DR Report 8402

United Kingdom Aircraft Noise Index Study: main report

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Directorate of Research
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SUMMARY

This report describes a programme of noise measurement and social survey at areas near major UK airports. The results are analysed with the aim of substantiating an Aircraft Noise Index — a measure of the disturbance arising from aircraft noise.

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PREFACE

This study was commissioned by the Department of Transport. We would like to thank the staff of the Civil Aviation Policy Division for their support and for helpful criticism during the preparation of this report.

The design and methodology of the study owes much to previous work with John Ollerhead of Loughborough University, Christopher Rice and colleagues at Southampton University and Jean Morton-Williams of Social and Community Planning Research (SCPR). SCPR carried out the social survey fieldwork for both the trials work and the main study, for which particular thanks are due to Carolyn Makinson and Patricia Prescott-Clarke respectively.

Within the Directorate of Research, many past and present researchers have contributed to the work leading to this report, in particular:

Ivor Davies, Head of the Noise Studies section, who did much of the early work on the design of the noise measurement programme and whose comments and criticisms on methodology have been much appreciated.

Brian Atkinson, who led the noise measurement fieldwork teams.

Past colleagues; Keith Nurse, Claire Atkins and Shirley Fenster, for their contributions to data analysis.

Grace Fray, for her work on statistical analysis and report preparation.

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We must also thank staff of the National Air Traffic Services and of the various Airport Authorities involved for the use of facilities and general assistance.

Peter Brooker
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GLOSSARY OF TERMS

Decibel (dB)	The decibel is a measure on a logarithmic scale of the magnitude of a particular quantity such as sound pressure (p) or sound intensity with respect to a standardized reference quantity. A sound pressure level, L, is expressed as $L = 10 \log \frac{(p^2)}{p^2_{ref}}$ dB p_{ref} is generally taken as 20 micropascals.
A-weighted Sound Pressure Level (L_A) *	This is commonly referred to by the term 'noise level' and is a weighted sound pressure level produced by electronic filtering (or 'weighting' of certain sound frequencies). The A-weighting was designed to approximate the response of the human ear to sound and it has been found to correlate better than the unweighted sound pressure level with the subjective assessment of auditory magnitude of many types of sound.
Perceived Noise Level (L_{PN}) *	This is a noise level obtained by computation from the sound pressure levels in octaves or third octaves. It employs a frequency weighting based on jury ratings of noisiness and is expressed in perceived noise decibels (PNdB).
Maximum Noise Level (L_{Amax})*	Defined, for the purpose of this study, as the maximum noise level recorded during an aircraft noise event.
The Single Event Noise Exposure Level (L_{AX})*	The level which, if maintained constant for a period of 1 second, would cause the same A-weighted energy to be received as is actually received from a given noise event.
The Equivalent Continuous Sound Level (Leq)	The level of a notionally steady sound which at a given position and over a defined period of time would have the same A-weighted acoustic energy as the fluctuating noise.
Aircraft Leq	The Leq corresponding to the acoustic energy associated with aircraft noise events in the defined period.
NNI	A composite measure of exposure to aircraft noise taking into account the average peak noise level and the number of aircraft in a specific period.
Movement	A landing or a take-off.

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* These terms are written in the text as LA, LPN,LAmax, LAX respectively)

Common Noise Area	An area within which the maximum noise level from any single aircraft overflight received at any point on the ground differs by not more than a small value (usually 3dB) from that received at any other point on the ground, assuming the noise level to be un-modified by the presence of buildings or ground effects.
Mode (of operation)	Mode refers to the direction of operation of an airport as a whole e.g. westerly or easterly. A particular location is exposed differently in each of the airport operating modes, e.g. to west-mode landings and east-mode take-offs. In the case of Heathrow there are two westerly take-off modes - take-off on 28L and 28R - which are usually mixed during the day.
Worst Mode (NB. Other authors may use a different definition)	At a particular location that mode of runway operation, i.e. take-off runway in use, which gives rise to the highest value of Aircraft Leq.
Modal Split	A statement of the proportions of operations occurring in each of the modes.
Average Mode	A descriptive term applied to noise metrics calculated having regard to the relevant Modal Split.
Logarithmic Average Noise Levels	L, the logarithmic average of individual peak noise levels, L_i ,is defined by $L = 10 \log \frac{1}{N} \sum_{i=1}^{N} 10^{L_i/10}$ dB This method attaches more weight to higher noise levels than does the more usual arithmetic averaging.
LT	Local Time - British Summer Time
Footprint	A noise contour which joins points on the ground which receive the same peak noise level from an aircraft during take-off or landing.
Runway Log	The official documented history of aircraft arrivals and departures at an airport.
Runway 28L/R *	Parallel Heathrow runways used for westerly take-offs and landings.

