

PhD ACTAM : Aeroacoustics of multi-axle landing gear

PARTENAIRES

ONERA

THE FRENCH AEROSPACE LAB

Key words : Bruit aérodynamique, avion, train d'atterrissage, méthode lattice-Boltzmann, mesures aérodynamiques, mesures acoustiques, analogie acoustique, soufflerie

Department : Aerodynamics, Energetics, and Propulsion Department

This PhD proposes to investigate multi-axle landing gear noise generation mechanisms in order to propose innovative low-noise designs.

JOB DESCRIPTION:

Reducing noise from civil aircraft near airports is a constant objective of the aviation industry. Propulsion noise has achieved spectacular progress in the recent decades, particularly thanks to the latest generation of turbofans with very high bypass ratio, so all other airframe-related noise sources now also require reduction efforts.

Among these sources, the landing gear is particularly prominent, but its design must meet very stringent functional and structural constraints, making it very difficult to modify in order to reduce its noise. On wide-body "double-aisle" aircraft (and some smaller "single-aisle" aircraft), the manufacturer must rely on landing gear with 4 (or even 6) wheels (Figure 1), which have specific noise sources related to interactions between wheels, interactions that are highly dependent on geometric

parameters such as the distance between the wheels and the angle of incidence of the bogie relative to the direction of the mean flow.

The objective of this thesis is to investigate the physics of these noise-generating mechanisms, with a view to proposing innovative low-noise designs, while respecting the constraints mentioned above.

This investigation will be based primarily on aeroacoustic numerical simulations of an academic 4-wheel landing gear geometry called LAGOON ("Landing Gear nOise database and CAA validation", an Airbus-DLR-ONERA project, 2007-2012) (Figure 2). These simulations will be conducted using the ProLB solver based on the lattice-Boltzmann method (LBM) (Figure 3).



Figure 1 : Main landing gear of the Airbus A380 (2 x 4 + 2 x 6 wheels)

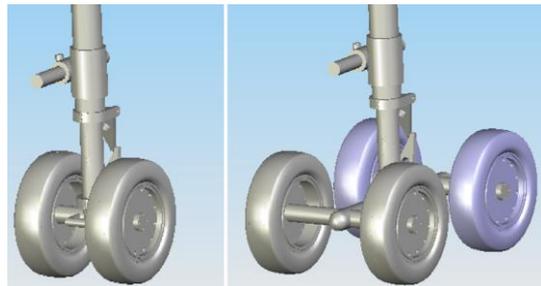


Figure 2: Simplified LAGOON landing gear 2-wheel (left) and 4-wheel (right) configurations

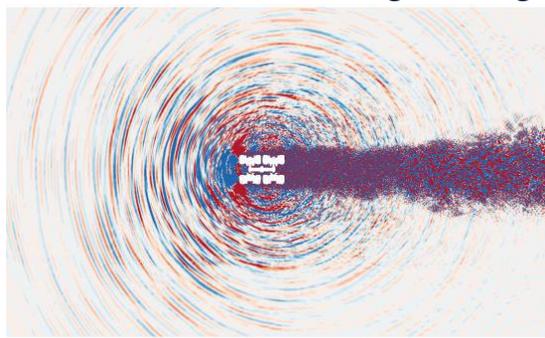
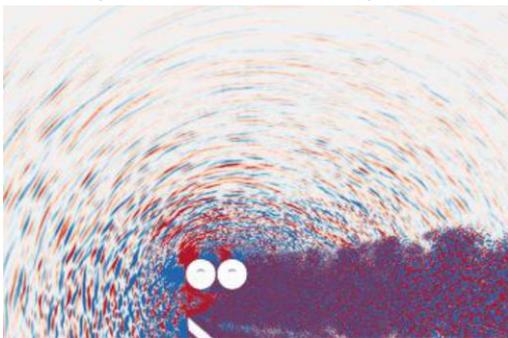


Figure 3 : Numerical simulation via the LBM of the noise radiated by a realistic 4-wheel main landing gear. Vertical (left) and horizontal (right) planes [2]

These simulations will subsequently be validated through dedicated tests conducted in collaboration with ISAE-SUPAERO using an existing model of the LAGOON four-wheel landing gear, built in 2008 at

the same time as the homonymous two-wheel model, but never tested. This model will undergo acoustic testing in the ISAE-SUPAERO SAA wind tunnel [3] (Figure 4), ideally complemented by aerodynamic measurements (PIV, LDV) in the ONERA F2 wind tunnel (Figure 5). This data will then be added to the LAGOON two-wheel database, which continues to be used worldwide [4].



