Continued experimental evaluation of a new approach to aircraft noise modelling

D.D. Land[1], G. Oldenziel, F. van der Eerden, J. Sijs
[1] *TNO Science and Industry, P.O. Box 155, 2600 AD Delft, The Netherlands, Email: derk.land@tno.nl*

Introduction

A new approach to aircraft noise modelling was presented previously [1]. In this approach the source levels, from which the immission levels are calculated, are not only obtained from direct emission measurements but also from ‘reverse engineering‘ schemes as developed within the European IMAGINE project. The objective of this approach is to combine measurements and model results so that both are enhanced. The measurements provide a validation for the model, and the model provides noise levels for a large area.
With the currently available Dutch models, flight paths of aircraft are expected to be accurate and absolute. Deviations from the route, or the engine settings are not taken into account. For real flights there is often the need to deviate from the flight paths resulting in incorrect estimates, from reverse engineering models, for the source levels.
The second section of this article describes the data, in the third section we describe the model itself and how the thrust and path deviations from the ’allowed’ flight path influence the model results. The forth section is the model comparison with the data and in the final section the results are discussed.

Data

The NOMOS [2] network around Schiphol Airport consists of a number of measurement posts where the acoustical signal is logged if the observed level is above a certain threshold. For most posts this threshold is at around 60 dB. In the remaining of this article NOMOS post 1 and 21 will be used. In Figure 1 the locations of the different posts is illustrated.

The data provided by the NOMOS network gives for every flight the spectral data at different positions along the flight path of the aircraft. The flight path data obtained from Schiphol Airport consists of the type of aircraft, the position (altitude, lattitude and longitude), the runway used and if the aircraft was taking off, landing or passing by. In total we used 2 weeks of data. In this article we only investigate departures, aircraft landing are not taken into consideration.

Models

In previous versions of the TNO aircraft noise model, the input parameters were the Noise-Power-Distance (NPD) tables, radar tracks and aircraft properties such as the number of engines and maximum thrust. The NPD tables relate the observed noise from an aircraft to the

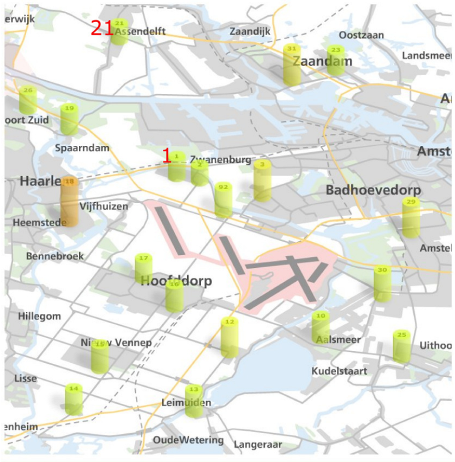

Figure 1: Overview of some of the NOMOS measurement locations around Schiphol Airport. Number 21 and 1 are used in this paper.

power settings and distance. When both the distance and noise are known, the power settings can be obtained. The NPD tables do not contain data for every setting of the aircraft, only the standard procedures are tabulated. The radar track data only contains the position of the airplane at different time intervals. The thrust or the actual mass of the aircraft during take off is unknown. In the current TNO aircraft noise model the source is

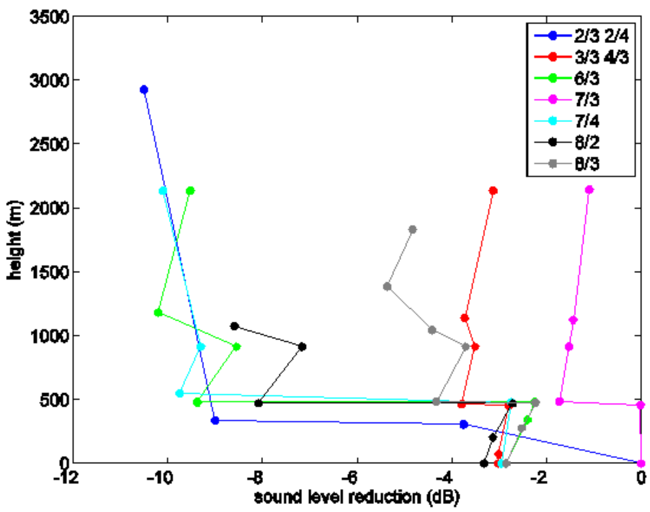

Figure 2: Sound level reduction for several different noise/mass classes versus the altitude of the aircraft.

described by a hemisphere which reflects the directivity of the noise produced by the source. The noise-hemisphere of the aircraft is positioned along the flight path and the noise immission on the ground is obtained by taking into account the noise propagation along the path from the

aircraft to the receiver. If the aircraft makes a turn, the hemisphere is tilted with the same angle.
The difficulties appearing with the data we received from Schiphol Airport is that it is not possible to reconstruct all the flight data that is needed as input for the acoustical model. Aircraft parameters such as the engine settings at every aircraft position and the aircraft mass, make it impossible to create a precise description of the (acoustical) source.
In Figure 2 a simple relation [1], based on standard procedures given in the appendices of INM, the Federal Aviation Administration's Integrated Noise Model, for a group of aircraft is given. The aircraft are grouped by weight and acoustic class and a reduction in their source sound levels is given for different elevations. Deviations from the procedures are not implemented and thus not available in the current TNO aircraft noise model.

