Preliminary Investigation Of Active Control Of Airport Run-Up Noise

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INTRODUCTION

Nighttime run-ups at the Vancouver International Airport (YVR) often occur between the hours of 11 pm and 6 am, creating noise in the neighboring communities to the north and south of the airport [1]. These run-ups consist of revving up the engine, sometimes to full power, as part of normal maintenance of the aircraft.

The purpose of this research is to determine the feasibility of using an Active Noise Control (ANC) system in order to reduce run-up noise that travels to neighboring communities. Propeller aircraft are commonly the source of most complaints, most likely due to the tonal nature of the noise produced by exposed propellers. In this paper, the selection of ANC strategies, run-up noise analysis, and computer simulations of a local control ANC system are discussed.

EXPERIMENTAL MEASUREMENTS

A Beech-1900D twin-engined turboprop aircraft was provided by Central Mountain Air for the noise measurements. During the full power run-up of this aircraft, the four bladed propeller rotated at approximately 1700 rpm. Two microphones captured the near field run-up noise, positioned at approximately 73 (Position 1) and 98 m (Position 2) away from the aircraft. The purpose of the second microphone is to enable a correlation analysis to be performed for the sound field at two different points in space. This analysis, however, will not be covered in this paper. A third microphone was positioned in a community north of the airport, approximately 3 km (Position 3) from the aircraft. (see Figure 1).

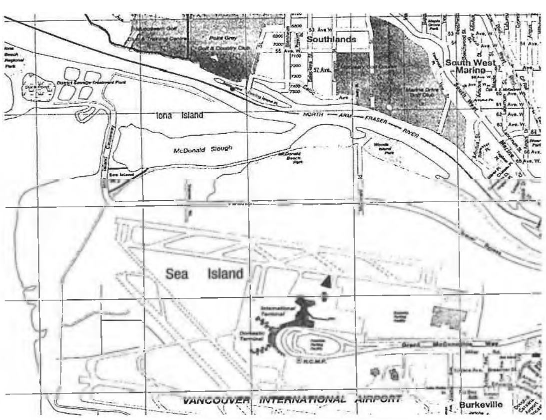

Figure 1. Map of YVR showing microphone positions (aircraft denoted by triangle)

ANALYSIS

An analysis of the run-up noise measured at Position 1 revealed a fundamental frequency of 111.7 Hz, along with several harmonics at an equally high level as the fundamental (see Figure 2). This run-up measured approximately 103 dB at Position 1, and measured approximately 80 dB at Position 3 (Figure 3). Note that at Position 3, the fundamental frequency is the only frequency to measure 80 dB and the harmonics registered lower. This creates desirable situation for ANC, as a system can be designed to attenuate this frequency only, resulting in a lower overall level in the community.

COMPUTER SIMULATIONS

In order for ANC to be used in this situation, it is evident that a global control system is not feasible, since the control sources would have to be within ¼ wavelength of the propellers in order to be effective [2,3]. This would correspond to a distance of 0.77 m to attenuate the 111.7 Hz fundamental frequency. Therefore a local control strategy must be adopted, with a zone of attenuation pointed towards the affected communities. A multiple input, multiple output (MIMO) ANC system would also be required in order to extend the quiet zone over an area of several square kilometers.

An adaptive ANC system was simulated using 21 control sources and 21 error microphones, arranged in parallel straight lines. The run-up noise source was first assumed to be a point source, and the noise was assumed coherent enough in order for ANC to be effective. The control-source-array is 20 m away from the run-up source, and the error-microphone-array is 20 m away from the control-source-array.

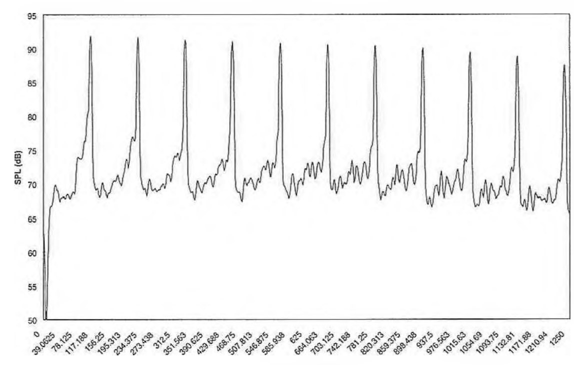

Figure 2. Noise spectrum of Beech-1900D aircraft at a heading of 255°, as measured at Position 1

It can be calculated that the optimal spacing between the control speakers and error microphones ranges from 0.5 - 0.74l [4].