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* A runway is designated by the magnetic bearing of its direction of use e.g. runway 28 has a magnetic bearing of approximately 280°.

Runway 10L/R*	Parallel Heathrow runways used for easterly take-offs and landings.
Runway 23*	Heathrow runway used for take-offs and landings in a south-westerly direction (used infrequently)
Runway 08,26*	Gatwick (or Luton) runways used for take-offs and landings in easterly and westerly directions respectively.
Runways 06,24*	Manchester runways used for take-offs and landings in easterly and westerly directions respectively.
Runways 17,35*	Aberdeen runways used for take-offs and landings in southerly and northerly directions respectively.

Note: Foreign words used in the text do not incorporate accent markings.

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* A runway is designated by the magnetic bearing of its direction of use eg runway 28 has a magnetic bearing of approximately 280°.

1 SYNOPSIS

1.1 Airports satisfy the demands of travellers and provide jobs: they also cause environmental disturbance to people living nearby. The major form of disturbance is that from aircraft noise. Airport planning and development planning must take account of the aircraft noise exposure to residents; the airport authorities and interested government departments have to view aircraft operations in the context of the related airport noise. These assessments are usually carried out in the UK - and in most countries of the world - by means of a noise exposure index. This report describes the background and execution of a research study into a UK aircraft noise index. The synopsis gives a brief general view of the report - which, by its nature, is largely technical and statistical.

1.2 The noise index which has been used in the UK since 1963 is known as the Noise and Number Index - NNI. Contours of equal noise exposure, rather like geographical height contours, are plotted for the area around an airport. A contour of 55 NNI units indicates the extent of the area of high annoyance, and is generally very close to the airport. A contour of 35 NNI units is taken to indicate the threshold of community annoyance : its area and shape are determined by the routes which aircraft follow - in the case of Heathrow several hundred thousand people live within the 35 NNI contour.

1.3 The NNI was established by means of social surveys and noise measurements. The social surveys measured, among other things, the annoyance from aircraft noise expressed by a sample of individuals living at different places around Heathrow. Noise data were then matched to this reported disturbance, measured by scales constructed from the social survey data, so that physical noise variables could be combined in an empirical expression to estimate annoyance. This empirical form - the NNI - thus provides a way of estimating the total disturbance at the time of the surveys and a way of estimating the disturbance resulting from a change in the scale or pattern of airport operations, or from a new airport.

1.4 The NNI expression is

$$NNI = L + 15\log N - 80$$

Here L is the logarithmic average aircraft noise level heard (estimated in a unit called PNdB) and N is the number of aircraft heard during the day. The logarithm (base 10) means that an equal proportional change in the number of aircraft produces an equal step in NNI; the factor '15' indicates the relative importance - the 'trade-off' - between the effects of noise level and number. Because both these terms are included, the highest disturbance through high NNI - generally corresponds to large numbers of high noise level aircraft: high noise levels for a few aircraft (and vice-versa) produce 'moderate' rather than high NNI.

1.5 Forecast NNI contours have been used in the assessment of noise disturbance at all the major public inquiries into UK airport development in the last two decades. While Inspectors and Assessors have, on the whole, accepted NNI as a well-based planning tool, a number of criticisims have been made by inquiry participants.

1.6 These criticisms of the form and use of the NNI are discussed in the main text. The major criticisms are, very briefly:

- The NNI is 'out of date': people's reactions and the change to jet traffic invalidate its use.
- NNI is 'out-of-line' with other countries' noise indices.
- The NNI does not weight sufficiently the importance of the number of aircraft.
- In the NNI expression the noise level and number are not averages from all aircraft but only from those above a noise 'cut-off', including all aircraft in this count would lead to a better match with disturbance.
- By not including in the count those movements during the evening and night the NNI is under-estimating disturbance.

