Sensitivity Studies in Airport Noise: Linear Approach

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Abstract

This paper presents the methodology used in Aircraft Noise Sensitivity Studies developed by the Environmental Acoustics Group of COPPE/UFRJ for INFRAERO, the company which manages 65 of the biggest Brazilian airports.

Five critical airports, considering the environmental noise impact, had been selected in a previous stage considering the number of people exposed to a level superior to 65dB(A) and the area contained in the curve DNL=65dB(A).

For the noise sensitivity studies, the cost function used was the area contained in the curve DNL = 65dB(A). The airport parameters adopted for the studies are the number of night and day movements for Chapter II (represented by 737200) and Chapter III (represented by 737500) airplanes [4].

The relative sensitivity coefficients had been determined studying the variations of the curves areas versus the variation of the airports parameters.

The results of this work will be used to help decisions on the management of the airports, regarding the noise matter.

The softwares used to determine the noise curves (Footprints) were the Integrated Noise Model (INM), HNM (Heliport Noise Model) and the NMPLOT.

Keywords

Airport Noise Control

Balanced Approach

Operational Procedures

Introduction

Sensitivity Studies may be defined as a methodology to evaluate the influence of a single parameter or group of parameters in a complex system. They can be applied in a great number of systems with several objectives. In this article we present the basic methodology that is being developed by the Environmental Acoustics Group of COPPE/UFRJ and applied to 65 brazilian airports aiming to evaluate the influence of certain type of aircraft in the noise curve area of an specific airport.

Fundamental concepts are used in order to define a linear boarding for studying the changes in the affected area by DNL=65dB(A) and its relations with the changes in specific locations near the airport.

The knowledge of how the noise levels change in specific points around the airport and the percentage of change in the total affected area can be used to optimize operational procedures in order to accomplish lower noise levels in airport surroundings.

The methodology can also be used to help manage an airport once it compares alternatives of change in fleet mix and turn of flights according to difference in noise levels.

Linear Approach

Considering:

x_1 = Number of 737500 aircraft daily movements (ICAO Chapter III)

x_2 = Number of 737500 aircraft night movements (ICAO Chapter III)

x_3 = Number of 737200 aircraft daily movements (ICAO Chapter II)

x_4 = Number of 737200 aircraft night movements (ICAO Chapter III)

Where one movement means one departure or one approach.

The sensibility coefficient values were determined by elaborating noise curves in Integrated Noise Model (INM) software for a percentual variation of each parameter while the others were kept the same.

$S_{x_1}^{\Phi}$ is called sensibility of Φ in relation to x_1 and is defined as:

$$S_{x_1}^{\Phi} = \frac{x_1}{\Phi(x_1,x_2,x_3,x_4)} \frac{\partial \Phi}{\partial x_1} \tag{1}$$

Similarly: (2)

$$S_{x_2}^{\Phi} = \frac{x_2}{\Phi(x_1,x_2,x_3,x_4)} \frac{\partial \Phi}{\partial x_2}$$

$$S_{x_3}^{\Phi} = \frac{x_3}{\Phi(x_1,x_2,x_3,x_4)} \frac{\partial \Phi}{\partial x_3} \tag{3}$$

$$S_{x_4}^{\Phi} = \frac{x_4}{\Phi(x_1,x_2,x_3,x_4)} \frac{\partial \Phi}{\partial x_4} \tag{4}$$

Where Φ is the area os the noise level curve.

First, the INM noise curves were developed for the initial situation, using the original values for x_1, x_2 , x_3 *and* x_4 and the correspondent Φ value calculated. Then, change in parameters, such as $x_1 + \Delta x_1$, x_2 ,x_3 e x_4 were introduced and new Φ values were calculated. The sensibility coefficient of Φ in relation to x_i is expressed as follows:

$$S_{x_i}^{\Phi} \approx \frac{x_i}{\Phi} \frac{\Delta\Phi}{\Delta x_i} \tag{5}$$

With a 10% relative variation of x_i parameter, follows:

$$S_{x_i}^{\Phi} \approx -10 \frac{\Delta\Phi}{\Phi} \tag{6}$$

Where $\Delta\Phi/\Phi$ represents the relative variation of the area when 10% of each of the four parameters is excluded. One should note that a 10% variation is sufficiently small and so a linear system may be considered.

The sensibility coefficients of Φ in relation to each of the airport parameters are expressed by the following equations.

$$S_{x_1}^{\Phi} \approx -10 \frac{\Phi_1 - \Phi_0}{\Phi_0} \tag{7}$$

$$S_{x_2}^{\Phi} \approx -10 \frac{\Phi_2 - \Phi_0}{\Phi_0} \tag{8}$$

$$S_{x_3}^{\Phi} \approx -10 \frac{\Phi_3 - \Phi_0}{\Phi_0} \tag{9}$$

$$S_{x_4}^{\Phi} \approx -10 \frac{\Phi_4 - \Phi_0}{\Phi_0} \tag{10}$$

Then, one may write the following approximated equation relating the logarithm of the noise curve area to the logarithms of the parameters.

$$\begin{aligned} &Log_e\Phi(x_1, x_2, x_3, x_4) = \\ &S_{x_1}^{\Phi} Log_e x_1 + S_{x_2}^{\Phi} Log_e x_2 + S_{x_3}^{\Phi} Log_e x_3 + S_{x_4}^{\Phi} Log_e x_4 + K \end{aligned} \tag{11}$$

Where K is a coefficient that should be calculated for each airport and represents the influence of the movements of the other aircrafts that operate in the airport.

This equation may be applied to study area variations in case of fleet and number of movements conservation or not. It should be calibrated using information up to date to determine K values.

Below are presented the sensibility coefficient values for the airports of Brasília, Recife and Salvador.

	Brasília	Recife	Salvador
$S_{x_1}^{\Phi}$	0,0000	0,0003	0,0020
$S_{x_2}^{\Phi}$	0,0135	0,0007	0,0084
$S_{x_3}^{\Phi}$	0,0503	0,0019	0,0253
$S_{x_4}^{\Phi}$	0,4150	0,0209	0,2322

Table 1: Sensibility coeficient values for three brazilian airports

It is verified that in the current situation, the noise curve area has a bigger sensitivity to the parameter that corresponds to the number of nocturnal movements of Chapter II aircrafts.

The influence of Chapter II aircrafts in the noise generated in an airport surroundings is much bigger than the contribution of Chapter III aircrafts. Depending on the airport in study, sensitivity to the nocturnal movement of aircraft 737200, for example, can be infinite when compared with the others, and may completelly mask Chapter III and IV aircrafts influence on the noise curve.

Conclusions

This work presented a set of approaches that have proved to be very useful in determining the influence of certain types of aircraft in the noise generated in a specific airport surroundings. The results of this work can help airport authorities in taking decisions regarding specially the comfort of nearby populations.

One may see, for example, that in many cases the only way to observe the influence of Chapter III aircraft in the noise generated by an airport would be to drastically decrease the nocturnal movements (or even daily movements, depending on the case) of Chapter II aircrafts (or increasing the movement of Chapter III aircrafts, what is neither advisable nor intelligent and, in many cases, impossible). In other words, it would be useless to remove Chapter III aircraft operations and keep Chapter II once the generated bother would practically be unchanged. This type of consideration can be very helpful in airport management.

The optimization of operational procedures is a matter of great interest not only regarding noise but in efficiency and other topics as well. The approaches presented in this work are the basics and may be used as a starting point for optimizing operational procedures.

Aknowledges

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