INVESTIGATION OF DASH-8 RUN-UP NOISE CHARACTERISTICS FOR LOCAL ACTIVE NOISE CONTROL

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1. INTRODUCTION

Recordings of noise from a deHavilland Dash-8 aircraft, provided by Air Canada Jazz, were made at Vancouver International Airport in August 2002. The measured narrow-band and 1/3 octave band spectra were calculated and analyzed in order to determine the blade-passing frequencies (BPF) and noise directivities for three different engine settings: idling, 50% power and full power. Decibel subtraction of the idling engine spectra from the 50% engine power spectra was performed to estimate the power spectra of a single engine. The results were compared to determine if and how an ANC system must be changed to obtain the best noise attenuation for the different run-up conditions.

2. RUN-UP NOISE MEASUREMENTS

The run-up measurements were performed on a clear summer night with low wind. Receiver microphones were positioned on a circle of radius 40m (measured from the center of the aircraft) at 20° increments. The area directly behind the aircraft was excluded due to excessive wind from the propellers, and because of safety concerns. Four different 1/2" free-field microphones in combination with a conditioning amplifier or sound level meter were used to record the data at the various positions. Portable Sony PCM-M1 DAT recorders were used to capture the data at a sampling rate of 48 kHz. In total, noise was recorded at 15 positions around the aircraft for three conditions: both engines idling, both engines at full power, and the right engine at 50% power while the left engine was idling.

3. SPECTRAL ANALYSIS

The BPF of the Dash-8 at idling engine power was found to be 18 Hz. A spike in the spectra at this frequency was clearly visible at all positions except those directly to the front of the aircraft, which were the farthest away from the propellers. The noise contribution at the BPF was not significant enough to produce a spike in the 16 or 20 Hz bands of the 1/3 octave band spectra. Thus, at idling engine power, the noise contribution at the BPF was not significant enough to dominate the overall noise spectra. Given also that the harmonics were weak or insignificant, it can be concluded that idling engine noise does not contain enough tonal noise for ANC to be effective.

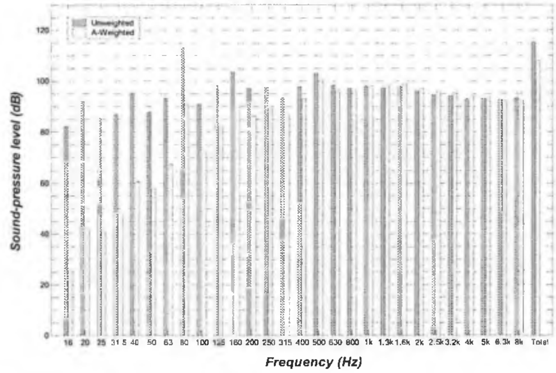

Fig. 1. 1/3 octave band spectrum of Dash-8 noise recorded at the position closest to the right propeller.

At full engine power, the BPF was found to be 80 Hz. The noise at this frequency reached as high as 120 dB at the positions closest to the right propeller. At those positions, the noise at the BPF was clearly dominant over the harmonics. The noise contribution at the BPF is also clearly visible in the 1/3 octave band spectra, as can be seen in Fig. 1. At other positions, the amplitudes of the first and second harmonics were close to or exceeded the amplitude of the BPF. In particular, the noise spectra measured at the front of the aircraft were dominated by high frequency noise (from higher harmonics).

Given the strong tonal noise components in the spectra, it may be possible to control full-power engine noise with ANC. The presence of strong harmonics suggests that it would be of interest to consider using ANC to control not only the noise at the BPF, but the noise at the first and second harmonics as well.

4. NOISE DIRECTIVITY PATTERNS

The noise directivity for both of the engines at idle settings is shown in Fig. 2. The lowest levels were behind the left propeller, at about 80 dBA; the loudest levels were to the front of the aircraft, at about 100 dBA. Both the unweighted and A-weighted directivity patterns resemble that of a dipole source, with the strongest radiation to the front of the plane, and low levels to the sides, as expected for a fan-like source [1]. However, unlike a perfect dipole source, the directivity is asymmetrical.

