THE WEST LONDON NOISE STUDY: USE OF COMPUTER-BASED MODELING IN AN ATTEMPT TO UNDERSTAND THE IMPACTS OF COMBINED NOISE SOURCES.

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1 INTRODUCTION

In 2002, the Department for Environment, Food and Rural Affairs (DEFRA) published the results of the 2000/01 National Noise Incidence Study (NIS)[1] carried out by BRE. This utilised 24-hour measurements made at over 1100 sites across the UK. (A similar survey was carried out in 1990). The selection of the measurement sites was designed to give a representative picture of the exposure of dwellings to noise. It was a complex process that involved local authority areas being selected at random but with a probability weighted by their populations. Within each authority, there was further selection firstly of two wards and then of ten residential addresses within these wards, also at random. These residential addresses became the noise measurement sites. Measurements were only made during normal weekdays (for example, avoiding school holidays).

In London, which comprises 33 local authorities, this selection process resulted in all the NIS measurements being made in the more populous outer boroughs – seven in all. No inner or west London boroughs were included. Whereas the NIS approach could be used in inner London, it was recognised that in west London a similar approach of a single 24-hour measurement may not provide the expected representative results because of the influence of the noise from aircraft using Heathrow Airport. Depending on the mode of operation at Heathrow, the result at a particular location for one 24-hour period could be very different from the next.

The Greater London Authority (GLA) commissioned the West London Noise Study to obtain an indication of how noise levels in West London compared with the rest of London and the country. Taking account of the difficulties that a random noise survey would present, the alternative methodology used is described below. It was based on computer modelling to provide results for the main operating modes of Heathrow Airport. The study also explored how the impact might change were the so-called Cranford agreement to be abandoned. Although it is recognised that there are some significant limitations to this approach, especially with the inherent uncertainty of the modelling data used, it is felt the fundamental principles of the method has merits and that it did indeed provide a means of obtaining the desired information.

2 SPECIFICATION FOR THE WEST LONDON NOISE STUDY

2.1 Aims

In detail, the aims of the study were:

1. To indicate how typical west London residential noise exposures differ from those nationally and in other parts of London for which data were available. This was to include using

available data to estimate what a survey like NIS might show if the geographic concentration and temporal variability of aircraft noise did not render assessment using NIS sampling methodology potentially unrepresentative.

2. To identify the aircraft noise contribution to (1) above, but in greater temporal detail than shown by published contours (e.g. showing the variation associated with changes in operational mode and alternation).

3. To present data for parts of London around Heathrow in such a form as to act as a basis for assisting in assessing the implications of any future proposals for changing the Heathrow operating regime.

It should be noted that for the WLNS it was decided to model only road traffic and aircraft noise. Consideration was given to including railway noise, but to do so would have necessitated the creation of a railway noise model, which would have been a large task. Although there are significant railway corridors in west London, it was considered that their impacts would be sufficiently localised that, in statistical terms at least, railways could be omitted for the purposes of this study.

3 METHODOLOGY

The main elements of the methodology were as follows:

1. To use the results of the London Road Traffic Noise Map (LRTNM) as the basis for the road traffic noise contribution[2];
2. To build a noise model of Heathrow Airport using the FAA model INM.
3. To combine the air and road noise exposure for various operational modes of Heathrow Airport and to determine the area of land exposed to various noise levels;
4. To use population databases to estimate the number of people exposed to various levels of noise;
5. To identify how Heathrow Airport contributes to the noise exposure in the area and how loss of the Cranford agreement might alter that exposure.

3.1 The Road Traffic Model

The four west London boroughs most affected by aircraft noise were to be modelled. These were Ealing, Hillingdon, Hounslow and Richmond. The available output of the LRTN was in terms of several indicators including L_{den}, L_{night}, L_{day}, $L_{evening}$ and $L_{A10,18}$. For this study, the day, evening and night results were used, i.e. the average daily L_{Aeq} for the periods 0700 – 1900 (day), 1900 – 2300 (evening and 2300 – 0700 (night).