1.7 To answer these and other criticisms, the Department of Transport (Civil Aviation Policy Division) commissioned the Civil Aviation Authority Directorate of Research to carry out this programme of research. The main objective is either to substantiate the NNI or, if necessary, to devise some better index of aircraft noise. Trials fieldwork took place in 1980, the major fieldwork in 1982 : the project having the title 'Aircraft Noise Index Study' - ANIS for short.

1.8 In the 1960s studies all measurement and social survey were carried out at Heathrow, partly with the intention of 'painting the environmental picture' there. ANIS was not designed in this fashion: first, the emphasis on the form of the index required an efficient statistical structure in which the effects of noise level and number could be disentangled; second, the importance placed on public confidence in the application of the results nationally meant that airports in addition to Heathrow needed to be examined.

1.9 The statistical design which was decided upon relies on 'common noise exposure areas', in which the noise climate for residents is approximately the same. Such areas are of the order of 1 sq km - but vary considerably in shape with distance from the airport and flight paths. Extensive noise measurements are taken at a central site within the area, and about 80 randomly chosen residents are surveyed by interviewers using a questionnaire developed from those used in the 1960s.

1.10 Areas for social survey/noise measurement were chosen through a statistical design which attempts to ensure that noise level and aircraft number are not correlated throughout the sample. The number of areas used at the airports were:

Heathrow - 20
Gatwick - 2
Luton - 2
Manchester - 1
Aberdeen - 1

These include locations which were sampled twice (with different respondents) because of their contribution to the statistical design/noise measurement cost effectiveness. A total of 2097 people were interviewed.

1.11 Much of this report is a statistical analysis of the social survey and noise measurement results, which requires some statistical knowledge on the part of the reader. The conclusions (Section 9) are expressed generally and are briefly summarised here:

Summary of Conclusions

(a) The study has been successful in disentangling the effects of aircraft noise level and number.

(b) Disturbance has in the past been measured through a scale which combines annoyance and reaction to interference with activities such as conversation and TV viewing. The study confirms that this 'Guttman Annoyance Scale' is a good measure of such disturbance, and agrees well with other scales used in the questionnaire, e.g. the degree of acceptability of aircraft noise exposure and the proportion of 'very much annoyed' people in the community.

(c) The 'trade-off' factor of 15 in the NNI is not substantiated: it places too much weight on the number of aircraft. A value of 9 or 10 is better.

(d) Noise events below 80 PNdB, the noise level 'cut-off', should be included in the calculation for an index.

(e) Aircraft movements outside daytime hours should be included in an index, but not weighted to be more severe in their relative effect than the daytime movements.

(f) Disturbance and physical noise variables are best correlated when the latter refer to the recent past when it reinforces general experience. (If however recent experience had been atypical, longer term experience might well have been found to correlate better with responses.) There is no strong evidence that the modes of runway usage producing the greatest noise exposure are the prime determinant of reaction.

(g) A good fit to disturbance responses is given by '24 hour Leq' - the 'average noise' over the whole 24 hours. Leq is essentially the noise energy received. (The use of Leq is common in other countries, often with 'time of day' modifications, but note again that this study does not validate any weighting of the severity of aircraft movements at different times of the day.)

(h) A major 'confounding factor', i.e. a social or demographic variable which affects response, is the proportion of people who work at or who have business with the airport: this has a very marked effect on response, e.g. in some study areas their effect results in an estimated lowering of 25% in the percentage saying aircraft noise is 'not acceptable'. Previous studies have not detected such a strong effect.

(i) Data from the five airports do not reveal any marked 'airport-dependent' response, i.e. an Aircraft Noise Index would not require modifications for use at different airports.

(j) The use of the NNI values and NNI contours in past planning assessments is probably not likely to have led to major distortions in the environmental picture.

(k) Continued use of the NNI would tend to lead to more considerable problems : NNI could overestimate the extent of environmental improvements through the introduction of more, but less noisy, aircraft - which would not contribute to the NNI because of the 80PNdB cut-off.

(l) It is suggested that 55 Leq could be used to represent the onset of community disturbance and 70 Leq a point of high disturbance.

2 INTRODUCTION

2.1 This report presents the results of an extensive programme of work aimed to either substantiate the Noise and Number Index (NNI) or, if necessary, devise a new index of annoyance due to aircraft noise. The study was commissioned by the Civil Aviation Policy Division of the Department of Transport (DTp).*

2.2 The next section of this report describes the need for this work. One of the main factors is the changed situation - both in terms of people's attitudes and in the nature of aircraft noise exposure - since the original studies (made in 1961 and 1967) which were used to substantiate the NNI. Because of the length of time since these studies, doubts have arisen as to the validity of the NNI.

