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Annual noise assessment in the vicinity of airports with different flights' intensity

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ABSTRACT

The noise metric recognized as universal to describe aircraft flight noise events and community noise pollution as a whole has not been yielded yet. Among a set of factors that impacts aircraft noise perception is a number of flights – number of aircraft noise events. This article deals with the number of flights' influence on applicability of the usually used environmental noise metrics: equivalent L_{eq} and maximum L_{max} sound level for the long-term interval of their observation. The correlation between L_{eq} and L_{max} levels is considered against duration of observation interval. As a result the definition of representative duration is obtained. Noise measurements provided within representative time interval allow to assess the annually averaged value of equivalent sound level adequately. The adequacy or representativeness of measurements results is based on accuracy criterion taking into account the 'noisiest' events only for long-term L_{eq} evaluation procedure under consideration. The long term noise descriptors are considered as the parameters of averaged 'virtual' flight noise event, for which the both $L_{eq,avg}$ and $L_{max,avg}$ are interrelated through averaged sound exposure energy for all events in observation. The results show that for airports with low intensity of flights (around 5 events per hour during the day) the long term equivalent sound level is heavily changing in relation with the long term maximum sound level, but for high intensity flight traffic this interrelation is quite stable. In the vicinity of airports with low flight intensity the maximum sound level as a noise impact metric is more sensitive than the equivalent level. Inside the areas, where the value of mandatory descriptors L_{den} (L_{dn}) is in conformity with established limits for environmental noise, proposed statistical post-processing analysis provides to recognize some additional reasons of community annoyances. The proposed in article assessment scheme was applied for data sets collected at the points of noise control closely to airports with low (about 30 flight noise events per day – Vilnius airport) and high (200–250 flight noise events per day – Madrid-Barajas airport) flight intensity.

1. Introduction

Today environmental noise is considered as one of the dominant pollution problems because of the great number of people impacted, including their risk to health damage, physical and psychological discomfort, and more general issue – annoyance by noise. Never-mind an aircraft noise contributes to the problem in national domain less than road traffic and railway noise, its management around the airports should be established. EU Environmental Noise Directive [1] and/or ICAO Balanced Approach [2] provided necessary tools for that. Each of them recommends that objective management decisions would still be based on conventional noise (level/index) contours, measured and/or calculated around the airports. For example, in recent years the requirements of the EU to develop and publish strategic noise maps has been realized in European Community and currently at further stage Noise Action Plans were developed on their basis with purpose to reduce a number of people impacted by noise [1]. But the essential purpose of an environmental impact disclosure, however, is to describe noise impacts, not the noise levels [2].

Aircraft noise impacts on environment significantly due to few reasons: close airports location to living areas, relatively large noise levels (over the background noise and comparing with other types of transportation noise levels) and repeating of flight noise events, especially during the night time. Beginning from 6th EU Framework Programme (namely from project SEFA – Sound Engineering For Aircraft) European Commission stimulates and

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supports investigations of the most sensitive noise indices for assessment of people perception to noise, their dependencies to effects and their abilities to be used for management of the impact. The high correlation between noise impact and measured noise descriptors is an obvious fact. For example, European Commission report [3] shows that an increase in equivalent sound level at night L_{night} on every 5 dBA may 1.5 times enlarge the percent of sleep disturbances, from 5% within level L_{night} = 45 dBA (on building façade) up to 12% within L_{night} = 55 dBA. Also it is obvious that the sleep disturbance depends on the façade sound insulation value and may be minimized by appropriate façade design. So the measured or estimated outdoors levels (equivalent L_{eq} or/and maximum L_{max}) must be used for specification of airborne sound insulation properties of the façade to minimize the impact of aircraft noise.

In accordance with EU Directive requirements [1] the calculations of environmental noise descriptors became mandatory, while measurements may be used just for validation of the results [4]. For environmental noise measurements main provision is described in international standard ISO 1996-2 [5], which refers to general test method development mainly. As stated in the standard, the sound levels shall be, if possible, determined from the exposure level measurements of individual aircraft flight noise events during representative time period. The representative time interval for L_{eq} measurements is introduced as the period which include "five or more of each type of aircraft contributing significantly to the sound pressure level to be determined" and for L_{max} measurements – "from at least five and preferably twenty or more occurrences of the most noisy relevant aircraft operation". So in general, data collected during such representative period may be used for the estimation of the common levels just during such a short term period of the measurements.