3.2 The Air Noise Model

Currently Heathrow Airport's noise exposure contours are calculated by the Environmental Research and Consultancy Department (ERCD) of the Civil Aviation Authority (CAA), using their in house ANCON noise model, which is not commercially available. The Federal Aviation Administration's (FAA's), Integrated Noise Model (INM) operates in a very similar manner to ANCON, though there are usually some minor differences in the resulting contours. A previous study had shown that it was possible to recreate the Heathrow noise contours using INM and the same method was adopted here[3]. Having recreated the average mode contours it would be then valid to manipulate the data to recreate each individual mode of operation of interest.

At the time of calculation, the most recently available contours for Heathrow Airport were those for 2003. The published report[4] was used as the basis to recreate the published average mode contours as described below. Helpfully, this report included results for the situation were Concorde not flying (which, of course, is now the case). Hence using those results, the analysis would more closely represent the current situation. In calculating any airport contours it is necessary to know the arrival and departure routes used at the airport and the type and numbers of aircraft operating on them. The routes particularly on departure were estimated from the report and later refined.

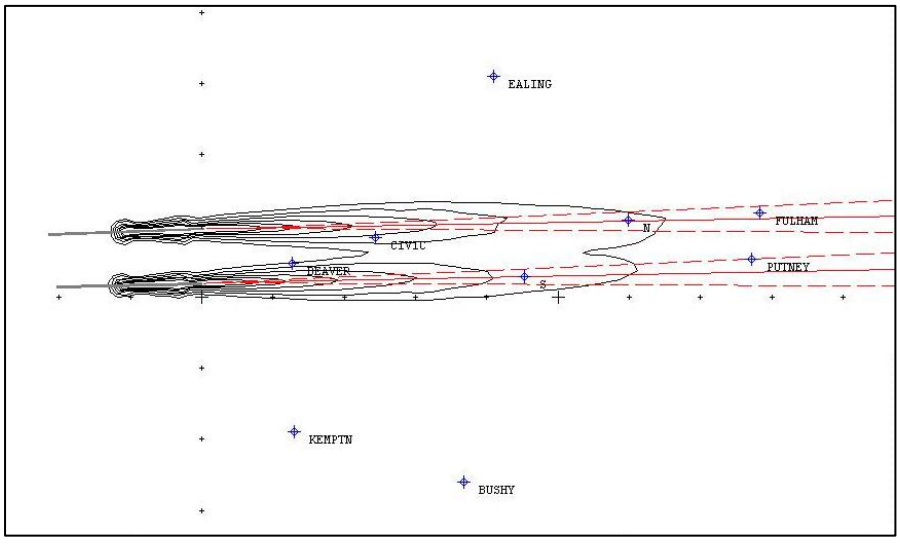
An iterative process was followed using simply aircraft substitutions and the results from noise monitoring sites in the London Borough of Hounslow. In the end it was found that using an A340 aircraft as a substitution could generate the westerly arrival contours based on the 2003 ERCD movement data. In order to produce these arrival contours the movement total was split 50/50 between arrivals and departures. 70% of the total arrivals were then taken as being westerly arrivals. The split between runways 27R and 27L (see section 3 below) was taken as being 53.5/46.5 (from the ERCD report). By making these adjustments, westerly arrival contour lobes were found to coincide with the published average mode contours.

The input data used is presented in Table 1 below and the resulting contours can be seen Figure 1.

