Flyover Noise Measurements on Landing Aircraft with a Microphone Array

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1 ABSTRACT

First results of a study on the noise sources of landing commercial aircraft are reported. The aircraft were examined with planar arrays consisting of 96 or 111 microphones on an 8 m by 8 m plate mounted under the glide path on the ground. The following airframe noise sources were identified in spite of the presence of engine noise, (i) landing-gear noise, (ii) flap side-edge noise, (iii) jet-flap interaction noise, (iv) slat-track noise, (v) slat-horn noise, and (vi) a previously not considered noise source near the wing tip which is tentatively called wake-vortex wing interaction noise. The latter noise source was a surprise and is shown to be by far the strongest noise source (6 dB(A) louder than the engines) on a regional jet aircraft. Landing gear noise is the most dominant airframe noise source on most other aircraft. It is found that the airframe noise signatures as well as the engine noise signatures of the various aircraft types differ significantly which indicates a substantial noise reduction potential for the approach noise certification levels.

2 INTRODUCTION

Airframe noise contributes considerably to the total noise emission during the landing approach of modern aircraft with relatively quiet engines. However, the relative contribution of the various airframe noise sources is not known as well as their relation to engine noise. Microphone arrays with the appropriate data processing software have shown their capability of mapping noise sources on fast moving objects. The focal position of the analysis can be moved with the speed of the flying object which increases the integration time for a frequency analysis and eliminates the Doppler frequency shift (Barsikow and King [1]) that would otherwise make a frequency analysis difficult. This feature was extensively used in studies of sound sources on high-speed trains (King and Bechert [2], Barsikow et al. [3], Brühl and Schmitz [4] and Barsikow [5]).

A linear microphone array was successfully applied by Michel et al. [6] for a study of airframe and engine noise of a Tornado combat aircraft in high-speed low-level flight. This was likely the first application of this technique to a flying aircraft. It revealed that the noise emission of this combat aircraft into the forward arc is dominated by an exhaust noise source at the nozzle exit and by airframe noise and that airframe noise is louder when the external stores were removed. Based on this experience, a large planar array was developed to enable a two-dimensional mapping of the sound sources on landing commercial aircraft.

Some 160 landings were recorded, including all frequently flown modern aircraft types. The staudy will enable a comparison of the noise emission of the various flap and slat designs, identify the best designs from the standpoint of noise emission and also identify avoidable noise sources on existing aircraft. The test results will also help to improve the prediction schemes for the various airframe noise sources. The data will allow to derive the directivity of inlet and exhaust noise during the landing approach. Some aircraft can be equipped with different engine types. The study will enable a comparison of the noise emission of these engines during the landing approach and identify the least noisy engine. Only some first results are reported in this paper.

3 TEST SETUP

3.1 Microphone array

A planar microphone array consisting of 96 condenser measuring microphones was developed and tested on the company airfield of Daimler-Benz Aerospace Airbus in Hamburg with flyover altitudes of about 30 m. The number of microphones was later increased to 111 for a large scale measuring campaign on the airport of Frankfurt/Main with flyover altitudes between 35 m and 40 m. The array was placed just outside the localiser protection zone under the approach path as shown in figure 1. The center of the array was located 8 m to one side of the extended runway center line. The aim was to look vertically at one wing of the aircraft and under a slant angle at the other wing.

The microphone positions of the smaller 96 microphone array were optimized with an evolution strategy (a random optimization procedure) for the largest possible amplification (difference in dB between main lobe and highest side lobe) for a set of frequencies which yielded the distribution of microphones shown in figure 2. The microphones are more densely concentrated in the center of the array and have wider separations toward the outer edge of the plate. One microphone is in the center and 19 microphone positions repeat every 72 degrees within a circle of 360 degrees. 15 more microphones were added near the outer edge of the plate to increase the effective diameter of the array to

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