In this article a representative time interval for L_{eq} measurements is treated more widely. That is the permanent time interval comprising the set of flight noise events of sufficient number of possible aircraft types operated above considered point of noise control including possible aircraft flight trajectories and operational conditions around the area of observation. Acoustical data must be collected during permanent long-term measurements with following to them appropriate data post processing procedures. Determined via procedures corresponding long-term statistical assessments of acoustic data of the aircraft noise events (e.g. L_{den}, L_{night}, L_{max}, L_E, etc.) may be extrapolated to much longer time period (e.g. one year). So it is logically clear that if the aircraft operated at considered airport and correspondent operational conditions do not change and flight noise events intensity also does not significantly change for a fixed area of the environment, such assumptions for the representative measurement time interval extrapolation (and application of the values of appropriate long-term descriptors) may be acceptable.

Note that estimation of noise impact of aircraft flight noise events at considered environmental site presupposes that common noise conditions must be taken into account, i.e. other significant noise sources must be considered also. It is necessary for determination of the background noise (or residual noise) level over which the aircraft noise level arises and the duration of aircraft noise prevailed influence depends on. E.g., for the urban case during day time an aircraft noise of 70–75 dBA L_{max} should be insignificant comparing with permanent road traffic noise of e.g. 60 dBA L_{eq} and significant for night time when residual noise is equal to 45–50 dBA L_{eq} usually.

So, the existence of the representative set of flight noise events assumes equivalently that there is an 'averaged' (virtual) event exists also – with appropriate 'averaged' parameters of maximum sound level $L_{max,repr}$, sound exposure level $L_{E,repr}$, equivalent sound level $L_{eq,rep}$, duration of noise event Δt_{repr} and residual (or background noise) level $L_{res,repr}$, all of them schematically are shown in Fig. 1 in a way as they were introduced in standard [6] for the description of parameters of single event. For L_{den} or/and L_{max} determinations during representative time period such 'averaged' event may be obtained for rating time intervals as day (12 h), evening (8 h) and night (4 h) separately.

In practice the noise impact metric accounts the contribution of any aircraft flight noise event via its incorporation into L_{eq} and L_{max} descriptors [7,8]. Note that the L_{max} descriptor is more understandable for community than any equivalent noise level or index. In various adopted metrics [5,9,10] and in going on investigations these descriptors are also widely used in combinations with other parameters such as number of flight events [11–15] and duration of noise events [12]. However, the common metric for various noise situations has not been yielded till now. For example, the composed metrics like DENL [1], DNL [2] and/or WECPNL [16] were recommended to be used by EC and ICAO accordingly for airport planning and management with respect to aircraft noise impact control. All of them are quite complicated for understanding by community. Simplified version of the WECPNL may be applicable for investigation of outlined problem, never mind that it has a restricted practical application now, but still in use for the assessment of noise impact in some Asia–Pacific region countries (e.g. in Japan and Korea [10]).

On our mind this situation is concerned with circumstances, which are not directly connected to levels of noise event, such as: indoor questionings are accomplished in most cases without taking into consideration the factor of building façade sound insulation; the differences between building construction traditions; aircraft noise events variety; and climatic differences. The aim of this work is not to find the universal descriptor or "better" formulas expressing the relations between the parameters of noise event (e.g. sound exposure and maximum levels as shown in WHO overview [7]), but the detailed consideration on statistically averaged values [17,18] of the parameters of these events inside representative measurement time interval (and influence of events intensity on the amount of representative sample – i.e. measurement duration) that would permit to extend obtained values to the annual period of their averaging. Also, to accomplish the statistical comparison of the acoustic data of flight noise events for sites inside zones with low and high flights intensity. Perhaps such analysis will help to yield the common criteria for objective estimation of aircraft noise pollution and its impact on population.

2. Data acquisition and parameters for investigation

The permanent noise monitoring inside the area affected by noise produced by any flight noise events is used for collection of

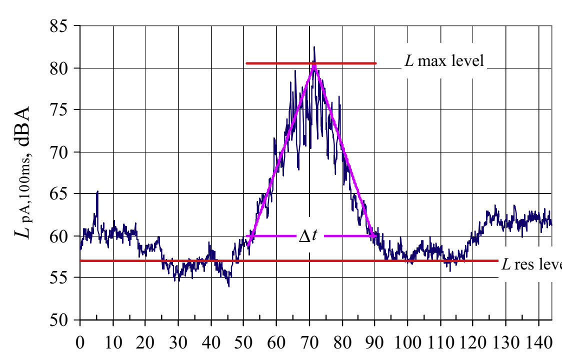

Fig. 1. Schematic view of 'averaged' (virtual) noise event for representative period for equivalent sound level assessment (with appropriate parameters of duration, maximum and residual levels of the event).