Table 1
Surrogate movements numbers to simulate the average mode arrival contours

	Day	Eve
Westerly arrivals 27R	225.0	46.1
Westerly arrivals 27L	195.5	40.1

Figure 1



Schematic Diagram of surrogate westerly arrival contours based on the input data in Table 1

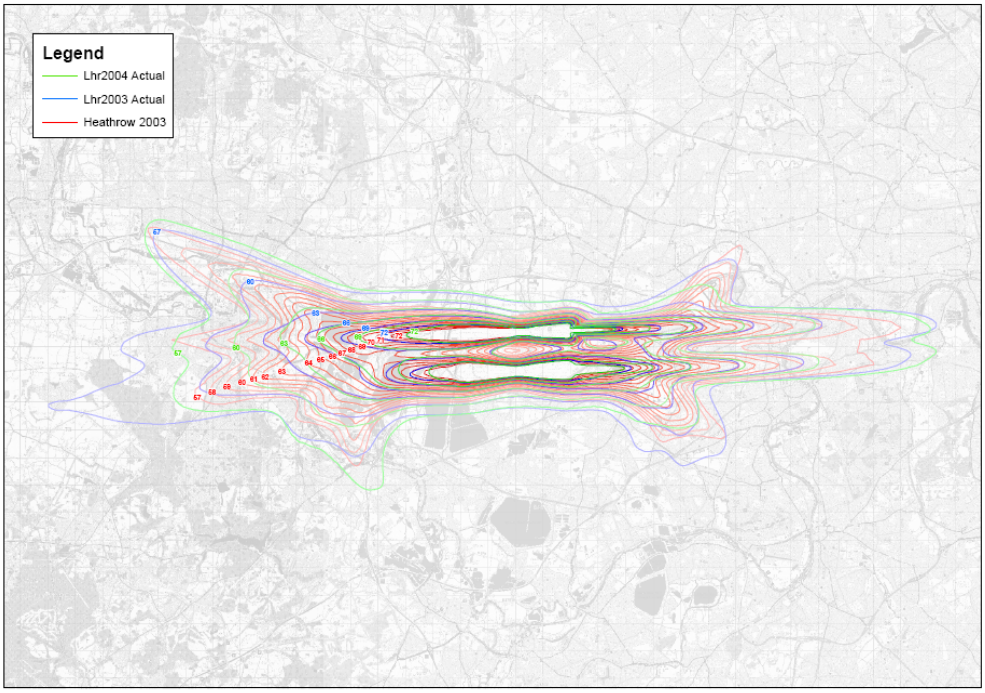
Having secured good similarity with the 57 dB(A) contour, it was agreed that it would be worth exploring the comparison with the other contour levels. Electronic copies of the 2003 contours were sought from the department for Transport. Unfortunately, the only available dataset included Concorde. It was agreed to wait until the 2004 contours were available (which would by definition exclude Concorde). Although not a direct comparison (there were slightly more movements in 2004), it was felt that they might be able to indicate whether the surrogate model was broadly consistent with the published contours.

Figure 2 shows the comparison between the surrogate model and the published contours for 2003 (including Concorde) and 2004 (excluding Concorde). There are several points to note:

- It is generally regarded that good accuracy is achieved if any differences are within 1 dB of the expected answer. Thus if the surrogate model is not more than 1 dB different from the published values, then the surrogate model is fairly representing the airport impact.
- The 2003 modal split was 70%/30% W/E - 2004 was 81%/19%. So it would be expected that the 2004 arrival lobes (to the east) would be longer than the surrogate model - let alone the fact, as mentioned above, that the number of movements increased slightly.
- Considering the 2003 contours, Concorde would not affect the departures over Ealing towards the north-east and there it can be seen that the surrogate result lies between the 57 dB(A) and 58 dB(A), i.e. it is within 1 dB(A).
- Similarly the departures over Burnham to the North West of the airport, are not affected by Concorde, and, again the surrogate model is within 1 dB(A) of the published values.
- The comparison of the higher level contours are in sufficient agreement once the issues mentioned above are taken into account.

Thus, the surrogate model does provide a good representation of the air noise impact of London Heathrow airport.

