METRICS CONVERSION IN AIRPORT NOISE

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Abstract. *Lately it has been necessary to adopt new metrics to deal with the zoning of airport noise in many countries in the world. Brazil changed from an IPR definition to a different one based on LDN. In the Europe Union the old metrics have been abandoned and substituted by the L_{DEN} metric. In order to apply this changes it is necessary to redefine the noise levels used to establish the noise areas on airport zoning. The search for this correspondence between levels associated to certain metrics is a general matter and may be approached in many different ways. A first approach would consist on determining the values from two different metrics on the same location in the same time. It is easy to verify that the relation between both metrics in different locations is not the same. In addition one may establish an approach based on the comparison between areas affected by a certain noise level. In this work different simulations based on the INM software were carried through and two different airports were studied. Noise footprints were constructed and compared in both airports for each of the metrics considered. The results obtained clearly shows that the matter cannot be solved in a general context for a metrics conversion. The correspondence between two metrics should depend on the considered airport once day, evening and night periods are treated differently and the aircraft movements also differ in every moment and varies from one airport to another.*

Keywords*: Noise Metrics, Balanced Approach, Integrated Noise Model, Airport Noise Control*

1. Introduction

The noise generated by an airport in its surroundings is due to many different factors. The airport´s physical conditions and climate, the number of daily and nocturnal flights, types of aircrafts that operate in the airport and the routes and procedures they carry through are the main factors that influence on the noise impact an airport has on its vicinity.

The FAA Integrated Noise Model [1,2] is a tool that allows the generation of noise footprints that are a simulation of the noise impact a certain airport has on its surroundings due to a specific context. One may input data such as airport reference temperature and altitude, aircraft types and number of movements, departure and arrivals routs and procedures etc and the INM outputs information such as affected area by a number of noise levels, and noise at specific location points.

The INM is very useful for carrying through sensitivity studies on which noise reduction situations are evaluated and also as a planning tool as it offers the calculation of different types of noise metrics as well as the insertion of new ones.

All over the world, the legislation that regulate noise pollution, especially around airports, is very conflicting in the metrics and noise levels used as parameters and limits and lately it has been necessary to adopt new metrics to deal with the zoning of airport noise. In France, airport planning used to be done based on the Psophic metric which has recently been substituted by L_{DEN} metric. In Brazil, the legislation regarding noise pollution control in airport surroundings is based on two different metrics:

- Aeronautical legislation, portaria 1141 DG5 which uses Day Night Sound Level (DNL) used to define airport zoning;
- CONAMA resolution, March 8^{th} 1990, that refers to ABNT NBR10151 norm, which uses L_{Aeq} metric (Equivalent Continuous A-Weighted Sound Pressure Level) used in urban areas fiscalization.

The differences between the two metrics continuously generates doubts and disagreement between authorities, airport administrators and society in general and it is extremely important to establish a relationship between them.

Noise metrics should be well defined and adequate to its purpose. One should consider the noise metric more suited for the evaluation it is being used on. The DNL metric, for example is adequate to proceed with airport zoning, but not the best one as an fiscalization tool. This work presents a methodology of comparing noise metrics and deals specifically with airport noise context.

2. Relationship between DNL and LAeqd

It is not possible to determine a direct equivalence between DNL and L_{Aeq} metrics once a DNL value is a constant that represent the whole day while L_{Aeq} is an average of the noise energy with respect to a certain period of time. This implies that whenever trying to relate these two metrics, the first thing to do is to establish an evaluation period for L_{Aeq} that may be compared with DNL. Considering that the Brazilian noise environmental legislation based on L_{Aeq} takes into account two different periods, day and night, it is interesting to introduce the following two periods of evaluation: One day period that will correspond to $L_{Aeq\ D}$ metric, beginning at 7am and ending at 10pm, and the night period which begins at 10pm and ends at 7pm the next day, corresponding to the $L_{Aeq\ N}$.

