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A NEW METHODOLOGY FOR THE PREDICTION OF NOISE EXPOSURE AROUND GENERAL AVIATION AIRFIELDS BASED ON A NORDIC DATA BANK

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INTRODUCTION

The appearance of noise exposure contours around an airfield does normally not disclose to the user - maybe a town planner - how many often rough assumptions which are hidden behind the smooth curves.
At major airports where fleetmix contains a high jet-percentage little care as to the calculation of noise from propeller aircraft might be justified. The persistent growth of general aviation and commuter air traffic demanding easily accessible airfields near big cities necessitates, however, the use of a realistic noise exposure calculation methodology if planners and local politicians do not wish to be blamed by the community. An example of one far too rough assumption used worldwide is that two-engined propeller aircraft are 3 dB more noisy than one-engined!
The new methodology described is intended for environmental control as well as a tool for land use planning. It must be based on realistic traffic information combined with noise and performance data not oversimplified. One of the basic concepts is to simplify and systematize the great multitude of data available in order to form a noise-related classification, usable both in case of specific aircraft types being known or unknown. The latter is normally the case for future calculations.

CALCULATION OF AIRCRAFT NOISE EXPOSURE

The Danish aircraft noise exposure index is defined:

$$L_{DEN} = 10 \log_{10} \frac{1}{86400} \left[\sum_{\substack{i=1 \\ \text{day}}}^{n} 10^{\frac{L_{AE(i)}}{10}} + 3.16 \sum_{\substack{j=1 \\ \text{evening}}}^{n} 10^{\frac{L_{AE(j)}}{10}} + 10 \sum_{\substack{k=1 \\ \text{night}}}^{n} 10^{\frac{L_{AE(k)}}{10}} \right] \quad (1)$$

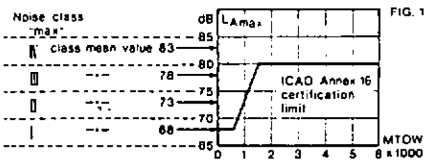
where L_{AE} is the single event sound pressure level, n is the number of events in each time period (day: 07-19 hrs, evening: 19-22 hrs, and night: 22-07 hrs), 3.16 and 10 are evening and night time weighting factors, and 86400 are the number of seconds in 24 hours.

The methodology is therefore based on the descriptor L_{AE}, but could easily be adjusted to descriptors as L_{Amax}, L_{PN}, or L_{EPN}.
Necessary information for noise exposure calculations are: noise and performance data, traffic-mix data, and flight track system data (the last of which will not be discussed in this paper).

NOISE AND PERFORMANCE DATA

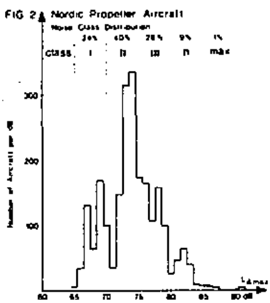
Noise classification

All piston-engined propeller aircraft with MTOW below 5700 kg are divided into 4 noise classes (see Fig.1) based on the so-called "noise figure" L_{Amax} which is the maximum A-weighted sound pressure level measured when the aircraft is passing 300 m overhead the microphone at max. continuous power in the normal operating range.



The noise figure L_{Amax} corresponds to the ICAO noise certification level without performance correction.
Aircraft beyond class IV ("max") are treated individually, whereas aircraft under class I are left out of calculations.

Fig.2 shows the distribution of noise figures for 80% of the 3000 piston-engined propeller aircraft (380 types) registered in the Nordic countries. Despite a slight variation from one country to another, the distribution can be used generally if the actual distribution is totally unknown or as a basis of fleetmix prognosis.

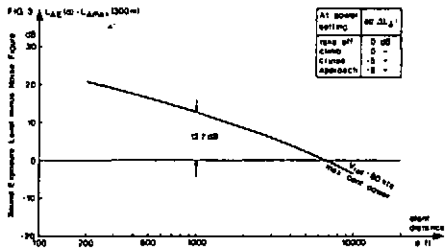


Sound exposure level L_{AE} as function of L_{Amax}

A general connection between L_{AE} and L_{Amax} is given by:

$$L_{AE}(d,v) = L_{Amax} + \Delta L_{Amax}(d) + \Delta L_{\tau}(d) + \Delta L_{V}(v) \quad (2)$$

where the distance dependency $\Delta L_{Amax}(d)$ consists of geometrical divergence and atmospheric absorption (which depends on frequency spectrum), the duration correction $\Delta L_{\tau}(d)$ depends on directivity pattern and on the curvature of the SPL vs. distance and finally the velocity correction $\Delta L_{V}(v)$ is logarithmic and based on a reference velocity.