Figure 2
Comparison of the actual 2003 and 2004 contours with the surrogate model



4 HEATHROW AIRPORT

4.1 Modes of Operation

Aircraft usually take-off and land into the prevailing wind. If the wind is coming from the west, this mode of operation is called westerlies; if from the east, easterlies[1]. The proportion of time that the operations occur in each direction is known as the modal split. As there are two parallel runways at Heathrow, there is a choice over which can be used.

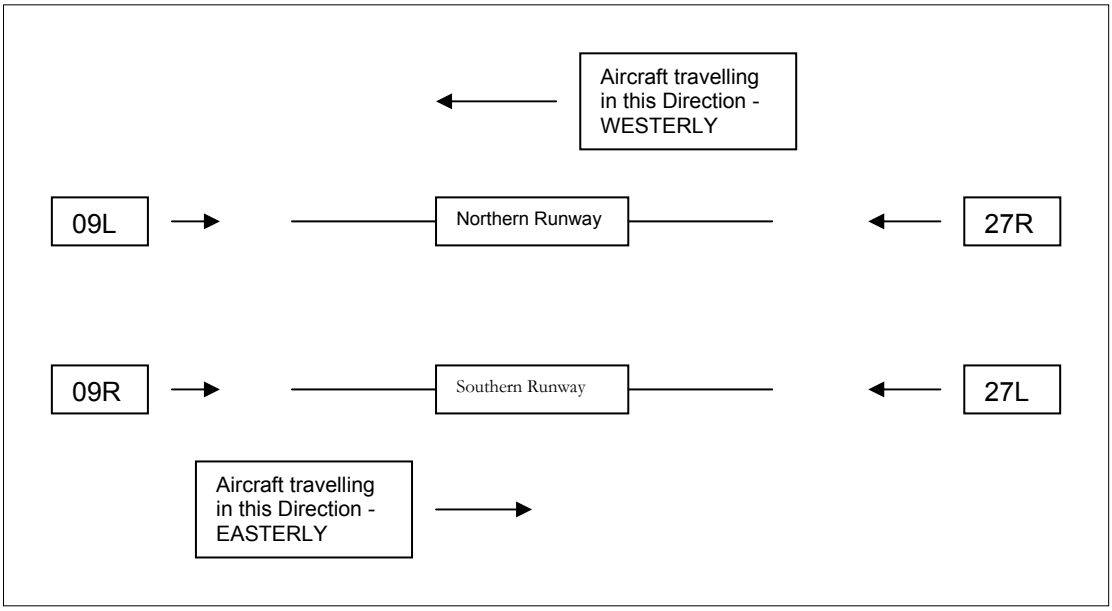
On westerlies, the system of alternation means that during the daytime, one runway is used exclusively for arrivals, whilst the other is used for virtually all departures. At 15.00 hours, this arrangement alternates so where there were arrivals, there are departures and vice versa.

On easterlies, the Cranford agreement currently prevents departures from occurring from the northern runway. Thus at present on easterly days, all departures occur from the southern runway and all arrivals occur on the northern runway.

The identifier for each runway depends on the mode of operation. So on westerlies, the northern runway is known as 27R, but on easterlies it is 09L. Figure 3 below shows schematically the Airport and the runway identifiers

[1] Although not relevant for this study, Heathrow operates during the daytime what is known as Westerly Preference, whereby in still conditions and even with a slight easterly wind, westerly operations occur. The original intent of this approach was to limit the number of departures occurring over West London.

Figure 3
Schematic Diagram of the Operational Modes of London Heathrow



4.2 The Operational Modes Investigated

In addition to analysing results from the LRTNM alone for the four London Boroughs, the following five operational modes of Heathrow airport were examined:

1. 24 hour period of westerlies, with arrivals using 27L (the southern runway) in the morning, and alternating at 15.00 hours (Day 1);
2. 24 hour period of westerlies, with arrivals using 27R (the northern runway) in the morning, and alternating at 15.00 hours (Day 2);
3. 24 hour period of easterlies, assuming all departures use 09R (the southern runway) with the split across the departure routes following the average published by the CAA in the annual contouring report (Day 3);
4. 24 hour period of easterlies, assuming departures use 09L (the northern runway) in the morning, and alternating at 15.00 hours (Day 4);
5. 24 hour period of easterlies, assuming departures use 09R (the southern runway) in the morning, and alternating at 15.00 hours (Day 5)

Heathrow Airport currently operates in Modes 1 - 3 only depending on the weather conditions. Modes 4 and 5 could be operated if the Cranford agreement were abandoned.