Measurements versus TNO model

With the flight data provided by Schiphol and the spectral data from the NOMOS posts, a comparison between the model and the data is possible. In Figure 3 and Figure 4 spectral data from NOMOS and the model are compared. The spectra are randomly selected from the dataset and it gives a first insight into how well the model fits to the data. The calculated spectrum

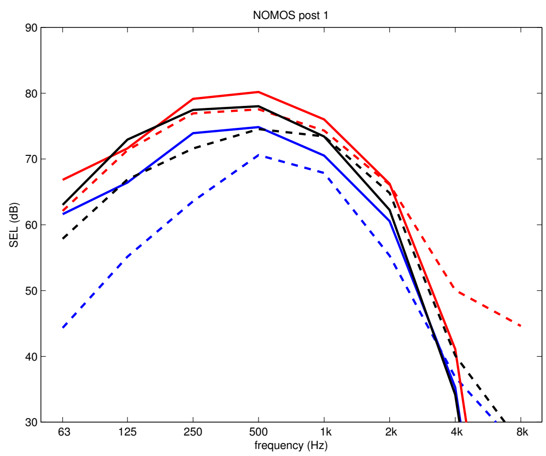

Figure 3: NOMOS data (dashed lines) from post 1 compared to data from the model (lines). The blue line is an Airbus 343, the red line a Boeing 744 and the black one a Boeing 772.

fairly fits to the measured spectrum. For NOMOS post 21 the difference is about 1 dB while for post 1 it is 3 dB. NOMOS post 21 is further away from the runway. The larger deviation between model and data at the measurement post closer to the runway could be explained by engine settings, which might play a more important role close to the runway.
In Figure 5 the NOMOS data is is compared to the model. The flights are all take offs. The differences between the model and measurements are in a wide range, with the measured data systematicly some dB higher than the model data. A first guess to explain the differences is the direction of the measurement posts compared to the runway. Flight procedures describe when which runway can be used. These procedures depend on the wind

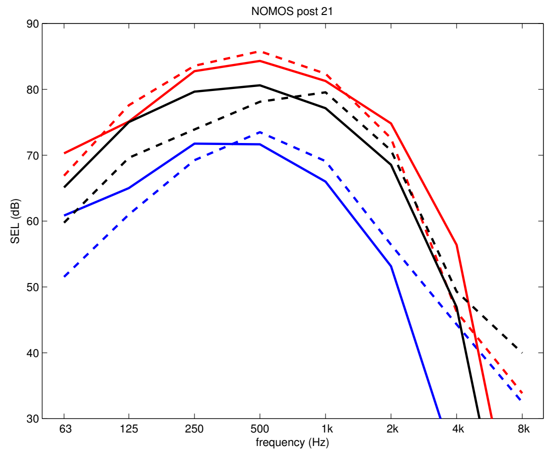

Figure 4: NOMOS post 21, further the same as figure 3

direction which will influence the propagation of noise. But this needs further investigation. In addition the ground effect, the reflection of sound waves of rigid soil, can add a few dB to the measured data.

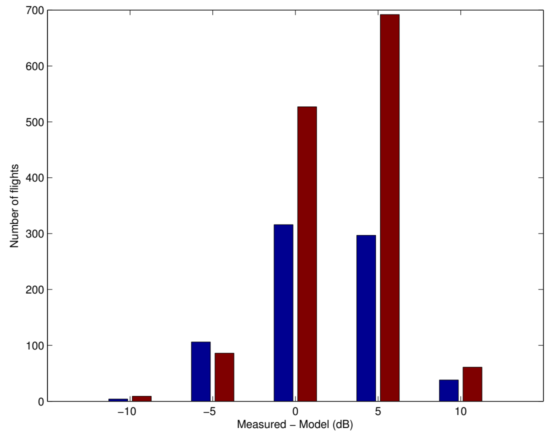

Figure 5: Differences between model and measurements for NOMOS post 1 (red) and 21 (blue). The dB values given are the integrated noise levels of the flight at the location of the receiver.

Conclusions

By combining a model with measurements, a so-called model-based monitoring approach is applied. The measurements provide a validation for the model. The validated model can be applied to determine noise levels in a vast area around the NOMOS post. With the aircraft noise monitor it is possible to get results which can be compared to measurements. There is still need for further improvements, especially the settings of the aircraft, ground and meteorological effects.

References

[1] An Experimental evaluation of a new approach to aircraft noise modelling, F. De Roo E. Salomons, Acoustics08, Paris, June-July 2008

[2] Aircraft Noise Monitor maintained by Schiphol Airport, URL: `http://194.229.29.150/nomos/main.mxml`