2.3 The study involved a programme of social surveys and noise measurements. The social survey fieldwork was carried out in the summer and early autumn of 1980 and 1982 by Social and Community Planning Research (SCPR). The noise measurement programme and the analysis of both noise and social survey results were carried out by the CAA's Directorate of Research (DR)**. In addition to measurements and surveys intended specifically for this study opportunities arose to incorporate work from projects carried out in both Aberdeen and Manchester.

2.4 In the remaining sections of this report descriptions of the various components of the study are given as follows:-

3. Background: a description of the NNI and criticisms of the NNI relevant to the need for a study.
4. The Study Design: the important distinction between measurement for the derivation of an index and for general noise assessment.
5. Execution of the Study: the noise measurement programme and the social survey.
6. Noise Results (main features)
7. Social Survey Results (main features)
8. Disturbance and Noise Exposure
9. Conclusions

2.5 The Glossary to the report gives definitions of the more commonly used technical terms concerning aircraft noise and airport operations used here. Some of these definitions may differ slightly from those found elsewhere in the technical literature.

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* Prior to June 1983 part of the Department of Trade (DoT).

** Prior to a January 1983 reorganisation known as the Directorate of Operational Research and Analysis (DORA).

3 BACKGROUND

3.1 This section summarises the history of the Noise and Number Index (NNI) and discusses those criticisms which are relevant to the need for a new study.

3.2 The NNI summarises the relationship between annoyance and physical variables, determined from a social survey of a sample of 1731 people in the vicinity of Heathrow Airport in 1961. (This study was carried out as part of the work for the 'Committee on the Problem of Noise', under Sir Alan Wilson: the NNI is sometimes known as the Wilson Index (Ref 1). Annoyance has a precise meaning here: it is the average reaction from a group of people experiencing a similar aircraft noise 'climate' - each individual's reaction being assessed from responses to a set of questions on the annoyance expressed in the context of interference with certain specific activities. From these responses an annoyance 'score' is calculated which ranges from zero to 6 in unit steps - this is known as the score on the 'Guttman Annoyance Scale' GAS (Ref 2, para 14 et seq: Figure 1 - from this reference - shows the computation of the GAS score).

3.3 Knowledge of annoyance through the GAS score permits the construction of an empirical formula which uses physical variables to estimate annoyance without recourse to a social survey in any specific application, i.e. an aircraft noise disturbance index. The NNI as determined* in 1961 is

$$NNI = L + 15\log N - 80$$

where L is the average peak noise level heard and N is the number of aircraft heard during the day (0700-1900LT). This particular combination of L and N is chosen so that

$$NNI = (constant) \times (GAS\ score).$$

The constant of proportionality is arbitrary; it was chosen to give an easy scale for NNI expressed in decibel units. It has become general usage for 55, 45 and 35 NNI respectively to denote 'high', 'moderate' and 'low' community annoyance.

3.4 Each year the Department of Transport issues the NNI contours for Heathrow, Gatwick and Stansted Airports (calculated by DR), together with a count of the population resident within each contour and the area each encloses, as a monitor of the changes from year to year in the noise environment. The NNI is similarly used to assess the effect of any development of existing airports. The boundaries of noise insulation grant schemes at several British airports are normally based wholly or largely on selected NNI contours.

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* The Wilson Committee's Report did not fully specify the NNI. A definition effectively arose from common usage after 1963. Note that all logarithms in this report are to base 10. See paragraph 1.4.

3.5 Following the introduction of the NNI, a second survey was carried out in 1967 (Ref 3). The objectives (paraphrased) included:

(a) To measure the change between 1961 and 1967 in levels of noise exposure and in social reactions to aircraft noise.

(b) To investigate whether the findings of the 1961 study remained valid in 1967.

(c) To increase knowledge of the ways in which exposure to aircraft noise affects annoyance.

The conclusions drawn from the results of the 1967 study were not straightforward. Statistical techniques, in particular 'multiple regression analysis' were used in the investigation of the relationships between annoyance and the numerous physical variables*. While these techniques are probably as powerful as any which might be used, they did not enable the effects of associated variables to be disentangled completely. The most important associated variables are the peak noise levels of aircraft and the number of aircraft heard - people who live near a major airport tend to hear both large numbers of aircraft and high noise levels. It is thus difficult to ascribe with any precision a changed response to variation in noise level or in number. (This is a problem with any social survey around a major airport.) The results of the second survey were taken as indicating that the NNI was a 'reasonable' index, but not necessarily the best which could be obtained. A number of alternative indices were put forward in the report but none had markedly better explanatory power than NNI with respect to the survey data.

