A PREDICTION MODEL FOR NOISE FROM LOW-ALTITUDE MILITARY AIRCRAFT

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INTRODUCTION

For a number of years, the National Physical Laboratory, supported by the Ministry of Defence, has been developing AIRNOISE, a mathematical model for computing aircraft noise contours (1). As part of the continuous programme of development of the model we were asked to extend it to include low-altitude military operations. The objective is to predict the complete time-history of the noise of these very rapid events, thus providing information on onset rates as well as maximum levels. In order to provide high quality data with which to validate and refine the model, a special noise trial - Exercise Luce Belle - was conducted in which a number of aircraft types flew low, straight and level at various speeds and engine power settings. This paper firstly describes the noise trial and then the prediction model. The comparison of prediction with measurements is discussed. In particular the effects of changes in the assumptions in the model about lateral attenuation are explored.

MEASUREMENTS

The noise trial is described in detail in two NPL reports (2,3).
The aircraft types used were Tornado GR1, Jaguar, Harrier GR5, Hawk T1A, F-15 and F-16. Each aircraft flew one or two sorties during which a number of conditions typical of those used in low-altitude training were replicated in a number of runs across a target area. At a primary site directly under the flight track, four sets of microphones, some at 1.2 m high and some in the ground plane were deployed. Two similar sets were deployed at a site 1000m perpendicular to the track. All of the signals were digitally recorded using either

DAT or PCM systems. Information on the actual height, speed and ground track for each run was obtained from a combination of kine-theodilite, radar and video tracking systems. Details of the data analysis techniques and the full set of results are given in the reports. As an example, Figure 1 shows the results for the Tornado at one of the locations on the primary site. The results from the trial have been used to update the rules governing permitted heights and speeds in the UK Low Flying System (4).

THE FLYBY PREDICTION MODEL

This model is related to the AIRNOISE model for airfield operations but is separate from it. The software is designed to calculate a time-history of the A-weighted sound pressure level, at a single point on the ground, for a flyby of an aircraft operating under defined conditions. The sound exposure level, the maximum level and the rise-time over the top 30 dB are also calculated. The calculations make use of the noise-distance-power database of AIRNOISE (5). The sequence of stages of the software is as follows. The user selects an aircraft type and an appropriate source noise directivity correction file. An engine power setting is selected and the associated coefficients of the noise-distance equation are read from the aircraft data file. The user then enters the aircraft height, speed and the lateral distance from the observation point to the flight track. From this the minimum slant distance is calculated. Then at one-tenth second intervals throughout the event, the slant distance and the angle between the line from aircraft to observation point and the flight path are calculated. A level is calculated at the observation point from the noise-distance equation and the directivity correction. Corrections are then made for engine power and for lateral attenuation. From the series of levels throughout the event, the other quantities are measured. The software is written in "C" Language and runs on a portable PC.

COMPARISON OF PREDICTIONS AND MEASUREMENTS

The model was originally implemented using the SAE procedure for lateral attenuation (6). In a companion paper to this one (7), the results of the UK noise trial, together with a large quantity of data from similar noise measurements on military aircraft in the USA have been analysed and it has been shown that the SAE procedure tends to over estimate the lateral attenuation at angles of elevation between 2 and 45 degrees.

It is proposed that the correction for lateral attenuation takes the form of

Attenuation (dB) = 20.49/Angle - 0.1818

Figure 2 shows a comparison of the measured time-history for a Tornado at 480 knots and 238 feet with the predicted time history assuming either the SAE procedure or the new proposal, labelled AL. Figure 3 shows a similar comparison for an aircraft height of 108 feet and speed of 426 knots. The differences between the two forms of lateral attenuation correction are most marked at times well before and after the maximum level is reached. These correspond of course to low angles of elevation. Over the top 40 db of the time-histories, there is excellent agreement between the predictions and measurement. Taking the results from all 18 overflights of the Tornado in Exercise Luce belle, Figure 4 compares measured and predicted values of L_{Amax}. Also shown are a linear regression fit to the points and the line of equality. On average the model underpredicts by about 1 dB.

CONCLUSIONS

A prediction model has been developed and implemented in "C" on a portable PC which generates time-histories of A-weighted sound pressure level for a flyby of an aircraft at given constant speed, height and power setting. A carefully controlled noise trial has been conducted to provide data for a range of aircraft and conditions. There is good agreement between the model predictions and measured data.

