Proceedings of The Institute of Acoustics

THE MEASUREMENT AND PREDICTION OF AIRCRAFT NOISE AT LEEDS/ BRADFORD AIRPORT.

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INTRODUCTION

The main commercial airport serving the Yorkshire region is strategically located close to the large urban conurbations of Leeds and Bradford. Whilst this geographical convenience acts as a bonus in terms of accessibility, it incurs the penalty of having residential dwellings in close proximity to the source of aircraft noise. The main runway is orientated north-west/south-east and at 1600 metres in length, offers the shortest available take-off distance of any commercial airport in the United Kingdom. At the present time the average number of commercial aircraft movements per twelve-hour day is about 26 (13 landings, 13 departures) of which less than one in five are jet aircraft. Towards the end of 1979 a public inquiry was held to examine the merits of a planning application by the Airport Authority to extend the main runway by 600 metres. A previous inquiry, held in 1969, had refused a similar application, mainly on the grounds of additional noise disturbance. This paper outlines the work involved during the preparation of supporting evidence on aircraft noise for the recent inquiry.

NOISE PREDICTION

There was little serious doubt that the Noise and Number Index should be used as a basis for evaluating aircraft noise disturbance at Leeds/Bradford. There was some doubt, however, regarding the validity of applying the same dose-response relationship, as developed at Heathrow, to an airport with relatively fewer aircraft movements. The trade-off in the NNI formula between the disturbing effects of the number of aircraft flyovers and the average loudness of these events means that for any level of disturbance, the average peak noise level at Leeds/Bradford could be more than 10 PNdB higher than at Heathrow. On the other hand, since the original NNI responses had been based on reaction to aircraft operations throughout a full day, the absence of night-flying at Leeds could result in some degree of exaggeration of the disturbance.

The Civil Aviation Authority were commissioned to prepare NNI contours for the existing situation based on actual movements during 1977 and, for the extended runway situation, using traffic forecasts for 1987. In line with normal practice, contours were first produced on the basis of assuming flat ground relative to the runway level. During subsequent manual checking of the contours it was found that, at the south-east end of the runway, the use of actual source to receiver distances resulted in corrections to peak levels of up to 7 PNdB. In this area the land falls from the end of the runway towards the city centre at an average gradient of about 1 in 20. Furthermore, the effect of the topography correction is most pronounced in the case of landing aircraft, due to the shallow angle of the glide-slope and, in this area, 85% of future movements would be landings. The nett effect of incorporating ground level information into the prediction process in this case was to reduce the area of the future 35 NNI contour from 18 sq.km. to 14 sq.km. and, more dramatically the number of residential dwellings within the contour reduced from 7,500 to 3,000.

In addition to the standard plotted contours, NNI data was also requested in the form of computer listings of NNI spot levels for the intersection points of a 200 metre x 100 metre grid aligned with the main runway. This data enabled more precise values to be quoted for specific locations such as schools and hospitals and was also used to construct contours showing the change of NNI from 1977 to 1987.

Individual aircraft noise profiles, were also supplied in the form of co-ordinates of distance from start of roll and height, together with noise reference levels for each segment of the departure and landing profiles. These proved particularly useful in enabling the County Council to write a basic version of the prediction program designed to test the sensitivity of forecast NNI to possible changes in the dependent variables such as aircraft type or runway usage. Using this technique it was later found that, by basing the future aircraft mix on the "busiest summer day", rather than the conventional "average summer day", NNI levels were exaggerated by approximately 4 NNI.

MEASUREMENT

Although the bulk of evidence in respect of noise was to be based on the predicted NNI levels it was considered essential to verify the accuracy of the prediction methodology by undertaking a programme of site measurement. The plan was simply to select a number of representative sites at different levels of NNI and to obtain, at each location, measured values of the appropriate peak noise levels. Using the standard 1977 frequencies for each aircraft mode it would therefore be possible to derive a "measured" NNI value for each site which could then be compared with the theoretical value. In addition it was felt that measured results could provide less tangible benefit by adding substance and understanding to the bare NNI contours.

The necessary requirements to ensure accurate results are set out in terms of the site conditions, measuring equipment and methodology, in the ISO document 3891 "Procedure for describing aircraft noise heard on the ground". In respect of site conditions the standard specifies a hard reflecting surface with an unobstructed cone of vision defined by the half-angle of 80° to the perpendicular. In a built-up area only a flat-roof location would normally meet this criterion. Because of the relative infrequency of some aircraft movements at Leeds/Bradford it had been decided to measure continuously for long periods using automatic equipment. This raised the further problem of the security of unmanned and rather expensive equipment. To discourage the acoustically-minded vandal, the microphone needed to be located beyond easy climbing height and out of sight of casual passers-by. Finally, to minimise the possible significance of variation in wind direction, sites needed to be located as close to the flight-paths as possible. In practice very few sites met all the requirements. Of the thirteen sites used all but two complied with the acoustic criteria and corrections had to be made to the results obtained at sites 2 and 4 to allow for additional reflection from nearby facades.

