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THE APPLICATION OF MATHEMATICAL MODEL FOR PREDICTING NOISE CONTOURS FOR MILITARY AIRFIELDS

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INTRODUCTION

The Ministry of Defence has been involved in measuring noise levels around military airfields since the early 1970s, when, following the introduction of Phantom type aircraft, concern was expressed about the health and hearing of residents living close to or beneath the take-off paths at Coningsby. Originally, hand drawn contours were developed, based on the Perceived Noise level (LPN) as the basic noise measure. The use of the Noise and Number Index (NNI) was considered for military airfields but as reported in a paper by Kanagasby [1] it was rejected as being unsuitable. The RAF Environmental Noise Committee recommended that the specification of noise around military airfields should be based on the equivalent continuous 'A' weighted sound pressure level (L_{Aeq}). The continued suitability of L_{Aeq} index for RAF military airfields was confirmed during the recent MOD policy review in a paper by Higginson [2]. The use of an L_{Aeq} contour was first put into practice in 1975 at RAF Brawdy. Here the L_{Aeq} 80 dB contour (again hand drawn) was calculated by measuring hourly L_{Aeq} levels at 15 measuring sites over a 2 week period. At this time it was the policy of the Government to respond to local complaints only where criteria regarding a 'new works' were applicable within the 1973 Land Compensation Act.

THE AIRNOISE MODEL

In the succeeding years the demand for information on noise levels around military airfields increased such that the National Physical Laboratory was approached and asked to produce a mathematical model for computing aircraft noise contours. The first full version of the model, AIRNOISE I, was handed over in 1982. AIRNOISE I holds a data bank of information on source noise and operational flight profiles for the RAFs current aircraft inventory. The basic source noise data were determined in a series of flight trials at RAE Bedford in 1981 [3]. From this information the model is able to compute the noise footprint in terms of a selection of the common single event noise descriptors. For a number of repetitions of the same event in a period of hours the equivalent continuous 'A' weighted sound pressure level $L_{Aeq,h}$ can also be computed. Sets of footprints covering a range of levels of a given descriptor, eg $L_{Aeq,12Hr}$ = 70, 75 and 83 dB can be displayed graphically and plotted either directly onto a map or onto a transparent overlay.

The application of AIRNOISE I has been very successful even though it does have some limitations. For instance it could only cope with flight tracks that were straight in and out of an airfield and secondly it could not summate the noise around an airfield for more than one aircraft or manoeuvre at a time. Consequently modification of the basic contours to account for a mix in traffic and changes in direction had to be completed by hand, and supported by validatory measurements.

AIRNOISE II has the additional capability of mapping noise exposure contours in $L_{Aeq,h}$ resulting from various aircraft operations including visual circuits. It takes into account both the number and the mixtures of aircraft types and their tracks. A sample set of contours is shown in figure 1.

APPLICATIONS

The mathematical model has been applied in a broad range of applications. An early application, whilst AIRNOISE I was still under development was at a public enquiry into the redevelopment of the airfield at RAF Stornoway. Here there were plans to extend the runway and since at the time the Tornado aircraft was only just being introduced it was not possible to measure the noise in situ. A range of contours were produced by the NPL at different scales but only for straight 'in and out' operations. The Isle of Lewis, where Stornoway is situated, is not in one of the most densely populated areas of the UK, and the occasional planned use of the airfield would not normally qualify for grant assistance. Nevertheless, following the public enquiry the local authority won a decision that grants for sound insulation should be paid to local residents within the qualifying contour as compiled by AIRNOISE I. In practice, the application of the latest internationally accepted prediction technology for lateral attenuation effects shows that the actual contours are not as large as was originally predicted and that a revised flight profile shows that the aircraft can turn on take-off thus avoiding most of the built up area. These modifications have been taken into account in developing AIRNOISE II.

AIRNOISE I was extensively used in the preparation of the study into the policy of the Ministry of Defence for providing sound insulation in the vicinity of military airfields. For this purpose predicted L_{Aeq} contours were produced for some 50 airfields. These were then used for counting the number of properties at each airfield which would be included within a scheme with a specified noise criterion for eligibility.