5 ANALYSIS

As indicated above, the corresponding day, evening and night noise levels were combined to provide total aircraft and road traffic noise levels for the five different days investigated. Using standard GIS procedures, the area exposed to different noise level bands was calculated for the three indicators studied. In addition, the equivalent results for population exposure were calculated using the same method as used for the LRTNM.

For the four London Boroughs examined the total area and population is shown in Table 2 below:

Table 2
Total area and population with the study area Boroughs

	Area (km^2)	Population
LB Ealing	55.5	300,948
LB Hillingdon	115.7	243,006
LB Hounslow	56.6	212,341
LB Richmond	58.8	172,335

The population data was taken from the 2001 census. Clearly, some caution should be exercised over the apparent accuracy of these figures.

5.1 The Effect of the Different Operational Modes

In order to see the variation in noise impact as a result of the varying operational modes of London Heathrow four notional locations, one in each Borough were examined in detail. The locations were selected to show the range of impact that occurs depending on the mode of operation of the airport. The four locations were:

- London Borough of Ealing – a location broadly under the flight path used by departing aircraft from Heathrow;
- London Borough of Hillingdon – a location in the Longford area just to the north and west of the airport;
- London Borough of Hounslow – a location that lies to the north of the Borough broadly under the approach route to the northern runway; and
- London Borough of Richmond upon Thames – a location in the Whitton area.

Figure 4 shows indicatively these locations.

Figure 4
Location Plan

Table 3 shows the L_{day} noise levels at these notional locations (combined road and air) for the five operational days examined.

Table 3
L_{day} Noise Levels at the notional locations

	Hounslow	Hillingdon	Ealing	Richmond
Day 1	68.7	70.2	49.1	49.5
Day 2	71.6	67.6	49.3	49.4
Day 3	60.8	60.2	62.2	58.2
Day 4	67.6	70.5	62.3	57.0
Day 5	65.7	70.1	62.0	57.6

The variation in daytime noise that occurs at these locations, depending on the mode of operation of the airport can be clearly seen.

A similar range of impact occurs during the evening and the night as can be seen in tables 4 and 5.

Table 4
L_{eve} Noise Levels

	Houns	Hill	Ealing	Rich
Day 1	72.4	57.7	50.1	45.6
Day 2	56.3	71.1	49.9	46
Day 3	60.0	60.2	61.9	57.4
Day 4	60.0	59.9	60.0	56.8
Day 5	68.6	71.1	62.1	55.0

Table 5
L_{night} Noise Levels

	Houns	Hill	Ealing	Rich
Day 1	58.0	60.0	48.0	42.9
Day 2	62.0	54.8	48.0	42.9
Day 3	52.8	55.7	52.3	47.7
Day 4	56.3	60.5	51.4	45.6
Day 5	52.4	55.5	51.0	46.5

5.2 Comparison with the London element of NIS

In order to compare these results with the (outer) London element of the NIS study, it was necessary to derive average noise levels from the NIS work. These are shown in Table 6

Table 6
Derived Noise Levels from the London element of NIS

	Noise Level
L_{day}	57.2
L_{eve}	55.2
L_{night}	48.6

These results have been compared with the results for the five operational modes examined in this study for each Borough in turn. Figures 5 – 9 show the results:

Figure 5

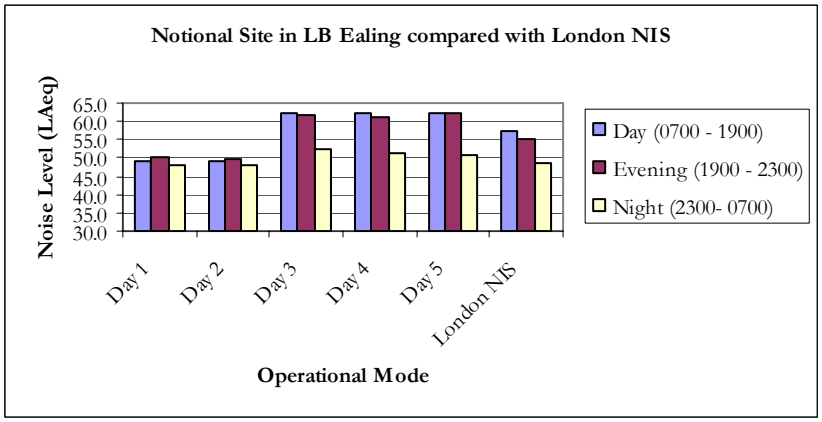


Figure 6

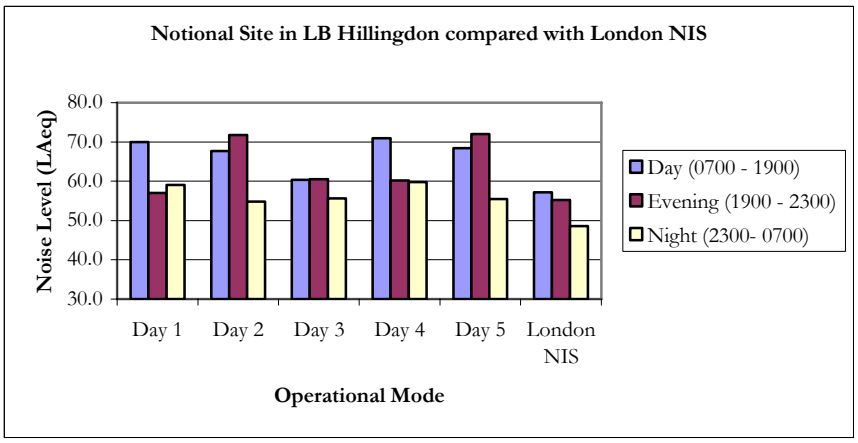


Figure 7

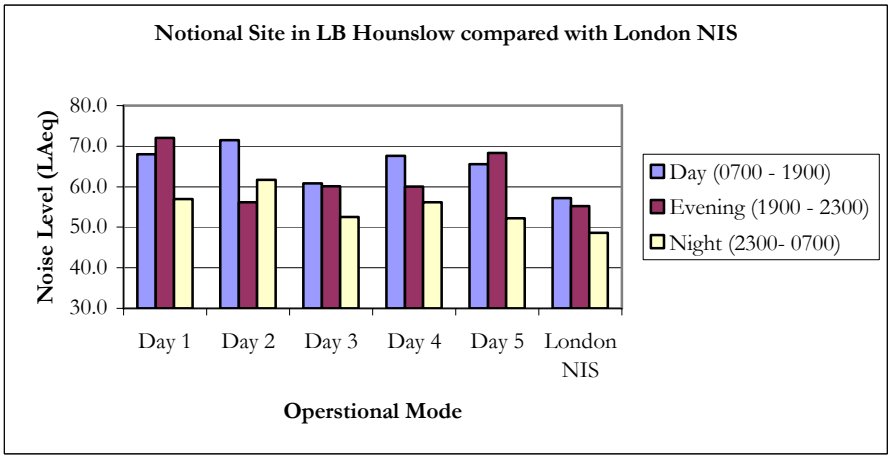
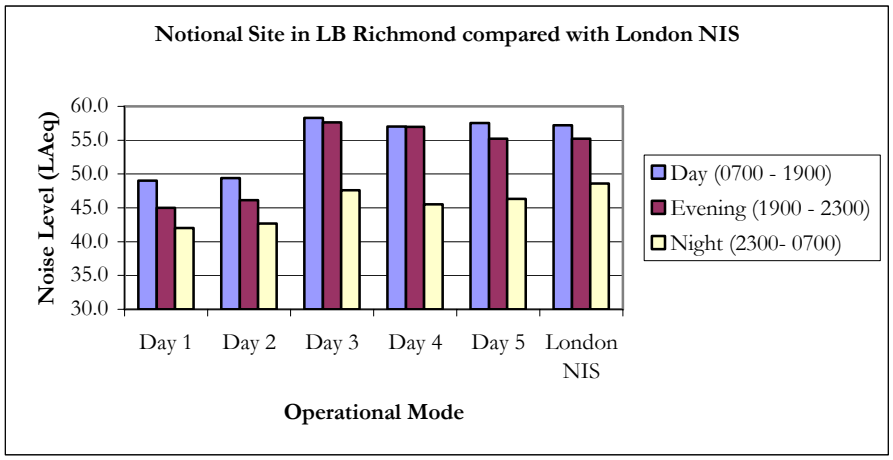


