Aeroacoustic assessment of blended wing body configuration with low noise technologies

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Keywords: Aeroacoustics, Low Noise Technologies, BWB, Distributed Electric Propulsion, Regional Aircraft, Shielding effect, Airport Noise, Footprint

Abstract. An aeroacoustic assessment of promising novel aircraft concepts (BOLT and REBEL, two Blended wing bodies respectively with conventional and hybrid engines) devoted to fly in 2035-2050 scenario coupled with Low Noise Technologies (LNT) developed inside the framework of ARTEM project (H2020)[1] has shown. The noise assessment of each noise source of the AAC (Advanced Air Concepts) has been provided including the attenuation due to the masking effects due to the fuselage. The results are then used for the noise impact on the ground, through a ray-tracing method and taking into account the installative effects, with a comparison with standard/similar aircraft. Finally, the noise assessment of a AAC&Standard fleet on a reference airport has been provided.

Introduction

The main noise sources of novel BWB configuration BOLT and REBEL have been analyzed though some of the most used semi-empirical or numerical models well known in literature, then noise predictions have been coupled with Low Noise Technologies in order to satisfy the community requests. The effects of the installation of these LNTs, together with the shielding effect due to the particular shape of the Blended-Wing-Body, have been analyzed, following the most common noise metrics, in terms of single aircraft and fleet simulation on a reference airport.

Aeroacoustic Approach

The methodology proposed for the aeroacoustic analysis of the noise impact of BOLT and REBEL follows four steps: i)Aerodynamic modelling, focused on REBEL and the effects of a set of DEP; ii)Aeroacoustic modelling for each noise sources, generating noise hemispheres; iii) Scattering modeling where the fuselage effects of the BWB have been evaluated; iv) Ground propagation modelling where the noise assessment at ground level for a single fly-over event and then a fleet simulation at two certification points have been performed.

Validation of noise models

Reference data for an aircraft with similar characteristic to one of two disruptive concepts analyzed – BOLT – have been collected in order to compare them with the results predicted with the noise source models.

The comparison has been made using the NPD (Noise Power Design) curves provided by ANP database[1] for a range of altitudes that varies from 630 to 12000 ft and the airspace has been defined to correctly predict the SEL (*Sound Exposure Level*) as a time integrated noise index derived from the SPL (*Sound Pressure Level*) as shown, for several thrusts, in *Figure 1* . The results show good agreement between experimental data and theoretical prediction.

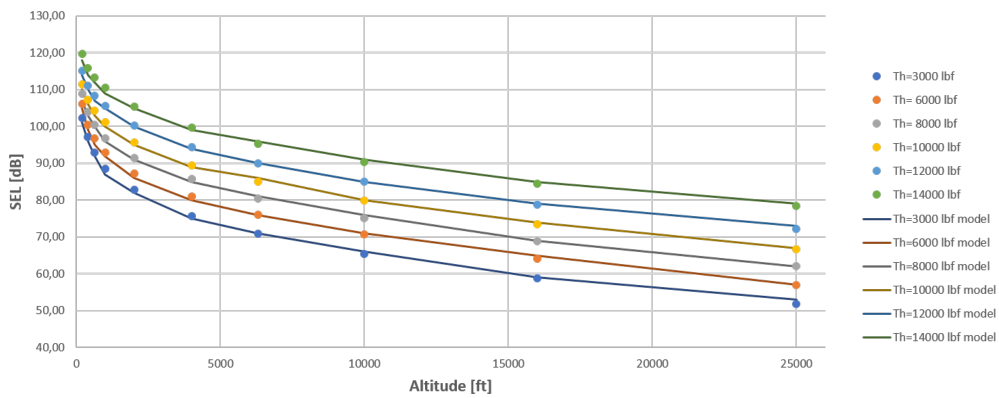


Figure 1: SEL comparison calculated for a reference aircraft similar to BOLT, for different thrusts. Circles represent exp data (SEL, ANP); Lines represent model (SEL predicted).

Fuselage shielding

The shielding effects by the BWB fuselage have been evaluated on hemispheres surrounding the aircraft, with a radius of 50m and with a twofold approach assuming the absence of mean flow: the first one is based on discontinuous Galerkin method developed by ACTRAN[2] while the second one is based on the fast shielding approach (method of Maekawa[3]), more suitable for medium-high frequencies. The results show a good agreement among two approaches and in particular show that, for the first two blade passing frequencies (the most annoying part of the overall noise), the attenuation due to the configuration can reach 20 dB (in front of the aircraft): the fuselage shielding plays a crucial role for the noise reduction of such aircrafts (*Figure 2*).