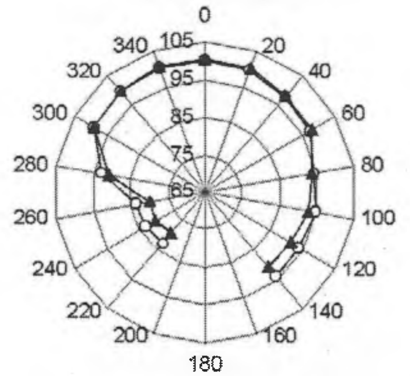

Fig. 2. Noise directivity of the Dash-8 with both engines idling. O= unweighted data, ▲ = A-weighted data.

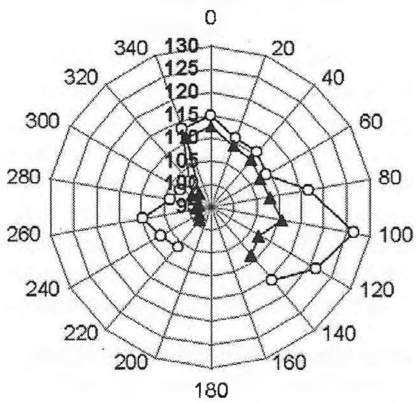

Fig. 3. Noise directivity of the Dash-8 with both engines at full power. O = unweighted data, ▲ = A-weighted data.

With both of the engines at full power, the directivity is as shown in Fig. 3. Clearly, it is very different from the idling results; however, the noise levels to the right of the aircraft are still louder than those to the left. The unweighted directivity pattern resembles the clover-leaf pattern characteristic of a quadrupole source, though asymmetrical, with the strongest lobe to the right of the aircraft peaking at 127 dB.

It has been determined experimentally [2] that an ANC system is most effective when it is placed facing the lobe of strongest directivity from the primary source. Thus, with the engines running at full power, an ANC system would likely be most effective if it was placed behind the right propeller (at 100°). The noise directivity of the Dash-8 was also found to be different from that of the Beechcraft 1900D [3]; this suggests that the position of the ANC system must also be optimized differently for different aircraft.

5. ESTIMATING THE NOISE RADIATION OF A SINGLE PROPELLER

It is also of interest to understand how a single propeller acts as a noise source; however, it was not possible to run one engine of the Dash-8 at above idling power with

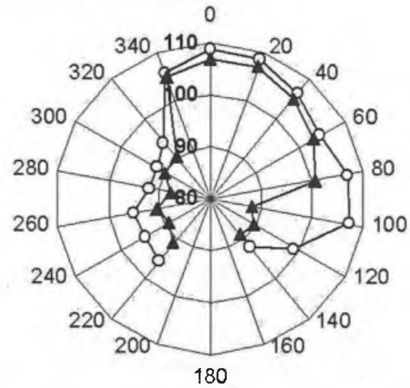

Fig. 4. Estimated noise directivity of one propeller engine at 50% power. O = unweighted data, ▲= A-weighted data.

the other engine turned off. To obtain an approximation of the spectra of a single engine operating at 50% power, the idling engine spectra were decibel-subtracted from the right engine at 50% power/left engine idling spectra.

The decibel-subtracted narrow-band spectra were virtually identical to the original spectra. The 1/3 octave band spectra show differences only at very low frequencies (<40Hz). The idling engine noise thus does make a small contribution to the noise of an engine operating at 50% power at very low frequencies, but not significant enough to change the total unweighted or A-weighted levels.

The directivity of the decibel-subtracted data is shown in Fig. 4. This gives an approximation of the directivity of a single engine operating at 50% power. The radiation is approximately dipole with the strongest headings towards 0° and 20°, and the weakest towards 300° and 140°.

Since the noise of both engines running at 50% power was not recorded, and it was not possible to record the noise of one engine operating at full power, the noise directivities for one propeller and two propellers cannot be compared directly. It can only be concluded that the directivity of two propeller engines operating at full power is approximately quadrupole, and that the directivity of a single propeller engine operating at 50% power is approximately dipole. The configuration of an ANC system thus must be changed accordingly for these two run-up conditions.

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