A major [4] trial where the model was extensively used was at RAF Leeming. This airfield is in the process of a major redevelopment to operate the 'air defence' version of the Tornado. Predicted contours were produced based on differing flight profiles. They indicated that some residents of the local village, which is built up right to the edge of the airfield, would be exposed to $L_{Aeq,12Hr}$ levels in excess of 83 dB. The local population voiced doubts about the validity of the computer predicted contours and also protested at the siting of Hardened Aircraft Shelters close to their properties. A dedicated trial was held in which two Tornado aircraft flew a variety of manoeuvres in a manner which represented the operational techniques to be used when the station becomes operational. The result of the trial demonstrated the accuracy of the AIRNOISE model, but illustrated the need to ensure that the input data used to calculate the contours were correct. Actual measurements underneath the flight path were found to be in excess of those predicted [Fig 3]. A measurement technique developed by NPL for tracking aircraft take-off profiles using 2 video cameras showed that the actual flight profiles were significantly lower than had been used [Fig 4]. When a mean value for the flight profiles was inserted into the model the resulting contours were shown to match [Fig 5]. The measurement accuracy is further illustrated by an error chart [Fig 6]. In a large scale noise measurement/video tracking exercise the tracking technique is used to provide information on the actual ground tracks on these routes. The use of the video recording technique has been very useful in sorting out the actual flight tracks at the Tri-national Tornado Training Station at RAF Cottesmore. There when runway 23 is in use there are 5 nominal major departure routes spread over an angle greater than 180^{o} [Fig 7]. Accurate information of this sort is vital if the modelled contours are to be precise.

Further examples include the production of contours down to $L_{Aeq,\ 12h}$ 55 dB for planning purposes by the local authority at Greenham Common even though the number of daily movements were only 2. American NOISEMAP source data [5] was incorporated into the model for this exercise. Similar contours have been produced for RAF bases in Germany.

FUTURE DEVELOPMENTS

What are the limitations of the model? To a certain extent we are constrained by the current computer memory but this is being remedied. More important is to ensure that the flight profile data is accurate, most of this relies on answers to questions given by pilots. Unfortunately they cannot fly exactly to the parameters required for the model and in any case there will always be a spread dependent on the meteorological condition operating at the time. VSTOL aircraft such as the Harrier present a problem in this area. There are at least 4 approach and landing profiles and several take-off profiles, none of which we can yet accurately convert into input data. Accordingly, NPL and ICOM are mounting an exercise to record the approach and take-off profiles along with the noise dose produced by a Harrier. The method used will be similar to that for the production of the original basic noise source data [3].

The next stage for the model is to include Helicopter operations. This is important to the UK since we have several well used helicopter fields in Northern Ireland, some of which are in the middle of townships. The local residents are just as entitled to sound insulation schemes as at any conventional airfield. Because helicopters do not normally fly conventional flight routes a factor to incorporate the average noise over an area will also have to be incorporated into the model. This will also be useful at conventional airfields where there is some dispersion of the noise due to varying flight routes. Further planned developments include incorporating the effect of ground noise. This is a difficult area bacause it does not appear to add to the overall L_{Aeq} contours of a station but produces a disproportionate number of complaints both in the UK and Germany. It does not appear to be a problem around civil airports and has therefore not figured in any of the social survey data published in recent years.

Finally if ground source noise is incorporated then there is no reason why the model cannot be extended to predict noise from say Army ranges and tank training areas.

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CONCLUSIONS

In conclusion, therefore, the Ministry of Defence has always striven to be a good neighbour regarding the impact of noise from airfields. We have successfully developed a mathematical model which has now been in existence several years. Regular validation has shown it to be accurate and its use in the future will replace much of the labour and equipment intensive monitoring work.

ACKNOWLEDGEMENT

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2. Higginson R. - Evaluation of Noise on the ground due to military aircraft operations. NPL Acoustics special report S12.

3. Fethney P and Hazell A F. - The external Noise of MOD Military Aircraft RAE Technical Report 83058 June 1983 MOD London.

