# THE INFLUENCE OF MODELLING A-SYMMETRIC LATERAL TRACK DISPERSION ON AIRCRAFT NOISE LEVEL PREDICTIONS

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## Abstract

*In the Netherlands, noise exposure forecasting is based on the assumption that lateral track dispersion, for both take-off and landing, can be represented by a symmetrical probability distribution. Radar track observations at Amsterdam Airport Schiphol (AAS) show that the actual track dispersion is certainly not symmetrical. As a result, forecasting noise exposure calculations can give rather large differences in noise load compared with noise exposure calculations based on the actual tracks.*

*An a-symmetric lateral track dispersion model is presented, using three tracks per flight route. Two-dimensional analysis shows that the model gives a better correlation of the calculated noise levels using modelled and actual tracks.*

## 1 Introduction

In the Netherlands, both noise zoning and noise control are based on noise load calculations ([1], [2]). The noise zoning and noise control calculation procedures differ in the representation of the flight tracks only. In the noise zoning calculations, modelled lateral ground tracks are applied, whereas in the noise control calculations, the actual ground tracks are used. In the current procedure, the lateral track dispersion model, for both take-off and landing, is based on a symmetrical probability distribution function, implemented in the NLR model ([3], [4]) with an automatically variable number of sub tracks.

For departures and approaches, radar track observations at Amsterdam Airport Schiphol (AAS) show that the actual track dispersion is not always symmetrical.

A study into thirteen European noise load calculation models and the US Integrated Noise Model (INM) [5] shows that half of the models (e.g. Austria, France) use a symmetrical dispersion distribution usually based on a fixed number of sub tracks, and the other half (e.g. the Danish model DANSIM, INM) use a combination of symmetrical and a-symmetrical dispersion distributions usually based on a variable number of sub tracks. Earlier literature can be found in [3] and [6].

From this, it was decided to investigate the effect of a-symmetrical lateral track dispersion, which, combined with the automatically variable number of sub tracks, will improve the modelling features in the NLR model [7].

In Section 2, the current procedure is described in more detail. The proposed model for a-symmetrical lateral dispersion within noise load calculations is described in Section 3. The influence of the a-symmetric modeling concept on the noise load calculation result is, in a two-dimensional example, illustrated with the situation on runway 06 (Kaagbaan) at Amsterdam Schiphol Airport (Section 4). Finally, the conclusions are presented, and further work on the subject is indicated in Section 5.

## 2 The current procedure

The nominal track and the dispersion band tracks are either defined by the radar flight track system FANOMOS [8], or, for take-offs only, defined by the Standard Instrument Departure descriptions. For arrival routes, a symmetrical distribution between the 95% dispersion limits is used (Figure 1). For departure routes a more complex procedure is defined. The nominal track should be positioned symmetrically between the two 95% boundary limits of the actual lateral dispersion band. To achieve this, the boundary limit with the larger distance to the nominal route is replaced by a virtual symmetry limit such that the nominal route now indeed is located in the centre of the new boundary limits (Figure 1). This is a very tedious procedure.

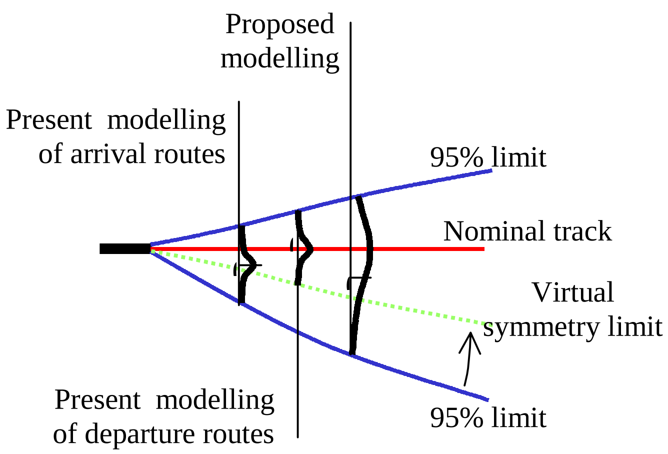



**Figure 0 Modelling of lateral track dispersion**

## 3 A-symmetrical modeling of track dispersion

The proposed model for a-symmetrical lateral track dispersion within noise load calculations is defined by three representative tracks per flight route, viz. the nominal track and the two 95% (or possibly 99%) boundary limits. The dispersion distribution function is created in the following way. The location of the actual nominal is shifted to the symmetry axis of the dispersion region by the transformation:

$$\text{If } d_{nom} > 0: \qquad t' = -2\sigma + b(t+2\sigma)^c \qquad (1a)$$

$$\text{otherwise} \qquad t' = 2\sigma - b(2\sigma - t)^c \qquad (1b)$$

where

$\sigma$ is one quarter of the width of the dispersion band,
$d_{nom}$ is position of nominal track with respect to centre of dispersion band,
$t$ is the position with respect to centre of dispersion band,

and coefficients $b$ and $c$ are defined such that

$t=2\sigma$ corresponds with $t'=2\sigma$,
$t=-2\sigma$ corresponds with $t'=-2\sigma$, and
$t=d_{nom}$ corresponds with $t'=0$.

$$b = \frac{1}{(|d_{nom}/2\sigma| + 1)^c}$$

$$c = \ln\left(\left[\frac{2 \cdot |d_{nom}/2\sigma|}{|d_{nom}/2\sigma| + 1}\right]\right) \qquad (2)$$

The above conditions for $b$ and $c$ are satisfied for

The track distribution is:

$$G(t) = (2\pi)^{-1/2} \exp(-t'(t)^2/2) \qquad (3)$$

The number of subroutes, $n$, and the locations of the subroutes in the dispersion band are given by

$$n=3^j \text{ with } 0\leq j\leq 6 \qquad (4)$$

and

$$t'(i)=\frac{i\cdot 2}{n} \qquad \text{for } i=\frac{-(n-1)}{2},\ldots,\frac{(n-1)}{2}. \qquad (5)$$

The probability, *m(i)*, of the traffic on sub route *i* is given by:

$$m(i)=\frac{1}{0.9545}\int_{\frac{t'}{2\sigma}=\frac{i\cdot 2-1}{n}}^{\frac{t'}{2\sigma}=\frac{i\cdot 2+1}{n}} G(t'/2\sigma)d(t'/2\sigma) \qquad (6)$$

Note that since the area within the Gaussian distribution between t'=-2σ and t'=2σ is 95.45% of the total area, scaling with the reciproke of 0.9545 brings the sum of the traffic on all subroutes to 100%.

The elegance of this approach is not only that the a-symmetrical lateral track distribution is better approximated, but also that the symmetrisation procedure is rendered obsolete.

## 4 The effect of lateral track dispersion modelling for runway 06 at Amsterdam Airport Schiphol.

For example, the actual flight tracks for approaches on runway 06 (Kaagbaan) of Amsterdam Airport Schiphol from the eastern direction show that aircraft turn into the runway within a distance of 6 kilometers of the airport (Figure 2). The turn-in track lies in the area of the 35 Ke contour, which is the limit for noise control. Therefore it is important to accurately estimate the noise levels, and therefore the route definitions, in that area.

At the distance of about 12 kilometers from the runway, the width of the dispersion region is 1264 m. The distribution of aircraft over the dispersion region is given in the black histogram in Figure 3a. The dispersion distribution is clearly a-symmetric, with a peak in the outer turn.

The a-symmetric distribution model compares much better with the actual dispersion (Figure 3).

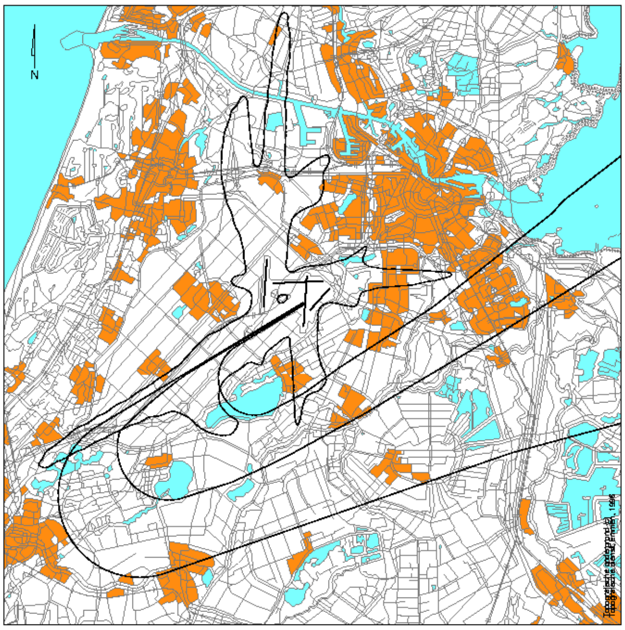
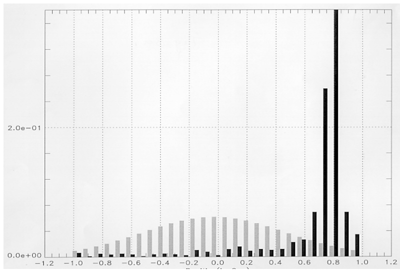
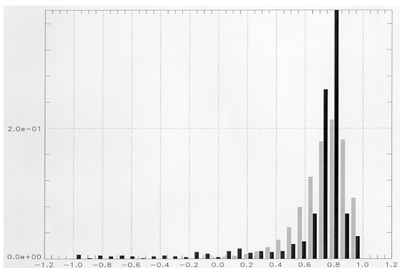