The usual way of establishing a correspondence between metrics would be to evaluate noise levels for them in different locations and proceed with some regression technique. The Integrated Noise Model may be used to this purpose and data may be validated with field measurement. In this study we do not realize any regression technique. Instead, we define a mathematical relationship between DNL and LaedD that takes into account the number of daily and night flights in the airport as well as establish a correspondence between the two metrics by evaluating the affected area by their noise levels.

The following graphic (Fig. 1) represents the noise levels during the day refering to DNL, L_{AeqD}, L_{AeqN} and L_{Aeq} metrics calculated for Recife airport using the Integrated Noise Model.

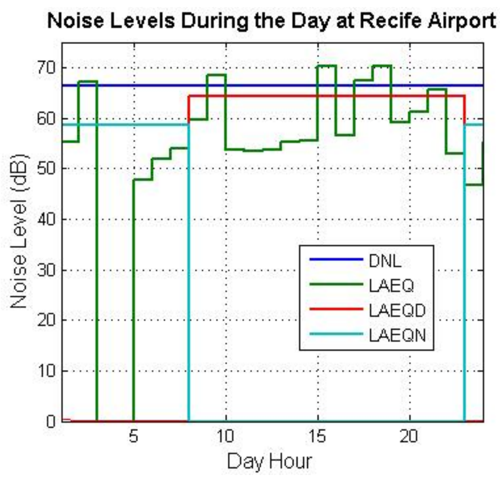

Figure 1: Noise levels during the day at Recife airport

The data inputed to INM refers to the present day operational scenario in the airport and it is easy to verify that the DNL level is not the best way of evaluating noise annoyance in the airports vicinity once it will be the same during all day when in reality what really happens is that there are periods of time on which the noise levels are high (even higher than the DNL level) and other periods when no noise is generated by the airport (aircrafts).

It is important to point out at this time that the present study takes into account only aircraft noise once it is based on the INM software. The actual noise levels on a certain location near the airport is generated not only by the aircrafts but also by the aircraft supporting ground equipment such as GPU, tolltrucks etc. A relationship between the generated INM values and the actual ones may be accomplished by field measurement or by mapping the noise generated by the airport without the aircraft noise and adding them correctly.

An equation relating DNL and L_{AeqD} levels is obtained by considering the following equations (Eq. 1, Eq. 2 and Eq. 3):

$$DNL = 10\log_{10}\left(\frac{1}{3600\times 24}\left[\int_{7am}^{10pm} 10^{\frac{L_A(t)}{10}}\,dt + \int_{10pm}^{7am} 10^{\frac{L_A(t)+10}{10}}\,dt\right]\right) \qquad (1)$$

$$L_{AeqD} = 10\log_{10}\left[\frac{1}{3600\times 15}\int_{7am}^{10pm} 10^{\frac{L_A(t)}{10}}\,dt\right] \qquad (2)$$

$$L_{AeqN} = 10\log_{10}\left[\frac{1}{3600\times 9}\int_{10pm}^{7am} 10^{\frac{L_A(t)}{10}}\,dt\right] \quad (3)$$

On which $L_A(t)$ is the instantaneous sound level.

If only one type of aircraft which should be representative of the airport is considered, a Sound Exposure Level (SEL_1) is generated and one may get to the following expression through little computational work:

$$DNL = L_{AeqD} + 10\log_{10}\left(\frac{15}{24}\left[1+10\frac{N_N}{N_D}\right]\right) \quad (4)$$

On which N_D is the number of daily aircraft movements and N_N is the number of night aircraft movements. It gets clear that what really matters is the number of aircraft movements per hour during day and night periods.

Equation 4 may be represented graphically as follows.

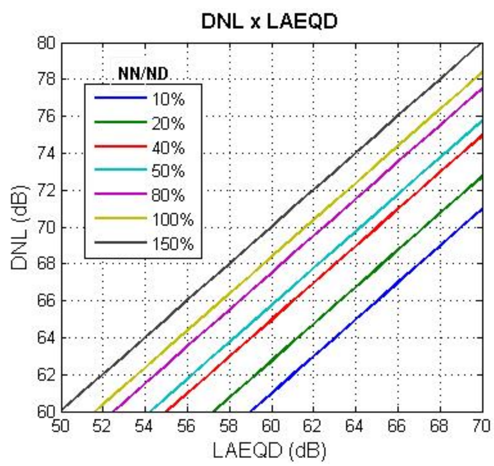

Figure 2: Relationship DNL and LAEQD.