4. Weston R J - A report on the noise survey carried out at RAE Leeming April 15-17 1985. ICOM Report 32/85.

5. USAF - US Noisemap - Aerospace Medical Research Laboratory, Wright Paterson Air Force Base, Ohio.

FIGURES

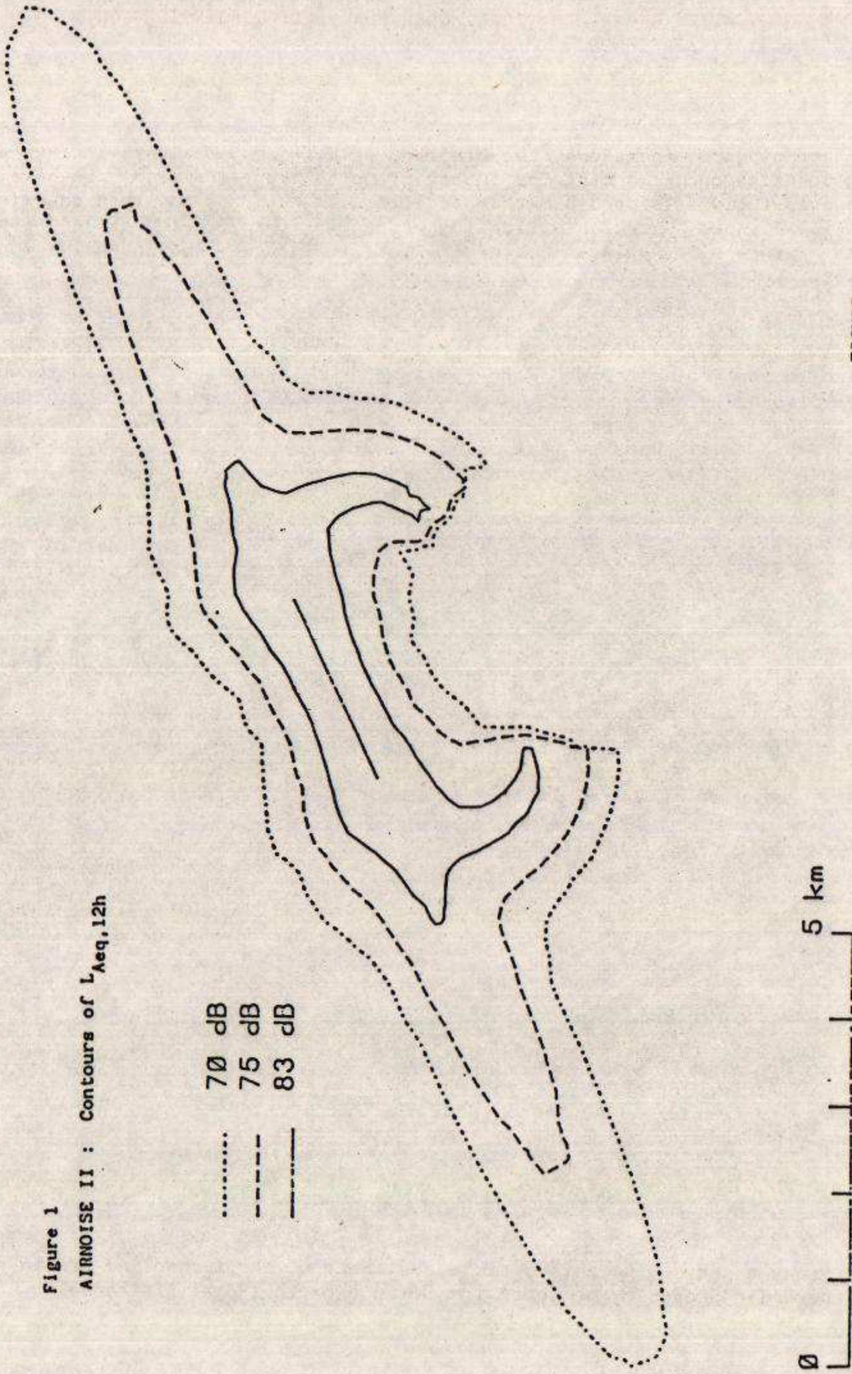


Figure 1
AIRNOISE II : Contours of $L_{Aeq,12h}$

FIGURE 1

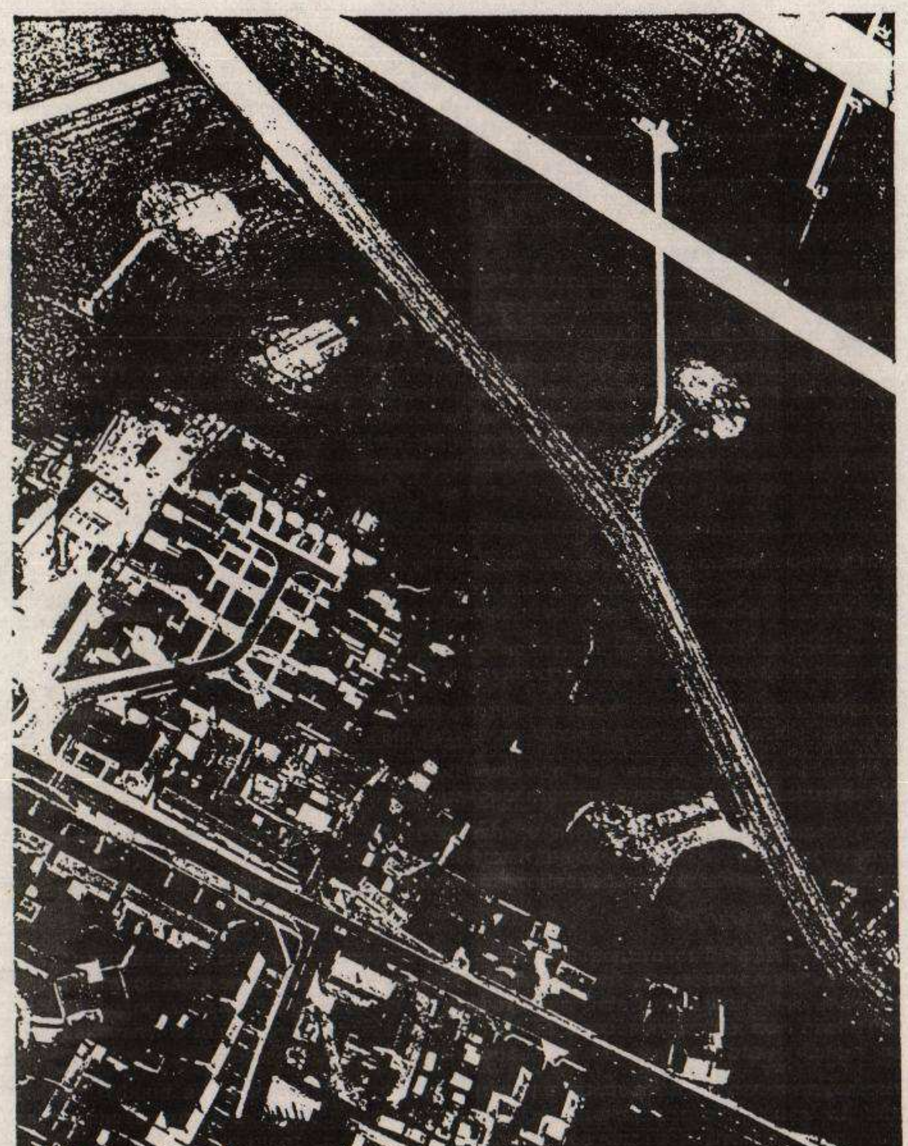
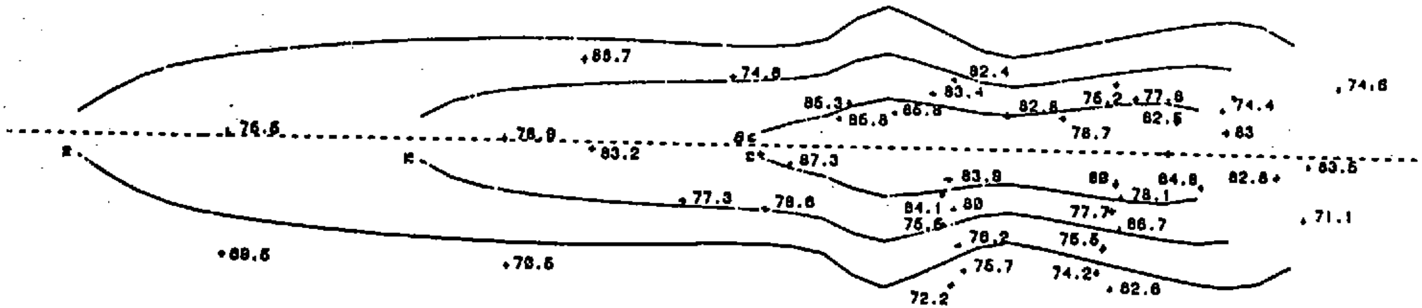