A spacing of 0.65l was chosen for this simulation, which works out to a distance of 2 m. First, an assumption of free-field conditions was simulated, and the results of this system are shown in figure 4. A very large zone of attenuation of at least 10 dB can be achieved using this assumption. However, the presence of nearby asphalt aprons and runways would create a situation closer to a half-space condition. This condition was also simulated using 21 control speakers and 21 error microphones, and assuming a reflection coefficient of 0.8. The results are shown in Figure 5.

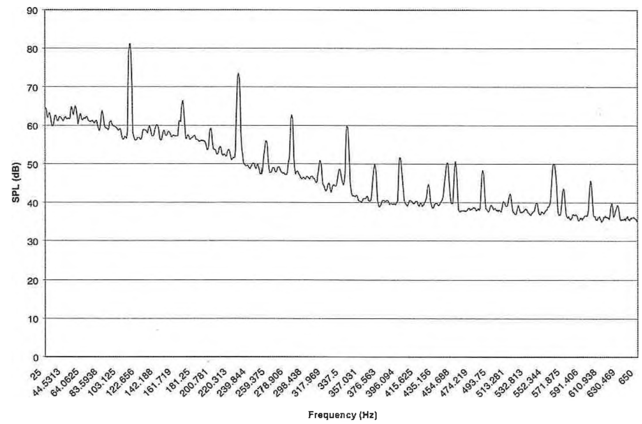

Figure 3. Noise spectrum of Beech-1900D aircraft at a heading of 255°, as measured at Position 3

It is important to note that a local control strategy will produce a redistribution of sound energy, meaning that in order for sound to be reduced in one area, it will mean that sound will increase in other areas. This is a key point, since the intent is to mitigate noise complaints in some areas without increasing the number of complaints in other areas. As can be seen in Figures 4 and 5, there is only a slight increase of 1-2 dB in areas away from the quiet zone. Most of the redistributed sound energy is localized around the control sources themselves, away from communities.

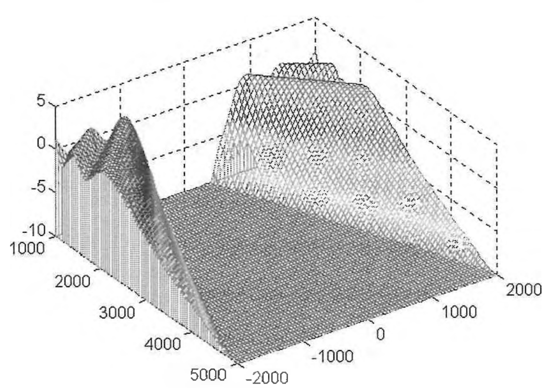

Figure 4. ANC simulation of local control using 21 control speakers and 21 error microphones in free space

CONCLUSIONS

The results of this preliminary investigation show that a very wide zone of at least 10 dB attenuation can be achieved using a local ANC system with 21 control speakers, using either a free space or half-space simulation. This attenuation can be attained without a significant increase in noise in other areas. A larger quiet area can be obtained using more control channels arranged both in a line and in a plane. Further research needs to be performed in order to determine the coherence of the Beech-1900D aircraft noise, and thus its compatibility with an ANC system. A laboratory setup of this experiment will be performed on a smaller scale in order to verify the theoretical findings.

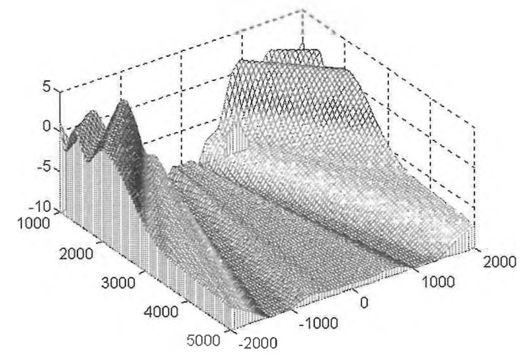

Figure 5. ANC simulation of local control using 21 control speakers and 21 error microphones in half space

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