3.6 No changes were made to the NNI as a result of the second survey report but it was apparent that the coefficient '15' in the expression for NNI, although providing some indication of the 'trade-off' between noise level and number, was not determined with precision. This threw a measure of doubt on the predictive capacity of the NNI for circumstances other than those at Heathrow in the early and mid 1960s.

3.7 In the early 1970s the Department of Trade sponsored a programme of research under Ollerhead at Loughborough University to investigate indices used in other countries and to evaluate the NNI further, in particular through small scale surveys at Heathrow and provincial airports. Ollerhead's results at the former were generally in line with those of the 1967 survey. The work on provincial airports (Liverpool and Manchester) provided some support for the use of the NNI at places other than at Heathrow (see Ref 2 for further details and references), but small sample sizes were involved.

3.8 Many criticisms have been made of the NNI - ranging from a general disbelief in the concept of a noise index to detailed points of statistical theory. Some criticisms relate to the NNI formula while others concern the use of the NNI as an index of noise annoyance. It is convenient here to reiterate and extend some

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* Multiple regression techniques are discussed in Chapter 8 and Appendix E.

of the points most relevant to the need for a new survey as distinct from criticisms of the NNI itself or noise indices in general (see Ref 4 for a more extensive discussion).

The NNI is out of date

3.9 One of the objectives of the 1967 survey was to determine what changes had occurred in the response to aircraft noise since 1961. As there has not been a similar official survey since 1967 the continued use of the NNI has been criticised on the basis that annoyance response and/or the nature of the aircraft noise environment have changed. People's reaction to aircraft noise, as measured by a scale such as GAS, could change because of general shifts in attitudes to disturbance or through changes in the frequency of the activities (e.g. watching television, conversation) used in constructing the score - Ref 2 presents a discussion of this point.

3.10 Of major concern are the changes in the aircraft noise environment. As an illustration consider the number of commercial movements at Heathrow and the proportion of jet aircraft*.

	1961	1967	1979
Movements	147,000	236,000	281,000
Jet Movements	38,000	146,000	253,000
Jet Movements as %	26%	62%	90%

It should also be noted that about 19% of total movements in 1979 were by wide-bodied jets which did not exist in 1961 or 1967. The differences in peak noise levels and of the durations of noise events between jets and non-jets are generally quite marked and they could result in altered reactions.

The NNI is 'out-of-line' with other indices used elsewhere

3.11 A large number of indices have been used in the assessment of aircraft noise by authorities in the developed world. Ref 2 gives an account of the more well known indices. If suitable approximations are made these indices can be reduced to similar forms**, ignoring scaling constants (see Ref 2 for definitions of LEPN and LPN which are similar to L).

UK	NNI	$L + 15\log N$
Netherlands	B	$L + 15\log N$
Germany, Austria	Q	$L + 13.3\log N$
Italy, Finland, Japan	WECPNL	$LEPN + 10\log N$
USA	CNR,NEF,CNEL, Ldn	$Lx + 10\log N$ (Lx: various noise level units)
Australia	AI	$LPN + 10\log N$
South Africa	NI	$L + 10\log N$
France	Psophic Index	$LPN + 10\log N$

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* These figures, used in the early stages of this study, were estimated from a variety of sources.

** Several of the countries in this list are reviewing their noise indices; this list should only be taken as illustrative of the recent position.

Of these indices the UK, French and Netherlands were based to some extent on social surveys, while the Q-index appears to have been derived from psycho-acoustic experiments. The others, as far as can be determined from the available literature, have resulted from modifications to the equivalent continuous index, Leq (which approximates to L + 10logN), to take account of information on complaints, laboratory work or 'expert opinion' on modifying factors, as well as some social survey data.

3.12 The Leq-based indices are seen to be the most common, but in western Europe, bar France, the indices in use weight the effect of the number of aircraft to a greater degree (through the constants 15 and 13.3, in constrast to the 10 used in Leq). One reason why different countries have arrived at different indices is probably that the disturbance which is meant to be represented by an index is assessed in different ways. The GAS score concept (Appendix D) is one of the more complex ways of assessing disturbance. Frequently annoyance has been assessed by asking question 12(a) in Fig D4 or by asking for a response on a scale of 1 to 6 (or similar) numerical rating.