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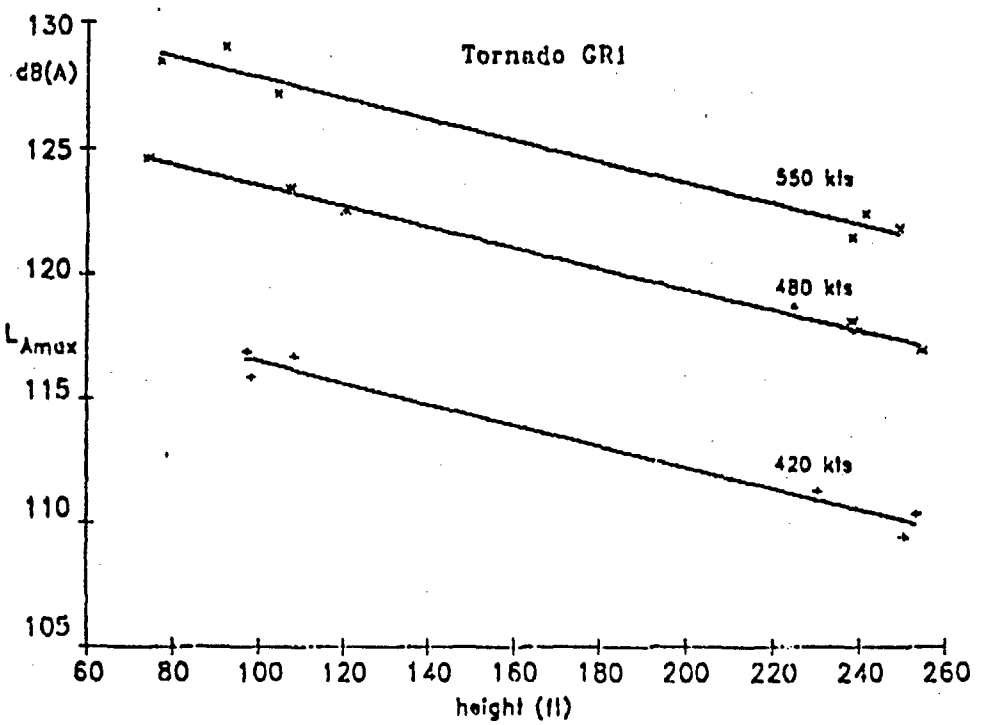

Figure 1. Maximum noise levels at primary site : Tornado

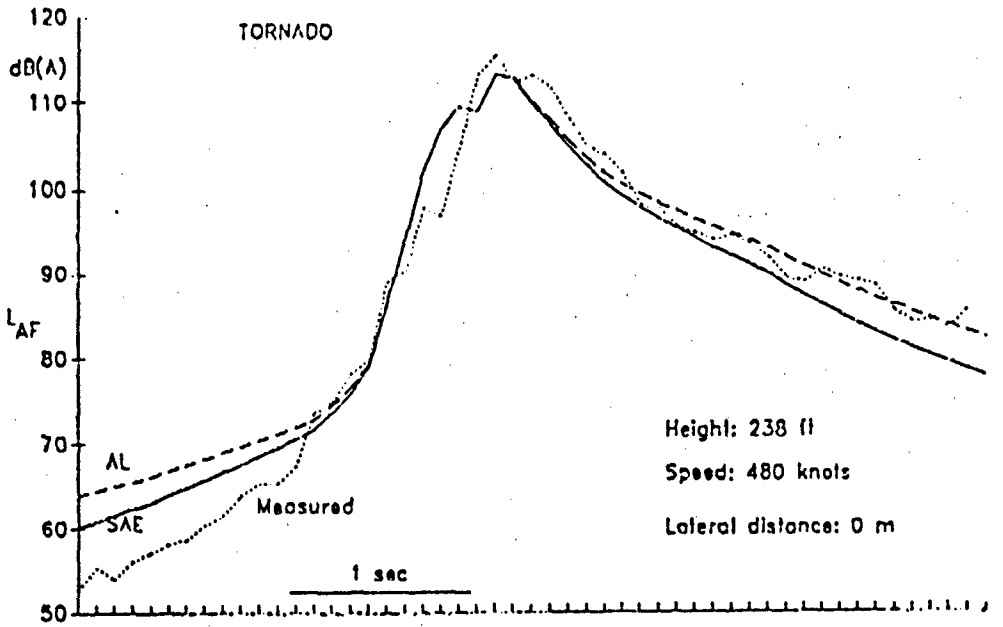

Figure 2. Comparison of measured and predicted time-histories.