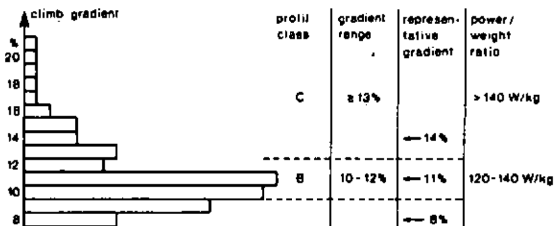


The authors examined the above-mentioned problems [1] and found that the curve of Fig.3 gives a good approximation to L_{AE} relative to L_{Amax} (at 300 m) for all piston-engined propeller aircraft below 5.7 t.

<u>L_{AE} as function of engine power setting</u>
Examination of frequency spectra for take-off, climb, cruise, and approach power for different aircraft types [1] showed that the slope of L_{AX} vs. distance is nearly independent of power setting. Based on calculations of propeller noise [2] and measurements the authors concluded that the values ΔL_{δ} to be added to L_{AE} at other power settings than max.cont. power can be approximated to the values in Fig.3 irrespective of aircraft type.

<u>Noise propagation effects</u>
Noise propagation effects are treated in [1]. It shall only be mentioned that the authors found that the ground attenuation model of SAE AIR 1751 which is intended originally for jet aircraft noise is usable also for piston-engined aircraft.

FIG. 4



<u>Take-off and landing profiles</u>
Based on flight manual data covering 63% of the piston-engined propeller aircraft registered in the Nordic countries a climb gradient classification is defined in Fig.4. Measurements of climb gradients [1] have shown no systematic deviation from flight manual data. Usable mean ground roll distances are for profile classes A, B, and C respectively: 600 m, 500 m, and 400 m. If the climb gradient is unknown, investigations [1] show that the power weight ratio (W/kg) yields a fairly good correlation to the climb gradient. Power weight ratios are given in fig.4. Landing profiles do not need to be treated individually for each aircraft type. Adequate reliability for the majority of calculations can be reached by letting IFR-landings follow a 3° glideslope and VFR-landings follow a 6° descent except for aircraft with MTOW exceeding 2,500 kg which follow a 4° descent.

TRAFFIC-MIX DATA

A data base reproduced in [1] covering nearly 380 piston-powered aircraft types has been prepared by a Nordic working group. It contains information on power, max. take-off weight, climb gradient, noise figure L_{Amax}, noise classification, and number of aircraft registered in the 4 Nordic countries (DK, N, S, and SF).
The main task at the beginning of any noise exposure calculation is to divide the traffic-mix into a number of groups with common noise and performance data.

Dividing into noise classes can be done in 4 ways:

- Dividing on specific aircraft types (use of data base)
- Estimation of noise class distribution directly
- Estimation of noise class distribution through weight class distribution. As an example the distribution for Danish registered piston-engined propeller aircraft (approximately 900) is given in Table 1.
- An average distribution, like in Fig.2, if no information is available.

Max. take-off weight			Noise class	Climb gradient class		
<1.5 t	1.5–2.5 t	2.5–5.7 t		A	B	C
27%			I	35%	60%	5%
55%	7%		II	90%	10%	0%
18%	66%	9%	III	5%	75%	20%
	27%	91%	IV	0%	50%	50%

Table 1 Table 2

Dividing into climb gradient classes can be done in 2 ways:

- Directly by use of the data base information on climb gradient or power weight ratio for specific aircraft types
- Indirectly by use of a general noise and climb gradient classification like the one in Table 2 (based on 1700 Nordic aircraft).

The number of operations may be calculated for each climb gradient class as an equivalent number of operations in one specific noise class.

CONCLUDING REMARKS

Thus it is possibly by means of a noise and climb gradient classification to reduce the number of necessary calculations to comprise only 3 "aircraft types" without hiding a number of rough assumptions behind the smooth noise exposure contours.

REFERENCES

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[2] D. Ford and E. Rickley: Noise Levels and Data Correction Analysis for Seven General Aviation Propeller Aircraft. FAA-EE-80-26.

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[4] Vejledning fra Miljøstyrelsen nr. 5/1982: Beregning af støj omkring flyvepladser.