Figure 4 : 120-microphone array for acoustic source localization installed in SAA wind tunnel at ISAE-SUPAERO.



Figure 5 : Simplified LAGOON 2-wheel landing gear in F2 wind tunnel at ONERA [1].

In terms of analysis, the numerical part of this thesis will be structured around the following themes:

- Firstly, a detailed flow analysis will be conducted. The asymmetry of the flow around the wheels, the instability of the separation points, the blocking effect, and the interactions between turbulent wakes and solid walls are all mechanisms to be considered.
- Secondly, digital acoustic antennas are currently a rapidly developing tool [5], and their application to the 3D localization of landing gear sources whose directivity is poorly defined requires further development that can be subsequently validated experimentally.
- Finally, Antoine Hajczak's thesis work at ONERA demonstrated the importance of quadrupole sources at the highest frequencies for an isolated landing gear wheel [6]. In subsequent work, we will seek to quantify the quadrupole sources relative to the dipole sources for different flow velocities on the landing gear geometry under study.
- If the progress of the work allows, a comparative numerical study of the open-flow (SAA) and closed-flow (F2) test configurations may also be conducted.



These analyses and developments will be validated and supplemented by the exploitation of the wind tunnel testing campaigns (to which the doctoral student may contribute if the schedule allows):

- Analysis of the aerodynamic measurements (PIV, LDV) to characterize the flow topology (asymmetry, instabilities, etc.).
- Analysis of acoustic measurements (3D directivity, 2D antennas) and application of the most suitable source localization methodologies [7] to characterize acoustic radiation and rank the different noise sources.
- Implementation of a methodology for comparing open and closed wind tunnel tests [8] (depending on the progress of the thesis).

The thesis will conclude with a synthesis work on the physics of noise sources in a four-wheel landing gear and the influence of geometric parameters (distance between wheels, bogie angle of attack), and finally, to propose low-noise landing gear concepts.

REQUIRED PROFILE:

- Engineering school or university (M2)
- Fair knowledge in aerodynamics and aeroacoustics
- Experience in numerical simulation (CFD)
- Attractiveness to experimentation
- Good level of oral/written English

DURATION : 36 MONTHS

LOCATION : ISAE-SUPAERO Toulouse & ONERA Châtillon

RESPONSIBLE OF THE SUBJECT :

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APPLICATION PROCESS : Candidature [CV, lettre de motivation, contacts de référence, derniers relevés de notes] à envoyer à : helene.parisot-dupuis@isae-supaero.fr

REFERENCES :

- [1] Sanders, L., Manoha, E., Ben Khelil, S., François, C., "LAGOON : CFD/CAA Coupling for Landing Gear Noise and Comparison with Experimental Database", 17th AIAA/CEAS Aeroacoustics Conference, AIAA 2011-2822.
- [2] Sanders, L., "4-Wheels Landing Gear Noise Impact Assessed by LBM Simulation", CEAS Workshop on Airframe Noise Reduction, Oct. 2024, Bucarest, Romania.
- [3] Parisot-Dupuis, H., Bury, Y., Barricau, P., Mellot, B., Characterization of ISAE-SUPAERO Aeroacoustic Wind Tunnel, 10th Convention of the European Acoustics Association, 2023.
- [4] Eric Manoha, Jean Bulté and Bastien Caruelle, "LAGOON : An Experimental Database for the Validation of CFD/CAA Methods for Landing Gear Noise Prediction", 29th AIAA Aeroacoustics Conference), AIAA-2008-2816.
- [5] Bouley, S., Chambon, J., Minck, O., Enhancement of array processing techniques for CAA-based acoustic imaging, AIAA AVIATION 2023 Forum, AIAA 2023-3819.
- [6] Hajczak, A., Sanders, L., Vuillot, F., Druault, P., "A comparison between off and on-body control surfaces for the FW-H equation: Application to a non-compact landing gear wheel", Journal of Sound and Vibration, 2020.
- [7] Parisot-Dupuis, H., Jomain, J., Mellot, B. and Méry, F., Systematic analysis of acoustic source localization maps for performance assessment, INTER-NOISE and NOISE-CON Congress and Conference Proceedings, 2024.
- [8] Fleury, F. and Davy, R., Beamforming-Based Noise Level Measurements in Hard-Wall Closed-Section Wind Tunnels, 18th AIAA/CEAS Aeroacoustics Conference, AIAA 2012-2226.