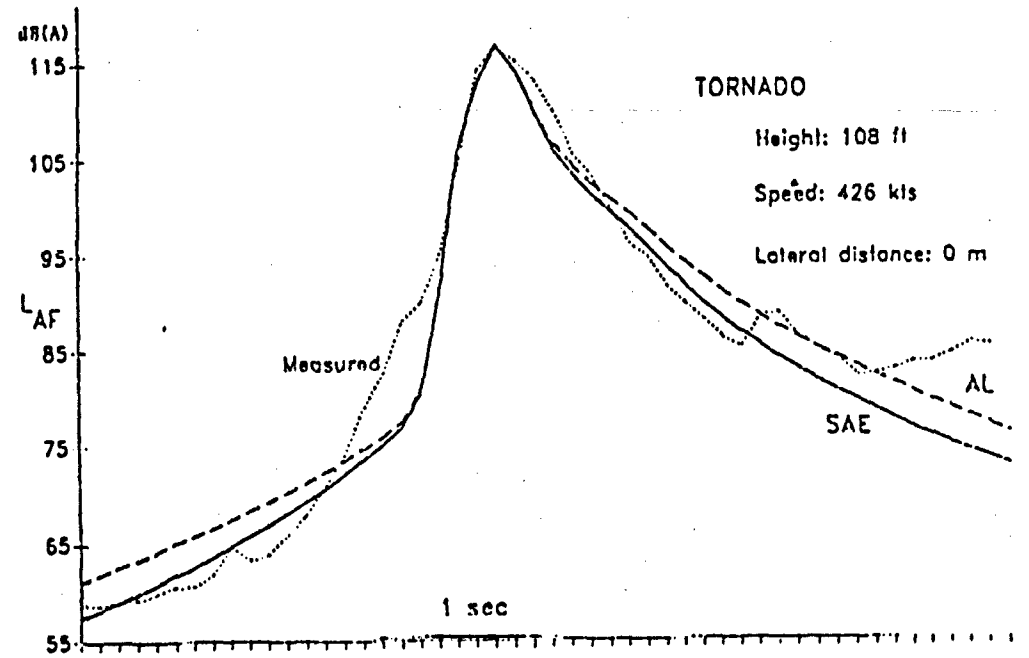

Figure 3. Comparison of measured and predicted time-histories.

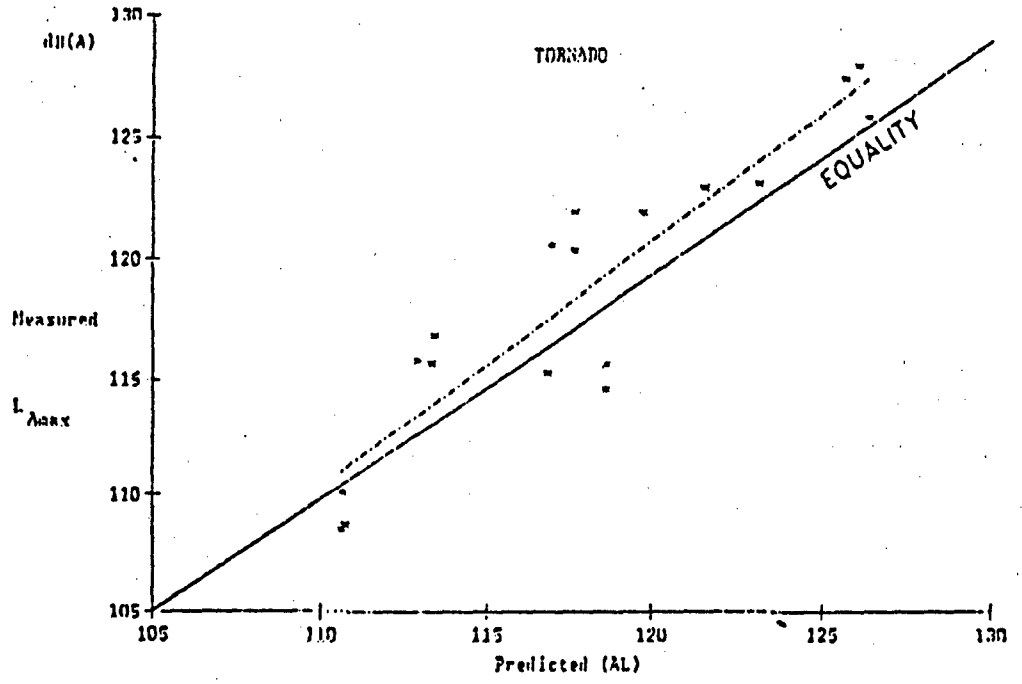

Figure 4. Measured and predicted values of $L_{\Lambda max}$.