A different approach for establishing a correspondence between different noise metrics is by evaluating the affected area by certain noise levels from each metric. This can be done through INM studies as long as the noise curves have similar shapes for each metric considered. Similar affected area implies on equivalence between the considered noise levels. Figure 3 show the correspondence for DNL, L_{Aeq}, L_{AeqD} and L_{AeqN} for two different Brazilian airports.

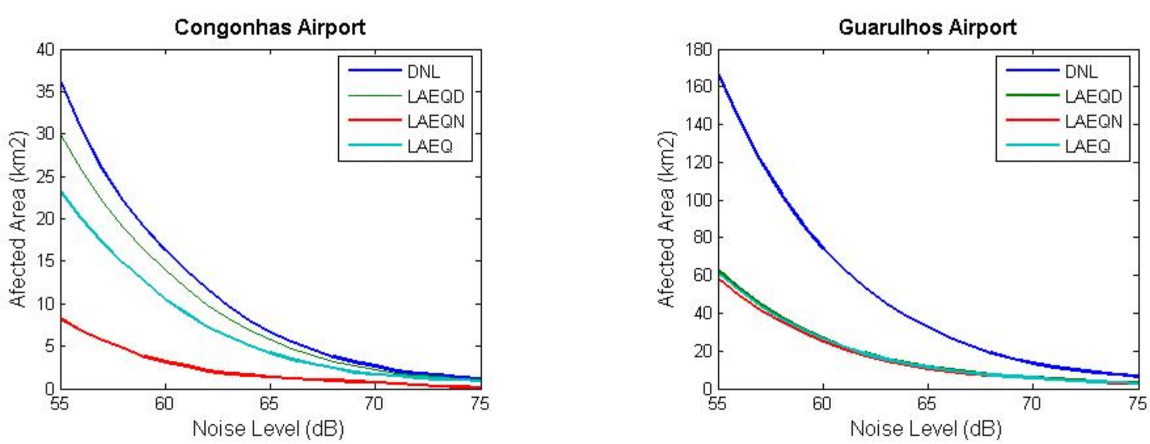

Figure 3: Affected area vs noise level graphics for Guarulhos and Congonhas airports.

It is clearly noted that the correspondent noise levels are different for each airport. While in Congonhas DNL = L_{AeqD} + 1dB (approximately), in Guarulhos the difference is of approximately 6dB. This is due to the fact that the airport's characteristics are different and this influences the relationship between noise levels for different metrics. In other words, every airport will have its own correspondence between DNL and L_{AeqD} due to the different number of flights, aircraft types, temperature, altitude etc.

Using INM to compare noise metrics is a practical way of establishing a relationship between them and is usually accurate enough while faster and easier to do.

3. Conclusion

A metric conversion methodology has been presented. It was first shown that every noise metric deals differently with the noise levels generated by an airport during different periods of time. That implies on different noise levels correspondence between the metrics on location point where the airport noise contribution is not the same.

In cases where the noise curves for different metrics have similar shapes it is possible to establish a relationship between the metrics used by evaluating the affected area by specific noise levels. This can be easily done through the Integrated Noise Model software. This is only useful on airports surroundings when two metrics coexists and there is the need to convert noise levels from one to another. The general context should be treated in a more specific context on which one would try to establish a scale between annoyance and noise levels at different metrics. A specialist fuzzy system may be used to determine this relationship for each metric.

4. Acknowlegments

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5. References

[1] INM 6.0 Technical Manual, Office of Environment and Energy, Federal Aviation Administration
[2] INM 6.0 User's Guide, Office of Environment and Energy, Federal Aviation Administration
[3] AEM area equivalent method. Federal Aviation Administration

6. Responsibility notice