Zanon A., Kuehnelt H. Forecasts of future scenarios for airport noise based on collection and processing of web data. *European Transport Research Review*, 2020. – 12:4. – 14 p.
2. De Gennaro M., Pretto M., Kuehnelt H., Zanon A. Predicting the effect of electric and hybrid-electric powertrains on airport noise. *Journal of Sustainable Aviation*, 2020. – 4:1. – 18 p.
3. Zaporozhets, O., Makarenko, V., Tokarev, V., Kazhan, K., Synylo, K. (2023). Modelling the noise characteristics of a regional turboprop hybrid-electric aircraft. *International Symposium on Electric Aviation and Autonomous Systems*. Warsaw. Available at: <https://2023.iseasci.org>