The Flyover Inter-Wheel Noise of a Generic Nose Landing Gear

Zhe Lu[1] & Alis Ekmekci[1]
1 Institute for Aerospace Studies, University of Toronto, Toronto, Ontario, CANADA

During the approach and landing phases of flights, landing gear noise accounts for up to 30% of the total noise emission for modern civil aircraft. Due to the installation effects, the nose landing gear generates a similar level of noise to that of the main landing gear despite having a smaller size and lower complexity. The significance of the nose landing gear's noise emission has been confirmed by flight test measurements using phased microphone array technique on different types of aircraft. Thus, the aeroacoustic characteristics of the nose landing gear have been extensively investigated.

This study focuses on the noise characteristics of the wheels of a generic nose landing gear. Specifically, the noise emission from the inter-wheel region and the effects of wheel shape as well as the presence of torque link component upstream of the strut are investigated. The aeroacoustic characteristics of the nose landing gear wheels have been studied in literature. Two tonal peaks were observed in the sideline spectra of a simplified two-wheel nose landing gear model in experimental tests of the LAGOON project [1]. A more detailed numerical investigation revealed the tonal peak generation mechanism as the excitation of certain acoustic modes of the facing rim cavities by the Rossiter-type feedback loop modes [2]. These sideline tonal peaks related to the facing rim cavities were also observed on both full-scale [3] and small-scale nose landing gear models in experimental studies [1, 4], confirming the universality of this phenomenon. However, these peaks are only discernible in particular sideline directions and, therefore, do not significantly impact community noise. The other interesting phenomenon associated with the nose landing gear wheels is the cross-stream ejection in the inter-wheel region. This cross-stream ejection was found to be highly unsteady [5] and potentially responsible for the higher broadband noise level of the cases with deeper cavity depth compared to those with shallower cavities for which no cross-stream ejection appeared [4]. However, the cross-stream ejection was observed through qualitative flow visualization and quantitative flow field measurements in a water tunnel at a relatively low *Re* number, and the far-field aeroacoustic measurements were made only in the sideline directions, leaving the impact of the ejection on flyover noise unknown.

To further understand the inter-wheel noise in the flyover direction and the impact of the cross-stream ejection phenomenon, phased-array measurements were made in both the sideline and flyover directions, and Particle Image Velocimetry (PIV) measurements were made in the inter-wheel region downstream of the strut. Both tests were carried out in an anechoic wind tunnel with a freestream velocity of 60 m/s. Two types of wheels, one with a simple smooth shape and the other with inner and outer cavities, were investigated and compared. The flyover noise localization maps show that the inter-wheel region noise from the wheels with cavities is significantly higher than that of the simple wheels. The major noise sources of the wheel with cavities are located downstream of the strut, while those of the simple wheels appear at the front of the strut. Meanwhile, the presence of the cross-stream ejection on the wheels with cavities is confirmed by PIV results. These imply that the cross-stream ejection, which happens downstream of the strut, enhances the noise level in the inter-wheel region of the wheels with cavities. Interestingly, the cross-stream ejection is seen to be suppressed effectively by the addition of the torque link component upstream of the strut, which is reflected by the reduction of far-field noise in both sideline and flyover directions.

Email address for correspondence: *alis.ekmekci@utoronto.ca*

References

[1] Manoha, E., Bulte, J., Ciobaca, V., and Caruelle, B., "LAGOON: Further Analysis of Aerodynamic Experiments and Early Aeroacoustics Results," *15th AIAA/CEAS Aeroacoustics Conference (30th AIAA Aeroacoustics Conference)*, AIAA, Miami, Florida, May 2009.

[2] Casalino, D., Ribeiro, A. F., and Fares, E., "Facing Rim Cavities Fluctuation Modes," *Journal of Sound and Vibration*, Vol. 333, No. 13, June 2014, pp. 2812–2830.

[3] Bennett, G. J., Neri, E., and Kennedy, J., "Noise Characterization of a Full-Scale Nose Landing Gear," *Journal of Aircraft*, Vol. 55, No. 6, Nov. 2018, pp. 2476–2490.

[4] McCarthy, P. W., *Aeroacoustics of Shallow Cylindrical Cavities with Specific Application to the Inter-Wheel Region of Aircraft Nose Landing Gears*, Ph.D. thesis, University of Toronto, Toronto, Canada, 2020.

[5] Feltham, G. and Ekmekci, A., "Flow Topology Around a Simplified Two-Wheel Landing Gear," *Journal of Visualization*, Vol. 17, No. 3, Aug. 2014, pp. 211–219.

Email address for correspondence: *alis.ekmekci@utoronto.ca*