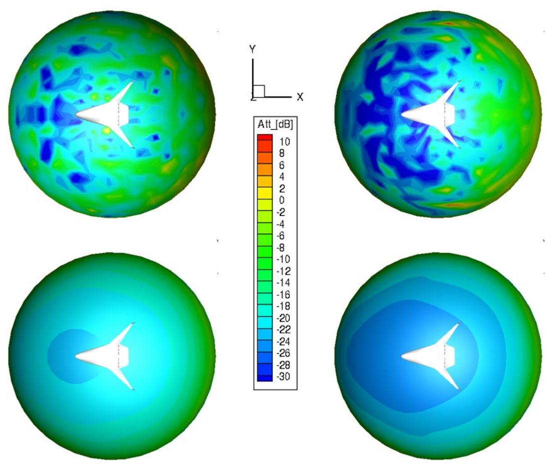


Figure 2: Attenuation effects at the BPF and comparison between DGM Method (on the top) and fast shielding approach (bottom figure). On the left 1st BPF, on the right 2nd.

BOLT and REBEL assessment

The attention is then focused on the noise analysis of BOLT and REBEL with and w/o low noise technologies (LNT) developed inside the framework of ARTEM project. Their coupling was done taking in account the feasibility of the single LNT analyzed, the degree of risk and the scaling to BOLT and REBEL. The main LNT analyzed and the related noise source involved can be summarized in the following list: i) Innovative liners on slanted septum core (fan noise); ii) High Lift Devices; iii) Flap porous treatments for Jet Interactions; iv) Jet Installation Effects; v) Landing Gear Effects. The contribution of each LNT has been considered in terms of Insertion Loss (IL). The noise predictions have been done considering firstly the noise results got with the noise models for each noise source of the aircraft, then applying the LNT related to each noise source and finally summing energetically the new noise results and projecting them on takeoff/flyover and landing

Materials Research Proceedings 37 (2023) 1-5 https://doi.org/10.21741/9781644902813-1

dedicated trajectories. The final assessment of this procedure is shown, only for BOLT, into *Figure 3*:

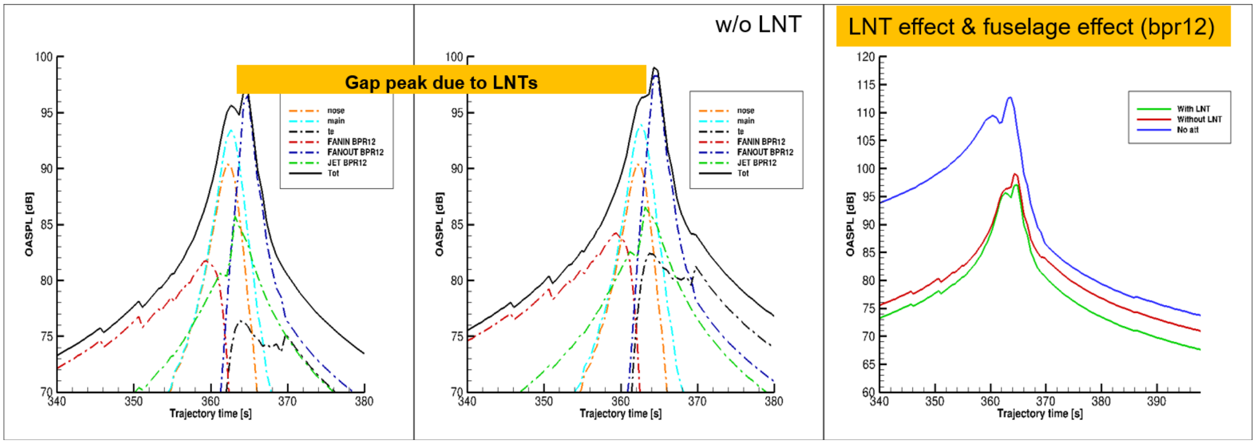


Figure 3: Each noise source is shown (fan, jet, main and nose landing gear, trailing edge, total). First two pictures on the left shows the gap due to LNTs; third on right the gap due to the fuselage effect. BOLT, takeoff, mic at x=2300 m.