Figure 2

Plot of the Original $L_{Aeq,12hr}$ Predicted Take-Off Contour

with results of the Actual Measurements



LEEMING F2V4

TORNADO

No. of Events - 50, Duration 12 hr

Scale 1:25000

FIGURE 3

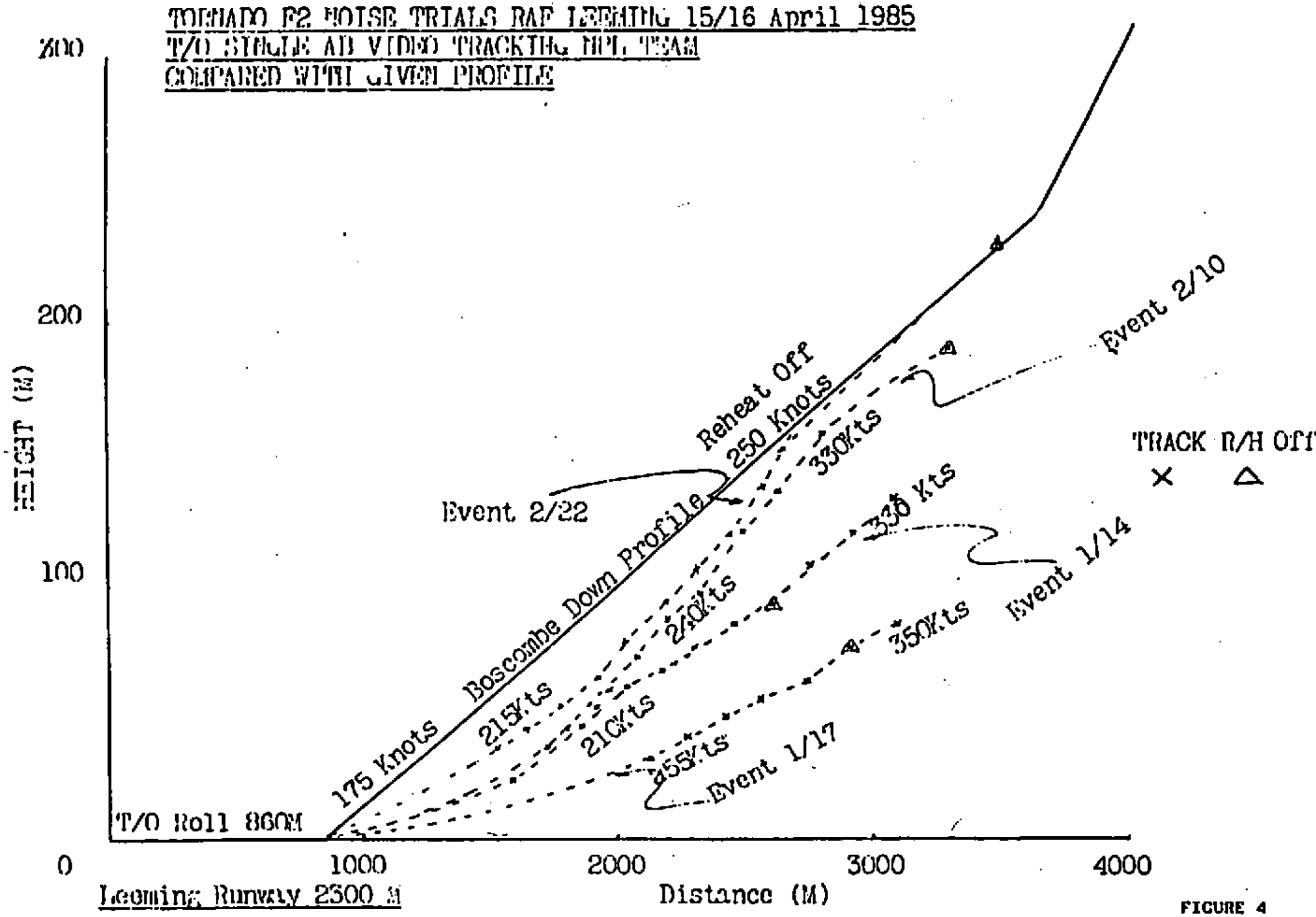
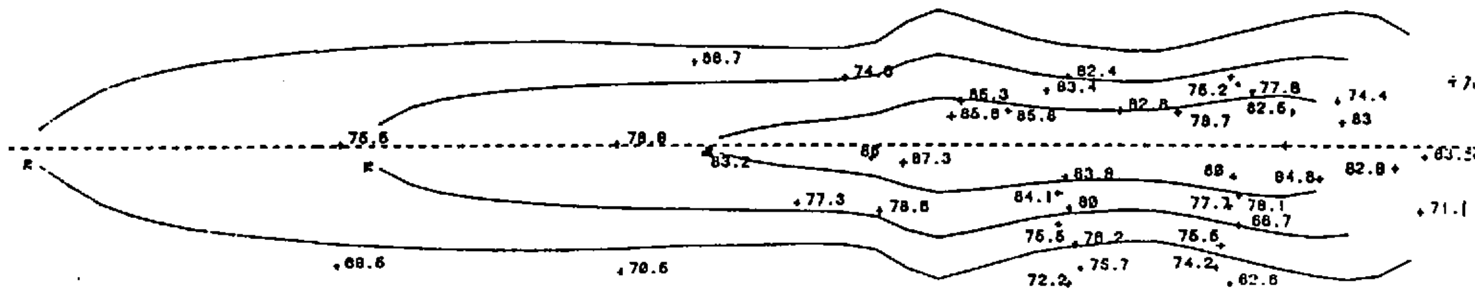