Figure 8



From the above it can be seen that:

- In the London Borough of Ealing, the notional site is less noisy than the average London NIS result when the airport is on westerlies. With the airport on easterlies, this site is much noisier than the average London result during the daytime and evening.
- For the notional site in LB Hillingdon, the results show that this location is noisier than the average London NIS result, at some times by more than 15 dB(A).
- The notional site in LB Hounslow is generally noisier than the average London NIS result, but on Day 2 in the evening when it receives the benefit of runway alternation, the results are similar.
- The notional site in LB Richmond is less noisy than the average London NIS result during the daytime and evening when the airport is on westerlies. When the airport is on easterlies, the results are similar.

5.3 The Noise Impact of the Airport

As a means of understanding the noise impact of the airport on these four London Boroughs and on the relative impact of the different operational modes, the percentage of the area and population exposed to 55 dB(A) or more was determined. The results are shown in Tables 7 – 10 below:

Table 7
London Borough of Ealing
Percentage of Area and Population exposed to 55 dB(A) or more

Percentage	% Area				% Population			
	L_{day}	L_{eve}	$L_{night\ -}$	L_{den}	L_{day}	L_{eve}	$L_{night\ -}$	L_{den}
Road Only	26.7	20.0	12.5	38.5	26.9	21.7	14.1	37.5
Day 1	26.9	20.2	20.2	39.3	27.0	21.9	21.9	38.5
Day 2	26.9	20.1	12.5	39.2	27.0	21.8	14.1	38.4
Day 3	51.6	43.8	13.3	63.4	50.8	45.5	14.5	63.0
Day 4	54.4	40.9	14.1	63.2	55.4	43.0	15.2	63.6
Day 5	53.4	47.6	13.1	63.8	53.8	49.2	14.4	64.4

Table 8
London Borough of Hillingdon
Percentage of Area and Population exposed to 55 dB(A) or more

Percentage	% Area				% Population			
	L_{day}	L_{eve}	$L_{night\ -}$	L_{den}	L_{day}	L_{eve}	$L_{night\ -}$	L_{den}
Road Only	27.6	24.7	15.9	46.9	22.2	19.9	12.1	41.4
Day 1	38.1	34.7	34.7	51.2	24.9	21.7	21.7	41.7
Day 2	38.1	34.1	20.9	51.2	24.7	22.6	12.1	41.7
Day 3	37.2	34.5	21.5	51.2	23.1	20.9	12.2	41.7
Day 4	38.3	34.4	23.4	51.3	25.3	20.9	13.0	41.9
Day 5	38.2	34.2	21.0	51.4	25.0	23.1	12.2	41.9

