inter•noise 2001
The Hague, Holland

The 2001 International Congress and Exhibition
on Noise Control Engineering
The Hague, The Netherlands, 2001 August 27-30

Aircraft noise management in The Netherlands vs. limited prediction capabilities of causal aircraft noise calculation models.

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Abstract

Causal aircraft noise calculation models (such as FAA/INM) are widely used as an analysis tool to assist in assessing the impact of aircraft noise in the vicinity of airports. Typical applications are land use planning (by means of a contour-set) and assessing noise control measures such as noise abatement procedures, alternative runway lay-out and/or tracks (by means of the total area within a certain contour, or the number of residents within the contour).

In The Netherlands, this concept of aircraft noise calculation models is extended to the set-up of limit-values along the contour-boundary, including enforcement and sanction procedures. The main argument is that only in separate points calculations can be supported by measurements. These regulations, demanding noise levels at single points to be predicted at least 10 years ahead, make high demands on the calculation procedure and set-up.

A sensitivity analysis of causal aircraft noise calculation models was executed, covering various aspects. The results show that accurate predictions (e.g. within 1 dB(A)) are hardly possible, whereas even 1 dB(A) inaccuracy corresponds to 20-25% uncontrolled traffic volume. Possible solutions are empirical or hybrid noise calculation methods, which are currently under investigation. These methods may achieve higher accuracy, at the cost of loss of causality; these methods rely on time-independence of the empirically determined effects.

1. Introduction

Environmental issues are becoming increasingly important in The Netherlands and other countries, and will shape aviation's growth in the future.

In The Netherlands, the so-called "kosten-unit" system for control and management of aircraft noise in residential areas will soon be replaced by the European L_{den}-system. The Dutch government is preparing this changeover, not only from "kosten-units" to L_{den}, but also simultaneously upgrading the control and management regulations.

2. Background

The "kosten-unit" based noise control and management system did not function smoothly. During the last 5 years, almost every year (as the basic evaluation period) discrepancies between noise regulations and actual noise loads occurred. However, these discrepancies were mostly totally irrelevant with respect tot noise-induced annoyance in residential areas.

Experts called them “absurdities” of the system [1], and they were mostly tolerated (no sanctions) by the government.

Obviously, this practice of tolerating irrelevant/minor violations is not politically desirable, and difficult to explain to the public. Therefore an upgrade of the noise control and management system is in preparation, to be implemented simultaneously with the changeover to L_{den}. The two main features of the new system are:

- based on calculations, but easy tot link with measurements;
- effective control over the number of aircraft movements (acoustically weighted as in L_{den}).

These are politically desired/required characteristics. The question remains whether they are technically realizable.

3. Accuracy

The dependence of L_{den} on the total number of aircraft movements (n) is 10 x log (n), see table 1.

Table 1: L_{den} vs. aircraft movements

Δ L_{den} in dB(A)	Δ aircraft movements in %
3	100
2	58
1	26
0.5	12
0.3	7
0.2	5
0.1	2
0.05	1

In order to control and/or manage the total number of (yearly) aircraft movements within 1%, which is the politically set goal (disallow 1% growth across the limit), the calculated L_{den} must be accurate within ± 0.05 dB(A). For acousticians, who mostly work with noise levels rounded to an integer value (sometimes one decimal figure) this margin is unbelievably small. In general, the accuracy of causal aircraft noise calculation programs is estimated to be ± 5 dB(A).

4. Prognostications

The control system including noise limits is supposed to be applicable approximately 10 years ahead. Future scenarios are difficult to compose, as is illustrated in table 2. Current prognostications (2001) for Amsterdam Airport Schiphol are compared to prognostications from 1996 that were used for the set-up of noise limits in the “kosten-unit” system.

Table 2: Prognostications of annual aircraft movements

Prognostication for the year	Annual aircraft movements			
	as prognosticated in		increase in	
	1996	2001	%	dB(A)
2002	320,000	460,000	44	1.6
2005		540,000		
2010/2015	440,000	600,000	36	1.3

These problems with prognostications do of course not prevent the set-up of noise limits (sort of a ceiling for annual aircraft movements due to environmental considerations), but at least obstruct an analysis of the economical impact of the noise limits.

