

VALidation and Improvement of Airframe Noise prediction Tools



Grant agreement: ACP8-GA-2009-233680

Background

The overall noise radiated by modern aircraft has two sources which are quite balanced at approach: the engine and the airframe. The airframe noise (AFN) has a broadband character and is mainly due to the interaction of the turbulent airflow with the high lift devices (slats and flaps) and landing gears, and to a second extent to cavities, spoilers and to boundary layers developing along the fuselage.

One of the major ACARE objectives is the reduction of perceived noise level of fixed-wing aircraft by 50% by 2020 compared to 2001. In achieving this required breakthrough towards quieter aircraft, reduction of AFN is very important already today and will become even more important in the future, especially for large aircraft, due to the already anticipated development of quieter engines.

With the clearly expressed tendency of modern airframe industry towards virtual prototyping and the increasing reliability of the design cycles on numerical simulations with the experimental verifications performed only at later stages of the design cycle, it is of utmost importance to increase the trust in noise predictions. However, the complexity and diversity of broadband turbulent AFN sources makes that prediction and subsequent reduction with present numerical tools extremely challenging and far from mature.

Objectives

VALIANT is tackling this challenge by generating new experimental data and validating and improving numerical tools for prediction of AFN generated from landing gears, slats, flaps and local separation regions.

Due to the extremely complex physical nature of the phenomenon and the high computational cost of computing full aircraft configurations on one hand, and a lack of a reliable experimental database on the other hand, VALIANT focuses on key generic test cases revealing the basic mechanisms of AFN generated by the most "noise-dangerous" elements of a real aircraft:

- Turbulent flow over a gap;
- Flow past airfoil with flap;
- Flow past airfoil with slat;
- Flow past two-struts (landing gear).

These four generic flows actually "cover" the most important sources of AFN generated by a real aircraft and therefore their study provides a sufficient basis for evaluation and improvement of the Computational Aeroacoustics (CAA) tools aimed at predicting AFN. On the other hand, these flows are "simple" in the sense that their accurate simulation and prediction of the noise they generate are computationally affordable.

For all these configurations, the components of the noise prediction chain (for turbulent/source region, near- and far-field propagation domains) and their mutual interactions are evaluated and avenues of improvement developed.

Description of work

The project is divided into four technical Work Packages (WP).

WP1 is focusing on the generation of a detailed and reliable experimental database for validation purposes for the four generic test cases listed above. Expected results are steady and unsteady aerodynamic data, as well as noise source localisation and far-field noise spectra and directivities. Acoustic measurements performed in a cheap large aerodynamic wind tunnel are also planned.

WP2 is aimed at a thorough assessment of currently available CAA approaches in terms of both turbulence and acoustics by comparing the approaches with each other and with the experimental data for the four generic test cases. This systematic comparison will highlight the strong and weak points of the numerical approaches and suggest avenues of further improvements of the weak points within WP3.

Based on the remedies proposed in WP2, the CAA approaches will be improved in WP3 in terms of turbulence representation and near-, mid- and far-field noise prediction. WP3 aims also at improving the analytical methods which are of significant importance to assess the noise around airports in term of EPNdB and to help interpretation of the numerical results.

The objective of WP4 is to assess the influence of the successive improvements in the numerical and analytical approaches. The exploitation plan will address the identification of best suited AFN prediction tools which may have the potential to be integrated into industrial processes in the future.

Expected results

This project, being an essential step towards new efficient AFN reduction concepts and their optimization in order to achieve the required breakthrough towards quieter aircraft, impacts then directly to European Community by:

- providing a high-quality experimental database for validation on broadband noise associated with generic configurations representative of the most "noise-dangerous" AFN mechanisms;
- validating and improving CFD/CAA tools for broadband AFN prediction within an expected accuracy of 1 dB, and generating a detailed numerical database;
- identifying the best suited AFN prediction tools which may have the potential to be integrated into industrial processes in the future, for designing efficient AFN reduction technologies.

It is expected that the improved prediction tools will allow a later optimization of the AFN reduction concepts leading to a further 3 - 5 dB overall AFN gain during approach (compared to year 2000 state-of-the-art).

VALIANT will also improve cost efficiency by reducing the cost of design and development cycle. This will be achieved by providing efficient AFN prediction tools in term of CPU time reduction and by allowing a partial replacement of extremely expensive experiments aimed at the testing and optimisation of AFN reduction technologies by reliable numerical predictions.

Finally, VALIANT will promote the participation of organisations from International Cooperation Partner Countries (ICPC) by building a strong collaboration with Russia, relying on their complementary expertise in aeroacoustics.

Keywords

Airframe noise, broadband noise, Computational Aeroacoustics, prediction tools, high-lift device, landing gear

Partners

von Karman Institute for Fluid Dynamics (coordinator)	BE
Institute for Mathematical Modelling RAS	RU
Ecole Centrale de Lyon	FR
Technische Universität Berlin	DE
Office National d'Etudes et de Recherches Aérospatiales	FR
Federal State Unitary Enterprise The Central Aerohydrodynamic Institute named after Prof. N.E. Zhukovsky	RU
Stichting Nationaal Lucht- en Ruimtevaartlaboratorium	NL
Deutsches Zentrum für Luft- und Raumfahrt EV	DE
Centre Internacional de Mètodes Numèrics en Enginyeria	SP
New Technologies and Services, LLC	RU
Numerical Mechanics Applications International SA	BE
LMS International NV	BE