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EVALUATION OF VARIATIONS OF THE ANNOYANCE DUE TO AIRCRAFT NOISE

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ABSTRACT

Annoyance due to aircraft noise has been assessed in France by the means of several surveys in the past. On request of the Ministers in charge of the Environment and of Transports, INRETS has carried out a new research as to brush up the data related to noise exposure and to annoyance. The aim is to check if the index IP, used in France for town-planning purpose, is still adapted and to determine what acoustical indexes are well adapted to take annoyance into account, and to test other indexes like Leq, Ldn, Lden. The effects of noise are translated by global annoyance scales, behavioral scales (to close the windows) and health composite scales (sleep troubles, stress, anxiety). The results of semi-directive interviews have been used to establish a questionnaire, itself tested during a pilot survey on 100 people. The final survey comprised 1473 questionnaires dispatched among 36 towns. Acoustic measurements (free field conditions) have been made during several days in these towns.

1 - MAIN RESULTS FROM THE SURVEY

This research began in 1998 around Paris Orly and Roissy airports. The questionnaires'survey and the noise measurements show:

- a strong degree of annoyance within 18% of the population
- no variation due to age, gender, income or education levels
- a moderate level of annoyance among 30% of the respondents

Aircraft noise is dominant, except between 7-9 am and 6-8 pm, when aircraft noise is mixed with road traffic noise or other secondary sources (neighborhood noise). One people out of two express with a variable intensity and frequency:

- difficulties to follow a conversation, or to hear TV or radio,
- the perception of a local atmospheric pollution, which is considered to have some health effects
- a lack of consistency in the action of the authorities

The reduction of aircraft noise is a priority for 28% of people and the further development of the airport generates some fear for the future. However, 10% of people only think to move in reason of the aircraft noise; other factors as family links, job or economical reasons create a positive link with the living area. Answers from interviewed people to the different questions designed to assess the impact of noise are showing an excellent relationship between them. Indeed annoyance level depends strongly on the negative opinions on aircraft noise, on the action of the authorities against noise, on the potential effects of noise on health, and the supposed decrease of the properties'value

2 - RELATIONSHIP BETWEEN AIRCRAFT NOISE AND ANNOYANCE

The main goal of this research consists in analysing the links between noise and annoyance. Noise levels have been measured and the data modulated according to the annual air traffic. Different periods of the day have been considered, to weigh differently during the day, evening and night period in a 24h index (Ldn, Lden). The acoustical units are PNL, PNLT and dBA. Special attention has been paid to low frequencies levels. Near 20 noise indexes have been tested. Annoyance is assessed through several scales, shown in the table below.

Annoyance	**Moment of interview**	**Scaling**
Spontaneous global annoyance scale	beginning of the questionnaire	4 points
Elicited global annoyance	beginning of the interview	4 or 5 points
Elicited global	end of the interview	0-10 points
Annoyance per period	beginning	0-10 each hour
Behavioral annoyance scale	middle of the interview	composed scale
Sleep troubles	middle of the interview	composed scale
Somatic disorders	middle of the interview	composed scale

Table 1: Annoyance scales.

Noise levels, measured then weighed by actual yearly air traffic, are representative of the noise climate around the airports. The aim of these several annoyance scales is to measure the multiple possible expressions of noise disturbance due to aircraft noise. There are strong relationships between the different scales and the global annoyance scale, proposed on the end of the face to face interview.

Annoyance middle of the interview	0,70
Annoyance beginning of the questionnaire	0,50
Behavioral annoyance scale	0,50
Annoyance per period (day)	0,36
Annoyance per period (evening)	0,34

Table 2: Correlations between spontaneous global annoyance and different annoyance scales.

A rather strong link is observed between annoyance level expressed at the end of the interview and annoyance level from the middle of the same questionnaire. However, annoyance reported during one precise period of the day is not so well correlated to the global annoyance. Analysis has shown that the global annoyance, assessed at the end of the interview has a more robust link with measured noise, in both cases that the relationship is analysed by correlation as a quantitative parameter or by a chi2 test when annoyance is considered as an opinion. So the annoyance due to aircraft noise is a global judgement, and not a simple addition of the elementary effects, like annoyance from specific hour periods, behavioral or somatic components

3 - RELATIONS BETWEEN NOISE INDICES AND INDIVIDUAL ANNOYANCE LEVELS

Three calculated LDEN are considered, even the levels are closely correlated. In the same way Leq 24h, LDN, LDEN are strongly correlated between them.
Correlations observed in the table 3 are statistically significant eventhough they are weak: indeed they are similar to those presented in previous researches. It can be observed in the table that the correlations are very similar, according to the different noise indices, even if IP is a little less correlated to annoyance. Another group of variables is well correlated with noise including the number of aircraft events exceeding L60 in dBA, L69 in PNdB, the emergency of Lmax over the residual noise level.

The spectrum in low frequencies are also well linked to annoyance, specially on evening, and during night, as LmaxA or PNdB. This means that the number of events, showing some characteristics of energy or spectrum partly determine the annoyance.