Then BOLT and REBEL SELs are predicted for each noise sources as shown in figure below:

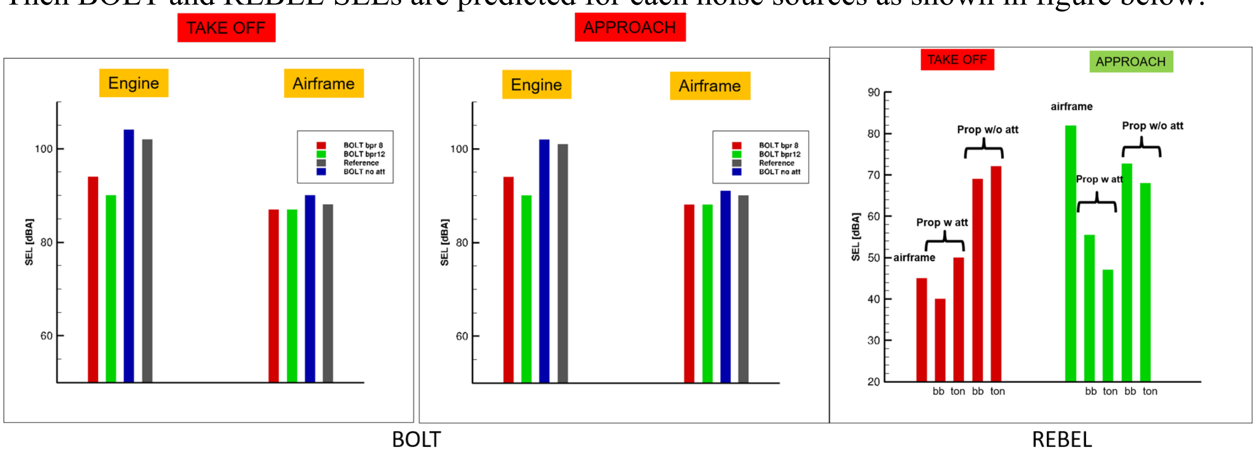
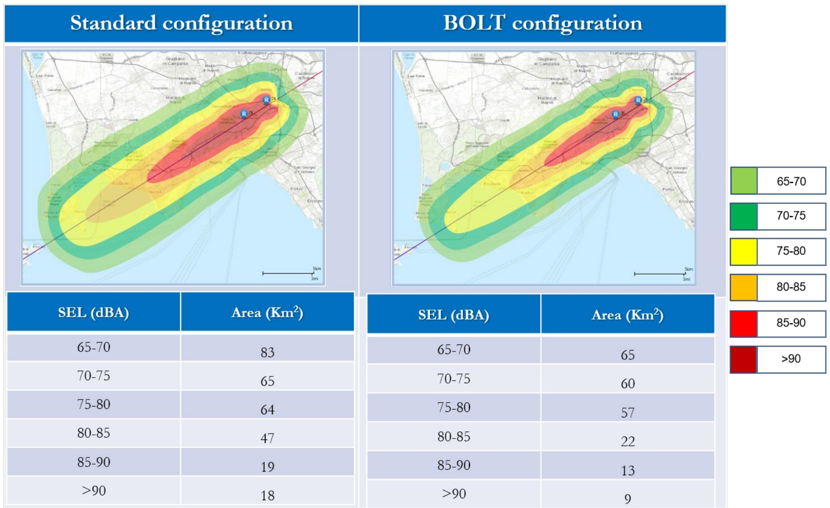


Figure 4: first two figures on the left: SEL of each noise source in BOLT; third figure on the right: REBEL SELs of each noise source (propeller noise, tonal and broadband component).

Acoustic impact on a reference airport

The acoustic impact on a selected airport (Naples, Italy) of BOLT and REBEL has been simulated. *Figure 5* shows the results derived from comparing BOLT with a reference aircraft. The results clearly show a noise reduction due to BOLT configuration. Same conclusions arise simulating a fleet simulation of AACs and comparing with standard aircraft. (*Table 1*).



Standard configuration

SEL (dBA)	Area (Km²)
65-70	83
70-75	65
75-80	64
80-85	47
85-90	19
>90	18

BOLT configuration

SEL (dBA)	Area (Km²)
65-70	65
70-75	60
75-80	57
80-85	22
85-90	13
>90	9

Figure 5: Acoustic impact comparison: Single event contours (take off).

L_{DEN} [dBA]	Area (standard – novel) [Km^2]
60-65	-3
65-70	-1
70-75	-1
75-80	0
80-85	0
>85	-0,3

Table 1: Equal loudness LDEN contours: standard scenario - 2050 scenario.

Conclusions

AAC as BOLT and REBEL satisfy the community requests of noise reduction. This is mainly due to the fuselage shielding effect of BWB configuration and secondary to the application of Low Noise Technologies. Further investigations will have to pursuit this twice way in order to reach the main target of the noise reduction.

References

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