Table 9
London Borough of Hounslow
Percentage of Area and Population exposed to 55 dB(A) or more

Percentage	% Area				% Population			
	L_{day}	L_{eve}	$L_{night\ -}$	L_{den}	L_{day}	L_{eve}	$L_{night\ -}$	L_{den}
Road Only	32.9	28.6	20.4	51.5	30.5	27.5	18.5	49.1
Day 1	69.0	59.6	59.6	78.4	72.0	61.2	61.2	80.8
Day 2	71.5	50.2	35.3	78.1	74.9	56.0	38.3	80.5
Day 3	69.0	65.2	34.1	80.7	67.2	64.2	29.0	78.5
Day 4	70.5	66.0	29.5	81.2	70.6	64.4	29.1	79.8
Day 5	71.5	59.9	31.5	81.2	70.6	61.7	26.8	80.3

Table 10
London Borough of Richmond
Percentage of Area and Population exposed to 55 dB(A) or more

Percentage	% Area				% Population			
	L_{day}	L_{eve}	$L_{night\ -}$	L_{den}	L_{day}	L_{eve}	$L_{night\ -}$	L_{den}
Road Only	19.1	13.0	7.3	25.8	26.8	22.2	15.7	30.9
Day 1	39.4	26.2	26.2	44.8	51.3	35.7	35.7	56.5
Day 2	38.0	30.0	8.5	45.0	51.0	45.3	16.7	56.7
Day 3	45.8	37.6	8.3	56.0	56.9	51.6	17.6	63.1
Day 4	44.6	34.6	7.5	54.5	59.8	50.1	16.1	64.3
Day 5	44.4	33.3	7.7	55.1	58.6	49.0	16.4	65.3

From the above it can be seen:

- It can be seen that the airport affects LB Ealing when operating on easterlies (Days 3 – 5). On these days, both the area and population exposed to 55 dB(A), L_{Aeq} roughly doubles during the daytime. It can also be seen that were the northern runway used for easterly departures (Days 4 and 5) there is a slight spreading of the impact during the daytime compared with all the departures using the southern runway only (Day 3).
- Because only the southern part of the London Borough of Hillingdon is affected by aircraft noise, the change between road traffic only and the airport operations is not so marked.
- The impact of the airport on the noise environment of Hounslow can be clearly seen. The percentage of area and population exposed to 55 dB(A) or more during the daytime and evening is doubled for most operational modes.

- The London Borough of Richmond-upon-Thames is affected by both westerly and easterly operations at the airport as can be seen by the increase in area and population exposed to 55 dB(A) or more due to the various operating modes.

6 CONCLUSIONS

- This paper has described the results of using computer based modelling techniques to investigate the variation in daily noise impact in four London Boroughs affected by the aircraft noise arising from operations at London Heathrow. The work has made use of the London Road Traffic Noise Map and has included the development of a surrogate aircraft noise model to examine different modes of operation at London Heathrow.
- Population exposure for six different scenarios for each Borough has been calculated from the results. Examining a notional site in each Borough has shown how the variation of operation at London Heathrow affects the daily noise impact and how the loss of the Cranford agreement may affect the noise impact and exposure in the future.
- Analysis has also shown the extent of the impact of the airport operations on the noise environment of the four Boroughs, and also how the noise levels compare with the (outer) London element of the results of NNIS.
- It must be remembered that the nature of the methodology and input data used means that the results should not be used to evaluate the situation in detail for a single location. Instead, the output should be regarded as a strategic evaluation of the noise impact of the airport in differing operational modes across the four boroughs.

7 REFERENCES

1. http://www.defra.gov.uk/environment/noise/research/nis0001/index.htm
2. http://www.defra.gov.uk/environment/noise/mapping/index.htm
3. ProcIOA 2002 – Noise Mapping as a Visual Tool – SW Turner and R Gibson (2002).
4. ERCD Report 0401 – Noise Exposure Contours for Heathrow Airport 2003