The equipment used comprised of two NOMAL 2A instruments using ½" condenser microphones, A-weighting and slow response. The sampling rate used throughout was two samples per second to minimise the risk of missing a peak level. In the NOMAL the analogue sound signal is digitised and stored on a magnetic tape cassette for later processing by a programmable calculator such as the WANG 2200B. At each site the microphone was orientated for grazing incidence and calibration reference levels were recorded at the beginning and end of each tape. During the processing of the data, levels below 67 dB(A) are ignored and the presence of an aircraft event is recognised only when the signal remains above the threshold level for greater than 4 seconds. The time of the event is printed, followed by the ½ second PNdB levels. Each noise event is subsequently matched against the airport records to identify the aircraft and mode of operation. The most common problem experienced with the equipment was caused by the persistent intrusion of rain-water into the connections of the microphone pre-amplifier cable. As this item carries a polarisation voltage of 200 volts the result is fairly impressive and always expensive. The application of self-amalgamating tape to all exposed joints eventually solved the problem. To reduce the incidence of damp microphones the windshield was normally shrouded in a nylon stocking and sprayed with a water-repellant solution.

RESULTS

Over a nett measurement period of 120 days, some 1300 individual aircraft noise events were recorded at thirteen sites. In respect of each site a mean peak PNdB value was obtained for each aircraft mode, together with the associated standard deviation of the sample levels. At most sites some of the possible events were not recorded and estimates were made by comparison with other data. Although individual standard deviations ranged from zero to 16 PNdB the majority fell in the range from 1.5 to 3.5 PNdB.

Measured NNI values have been calculated for eleven of the thirteen sites, where sufficient data was available, and these are shown in the table below together with the relevant predicted values. The sites are listed in descending order of NNI and their location relative to the runway is shown, together with the number of measured samples obtained.

DISCUSSION

The tabulated results represent the end-product of a considerable expenditure of time and effort and there is an obvious temptation to extract from them clear and unambiguous conclusions to validate the original hypothesis. However, the reality is somewhat less positive. At the detailed stage of peak

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PNdB levels of individual aircraft the comparison of measured and predicted values showed little consistent agreement either in terms of sites or aircraft. In terms of the degree of scatter in the results it was found that the highest standard deviations occurred at those sites either close to, or far removed from, the runway. This aspect was re-affirmed in the context of the good agreement found between measured and predicted NNI values at those sites located in the 35 to 45 NNI zone. The sizeable difference in values found at Site 1 is probably due to the proximity of this location to the runway, with the result that minor variations in operational procedure will have significant effects in terms of measured noise levels.

TABLE 1: COMPARISON OF MEASURED AND PREDICTED VALUES OF NNI

SITE NO.	1	2	3	4	5	6	7	8	9	10	11	12	13
LOCATION	← SE →				← NW →		SE	NW	← SE →				
NO. OF SAMPLES	270	95	216	61	74	54	97	104	65	39	52	10	27
MEASURED NNI	49.9	42.9	40.9	38.9	36.9	35.1	33.9	32.5	32.5	29.2	28.0	-	-
PREDICTED NNI	52.2	43.1	41.0	39.5	37.8	36.1	33.0	29.2	29.2	26.2	25.7	15.6	15.4
DIFFERENCE	-2.3	-0.2	-0.1	-0.6	-0.9	-1.0	+0.9	+3.3	+3.3	+3.0	+2.3	-	-

CONCLUSIONS

Because of the large number of uncontrolled variables which influence the measurement of aircraft noise it will not normally be possible to guarantee a high level of precision particularly in terms of individual aircraft. The only practical method, therefore, for assessing the levels of noise disturbance in the vicinity of airports must continue to be by modelling the situation and using standard aircraft profiles to construct NNI contours. The results of the comparative study at Leeds/Bradford suggest that NNI is a relatively stable index and the accuracy of predictions is likely to be acceptable outside the immediate vicinity of the runway area.

ACKNOWLEDGEMENTS

The work described in this paper was carried out on behalf of the Airport Joint Committee. The author wishes to express his thanks for permission to publish it.

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