TORNADO F2 NOISE TRIALS RAF LEEMING 15/16 April 1985
T/O SINGLE AB VIDEO TRACKING NPL TEAM
COMPARED WITH GIVEN PROFILE
HEIGHT (M)
0
100
200
300
Distance (M)
1000
2000
3000
4000
Leeming Runway 2300 M
T/O Roll 860M
175 Knots
Boscombe Down Profile
250 Knots
Reheat Off
Event 2/22
Event 2/10
Event 1/14
Event 1/17
215Kts
210Kts
240Kts
330Kts
330 Kts
350Kts
355Kts
TRACK R/H OFF

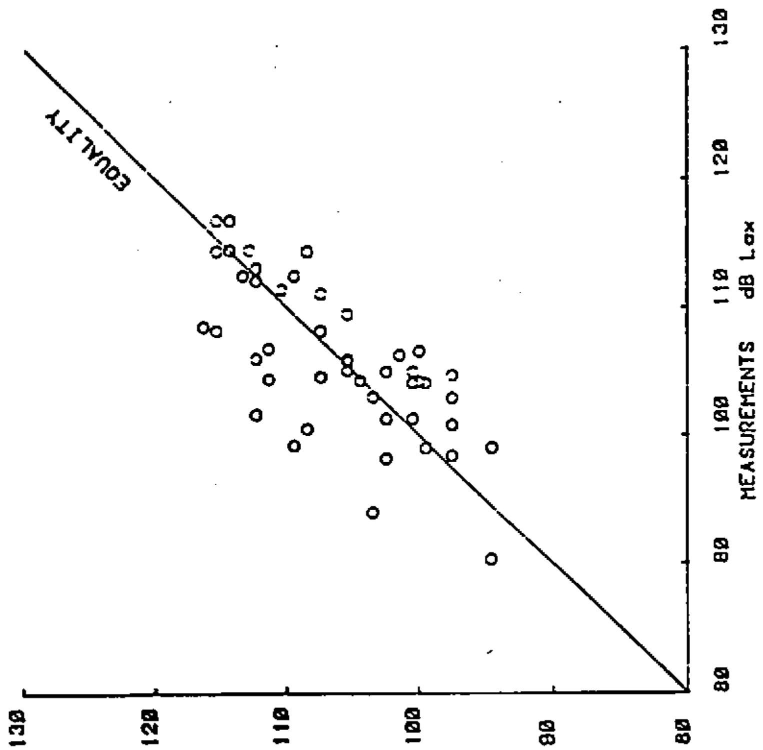
FIGURE 4

Plot of the Modified $L_{Aeq,12hr}$ Computed Take-Off Contour with results of the Actual Measurements