5. Sensitivity

In order to preserve the possibility of a direct link to measurements, the noise control system must be in terms of noise limit values at various points around the airport. These points are chosen at a certain L_{den}-contour. Apart from the annual number of aircraft movements, there are numerous other effects that influence the noise load at these points. Many investigations [2, 3] were carried out to quantify these effects. Table 3 gives a selection for typical Amsterdam Airport Schiphol scenarios, with its tangential 5-runway system. Most L_{den}-shifts given here result from "kosten-unit" analyses, using a simplified conversion scheme.

Table 3: Sensitivity

Description	ΔL_{den} in dB(A)
implementation of officially prescribed computation method, comparison of three independently developed computer programs	0.5 - 1
update of officially prescribed databases (noise and profile data)	0.46
night an evening penalties	
- nightflights (5 vs. 7%)	0.33
runway usage	
- actual vs. prognostication	1.01
- cross- and tailwind criteria	0.41
- individual year vs. 30 year average	0.44
- noisy aircraft on specific runways	0.70
- runway maintenance	1.08
track usage	
- actual vs. prognostication	0.58
vertical dispersion	
- usage of highest stage-weight	0.28
horizontal dispersion	
- actual (radar) vs. prognostication (model)	0.46
- half vs. full width perpendicular to backbone	0.49
- no dispersion vs. full width	0.56
- asymmetric "Gaussian" distribution	0.40
lateral ground attenuation	
- SAE AIR 923 vs. SAE AIR 1751	0.33
aircraft	
- quieter aircraft (accelerated fleet modernization)	0.74
noise abatement procedures	
- 3000 ft vs. 2000 ft approach level	0.19
- reduced flaps vs. full flaps approach	0.15
- delayed gear approach	0.07
- ICAO-B (IATA) departures vs. ICAO-A (ATA)	0.25

The table gives averaged absolute shifts for all points on a certain contour. Individual points show higher noise load shifts, typically up to five times the average shift, i.e. up to ± 5 dB(A).

Conclusions

Aircraft noise control and management, based on the "kosten-unit", as implemented in The Netherlands, does not function smoothly. A changeover to the L_{den}-system, as initiated by the European Union, is in preparation. This changeover is also seen as a fresh start for the control and management system, straightening out "absurdities" of the old system.
However the outline of the new system seems to be very similar to the old one (noise limits in fixed points, no margin (0.05 dB(A))).
Improvements are that fewer points are chosen, and only in residential areas. Seen the sensitivities in table 3 (to be multiplied by five for individual points!), a coherent set of noise limits in fixed points surrounding the airport within 0.05 dB(A) accuracy, valid for the next ten years, seems impossible to achieve. Current state-of-the-art causal aircraft noise calculation models, although technically immaculate, can not provide these noise limits. This is a major misunderstanding between politicians and technicians/acousticians that seem to be very persisting.

Some of the uncertainties as mentioned in table 3 can be (partly) eliminated or reduced, using the following concepts:

- horizontal dispersion: calculate contributions in each point for each operation type or class based on radar tracks in a certain year, and assume that these contributions do not change in future years (apart from the number of operations);
- various: determine the difference in a certain year between the actual noise load and the calculated noise load in each point, and assume that these differences do not change with time;
- various: use margins, e.g. for meteorological induced (may vary from year to year) runway usage, however reducing traffic volume controllability;
- runway and track usage, horizontal dispersion: calculate noise loads for a one-runway, one-track (no dispersion) airport with the same number of operations as the actual airport, these noise loads can of course no longer be measured;
- runway and track usage, horizontal dispersion: use a more global noise limit, e.g. in terms of the number of houses within a certain L_{den}-contour (not measurable), which will be less sensitive to the actual distribution of noise, and allows and stimulates new tracks that avoid residential areas.

The above concepts are currently under investigation, trying to reduce the disadvantages (loss of causality, loss of volume controllability, not measurable, loss of simplicity) and to optimize the technical performance of the system.

References

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