**Figure 2 Approach Tracks for Schiphol Runway 06 (1 August 1995 - 31 August 1995)**



a. Symmetric distribution model



b. A-symmetric distribution model

**Figure 3 Comparison of track distribution according to the two distribution models (grey), compared with 791 actual approaches on runway 06, from 1 August 1995 to 31 August 1995 (black).**

The effect of the dispersion model on the ground noise level is investigated by evaluating the noise contribution of an aircraft passage at the average flight height ($h=0.1*2\sigma$) to the immission at various points at the ground in the two-dimensional plane perpendicular to the track. The lateral position of the aircraft is given by the probability distribution. In Figure 4 the relative noise levels (with respect to the noise at 1m distance to the aircraft) are shown for the modelled distributions versus the actual dispersion. In the immission point closest to the nominal route, the deviation from the ideal relative noise levels (represented by the line $y=x$) is considerably reduced for the a-symmetric distribution compared to the symmetric distribution. The increased deviation further away from the nominal route is acceptable since at that location the absolute noise levels are low and consequently the deviation is less relevant.

## 5 Conclusions and Further Work

Two dimensional calculations with the proposed a-symmetric lateral track dispersion algorithm show a better correlation with calculations based on the actual flight tracks compared to the present symmetrical approach. How this works out for the year-based noise monitoring and control, still has to be evaluated.

It is, however, expected that the better representation of flight track dispersion is relevant in areas where the noise loads are equal or above the regulation limit of 35 Ke.

Priority for further study is the evaluation of the a-symmetrical lateral track distribution for the year-based noise monitoring and control.

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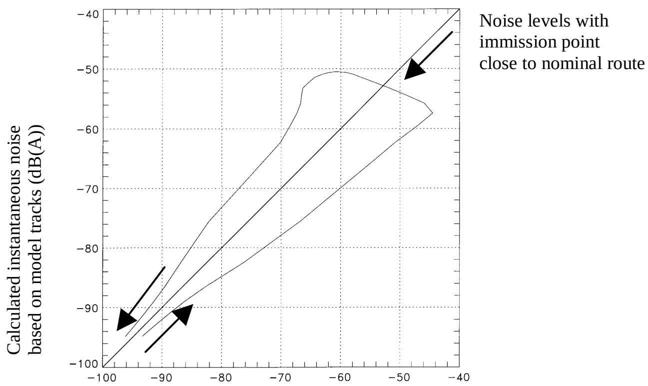
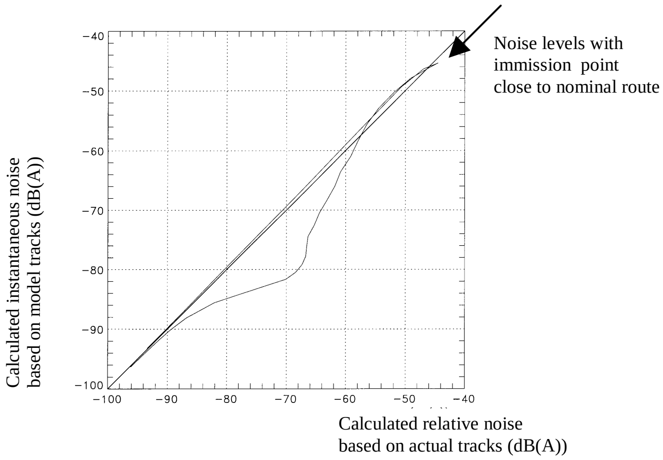



a. Symmetric distribution model




b. A-symmetric distribution model

**Figure 4 Relative noise level for modelled distribution versus relative noise level for actual dispersion (dB(A)).**