Indices (24h)		**Annoyance**
LDEN 6-20-24h	Level Day Evening and Night	0,310
LDEN 7-19-23h		0,302
LDEN 6-18-22h		0,306
LEQ	Level Equivalent Quantity	0,296
LDN(A)	Level Day and Night	0,302
IP	Calculated Indice on PndB and number of plane	0,264
NEF	Noise Exposure Forecast. EPNdB	0,308
E(A)	Mean emergence of noise planes	0,289
PNL 69 dB	Perceived Noise Level	0,295
Lmax 60 dB	Maximum noise level of aircraft	0,301
Runway	Assessed position of home under or near runway	0,297

Table 3: Correlation between noise indices (24h) and individual annoyance levels.

A combination of energetical indices and number of events has been tried to observe a possible improvement in correlations noise-annoyance. This addition of the number of noisy events doesn't improve the statistical relationship a lot, which should have increased the predictability of annoyance. So we can conclude that information included in the global noise indices (Leq, IP, LDN, LDEN) seems to consider, in this survey, the information concerning the number of events and the spectral characteristics.
A third category of parameter has been identified to play a role in annoyance expression. The location of the flat of respondents should be taken into account: people living in housing under trajectories are more annoyed that those living in towns located laterally to the runways, without a clear link to the fear of a crash.
A correlation noise-annoyance has been calculated with a mean value of annoyance, when there are more than 20 interviewed persons per town and the mean levels of noise.

	IP	**LDEN**	**LDN**	**Leq(A)**
Correlations with annoyance	0,60	0,71	0,71	0,71

Table 4: Correlations between mean value of annoyance and mean noise indices.

When we control the individual aspects of annoyance due to noise, the linear correlation is largely improved. The index I.P is a little bit less correlated.

4 - ANALYSIS OF THE RELATIONSHIP NOISE-ANNOYANCE FOR LEQ, IP, LDN, LDEN

An analysis has been developed to observe if functions and curves noise-annoyance could provide information on possible thresholds. A software segmentation has been applied. Results show that the segmentation points are similar to those existing in previous researches. However, in this survey, LDN and LDEN provide clearer inflexion that IP and Leq.

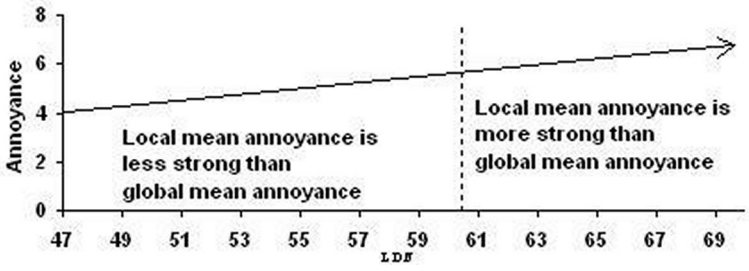

Figure 1: Variation of mean annoyance with LDN (correlation: 0,71).

In relation to Leq 24h, annoyance is clearly increasing from 60 dBA, which is similar to the data from other researches; in DORA study (1) the use of Leq is examined. In Switzerland (2) annoyance is

increasing from 59 dBA in Leq 6-22h and 56-58 dBA for Leq24h. In the ANIS report (4), the inflexion of the annoyance curve appears at 57 dB(A) Leq24h, and the authors suggest to respect 55 dB(A). In our study there is a clear acceleration of annoyance from 61 dBA in LDN

5 - CONCLUSION

Annoyance due to noise, as all judgment, can not be reduced or be understood through a simple measure of the physical stimulus. A strong variability indeed exists due to each subject, considered in a noisy place. Other studies have shown that, globally speaking, annoyance increases when noise is increasing, but the correlation between the parameters acoustic levels and annoyance remains weak.

Other studies (3, 4) have shown previously that, roughly speaking, annoyance is growing with noise; even if the relationship remains weak (correlation coefficients between $0{,}3 - 0{,}6$), two main reasons can be evoked for that:

- annoyance depends on a very variable noise exposure, in space and time, for a person living in a particular place,
- the annoyance expressed is related to personal factors, psychological, sociological and economical, which are, by definition, non-acoustical.

An other reason can be evoked: indeed the human requirements in matters of environment have relatively increased since several decades. At Dusseldorf airport, where the traffic has increased but the noise levels are decreasing since 1987 (5), both in mean value and in mean Lmax, the percentage of annoyed people is progressively increasing. Consequently, the relationship between noise levels and expressed annoyance is decreasing, because several factors, other than physical noise levels, seem to increase annoyance (number of movements, fear of traffic increasing on the existing second runway, increased sensitivity) without any noise levels increasing.

The correlations obtained in our research, between annoyance and the noise indexes (Leq, Leq AV, LDN, LDEN or even IP) expressed in dBA are rather equivalent, and then of the same interest to predict annoyance.

Finally, it seems that a measured index (Leq, LDN) would correspond better to peoples expectation who live near airports, in terms of understanding the noise exposure and improve acceptation; it should certainly be simpler to measure or to compute by the acoustician, and to understand by the habitants.

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