LEEMING F2V6
TORNADO
No.of Events - 50, Duration 12hr
Scale 1:25000

FIGURE 5



TORNADO F2 NOISE TRIALS April 1985 Fig 6

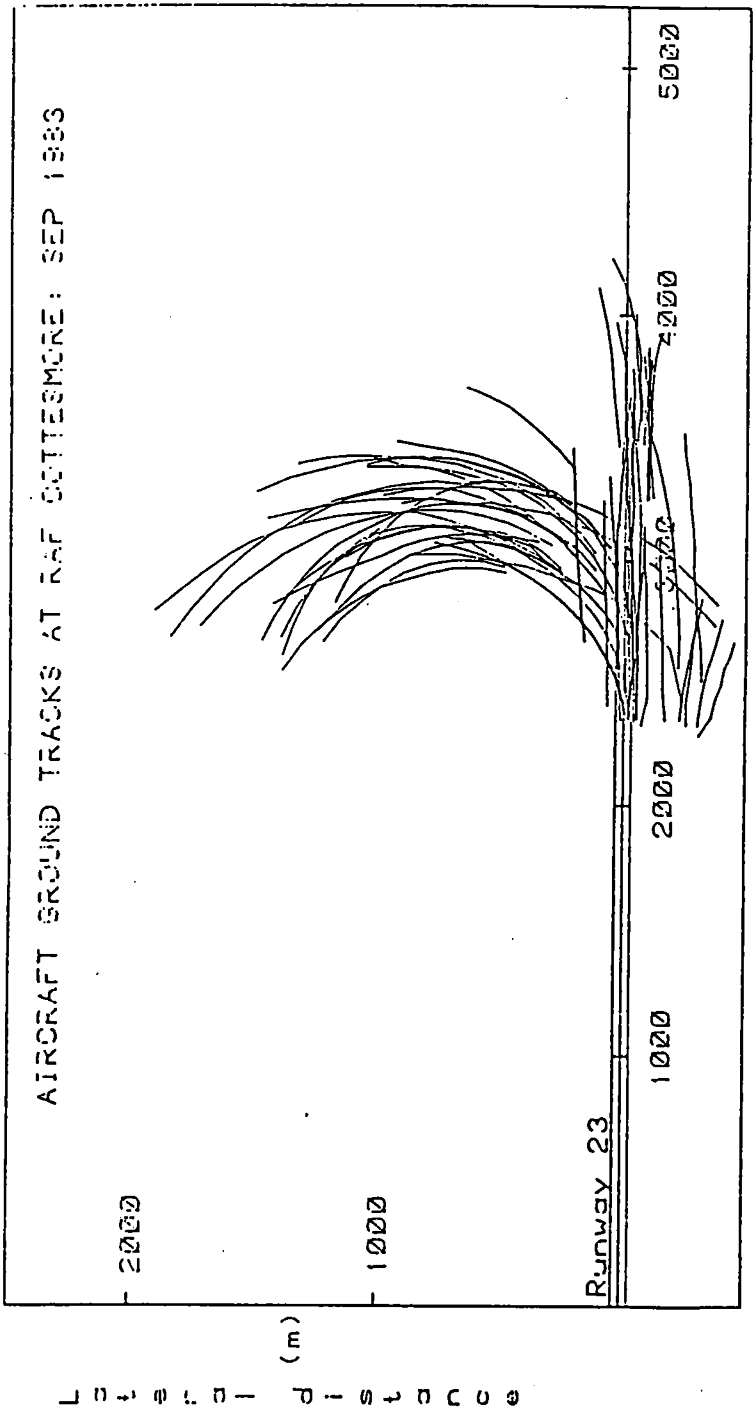

AIRCRAFT GROUND TRACKS AT RAF COTTESMORE: SEP 1983
5000
4000
3000
2000
1000
Runway 23
2000
1000
Distance from threshold (m)
Lateral Distance (m)

FIGURE 7