The NNI does not weight the number of aircraft adequately

3.13 At several public inquiries the NNI has been criticised on the grounds that it was formulated at the time when movements, in particular jet movements, were rather fewer than at present. The argument is that although it is an empirical index (in contrast to a number of those itemised in para 3.11) the environment is so different now that the 15logN term represents a considerable extrapolation and should be replaced by a term with a stronger 'N'-dependence, ie. the 15logN factor should be altered to something increasing more rapidly as N increases.

3.14 It should be apparent that this criticism has something in common with both of the previous ones. However, it is clear that a move from the NNI to another index (or a revised NNI) needs evidence to justify such a change. If the change were to one of the Leq-based indices of para 3.11 then this would result in a lessening in the effect of the number of aircraft on the estimated disturbance revealed through the index. Without quantitative evidence, at a time of generally increasing aircraft numbers, this would no doubt appear to residents near airports to be, at best, rather unfortunate and more probably just a manipulation of the index.

3.15 However, if a research study had been executed which substantiated such a change, then any critical reaction would need to challenge the report on technical grounds such as social survey and noise measurement methodology and the statistical analysis leading to a new index.

The NNI needs modification because of 'X'

3.16 A number of criticisms of the NNI relate to its functional form: several factors - 'X' - have been said to be important in disturbance, but are not taken account of properly in the NNI. This subject is discussed at some length in Ref 4. The factors in question include:

: Background noise (also definition of aircraft noise 'heard')

: Airport dependent factors (ie resulting from people's reaction to an airport rather than measurable parameters)

: Effect of different modal split on disturbance

: Duration of aircraft noise

: Diurnal/Weekly/Seasonal patterns

Ideally, i.e with infinite resources, these questions could be answered by means of a social survey and associated noise measurement programme. But the sample sizes required (See Appendix E for some considerations) would be enormous and the statistical processing extremely expensive. Disturbance which is dependent on the nature of the airport itself raises considerabe questions: if it were known that (say) people at Gatwick at 45 NNI were in fact generally more annoyed than those at Heathrow at the same NNI value, would this justify different treatment? If the physical exposure in all regards is comparable would different treatment be equitable?

3.17 The case of background noise and the aircraft 'heard' cut-off of 80 PNdB used in the NNI* is more subtle. It is probably true that background noise affects reactions to aircraft noise, but the effect on the NNI may not be so marked because disturbance (through the GAS score) is assessed over the whole day; during the evening the background noise is generally lower at most locations and disturbance through aircraft noise will thus tend to be more noticeable. If a background noise term were to be included it would mean (presumably) that places with high background noise levels would be seen as less disturbed than those with low levels. Again this would be difficult to justify on equity grounds if only aircraft noise were to be controlled. An insuperable problem in general application would be the wide variation in background noise over a locality with about the same aircraft noise exposure.

3.18 To some extent the inclusion of a greater number of aircraft in the index through a reduced cut-off might help - but it would not solve the background noise question. It has to be accepted that any fresh survey will not solve all these problems: it would seem best to concentrate on uncovering the L-N trade-off.

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* Only those aircraft producing 80PNdB or more contribute to the noise level and number components of the NNI.

Movements in the evening and night periods should be accounted for in the index

3.19 Unlike many other indices the NNI does not take account of movements in the evening and night period; daytime movements serve to indicate the general level of aircraft traffic. However, some indices do weight evening movements to a greater extent than daytime movements. Arguments have been advanced as to why this is not in fact required (Refs 2,4), but a study would provide some quantitative evidence. Note that NNI has never been used in the UK to assess the impact of aircraft noise at night, the argument being that annoyance and sleep disturbance are distinct problems which should be treated separately.

3.20 The NNI has proved to be a useful tool in the general assessment of noise impact, particularly in airport planning studies. However, some of the criticisms of the NNI formula and the way in which it is used have led to a general weakening of public confidence. This underlines the need for the further investigation which is the subject of this report.

4 THE STUDY DESIGN

4.1 The previous section presented some of the reasons for a study. How should such a study be carried out - what should be the objectives and the methodology?

4.2 It was agreed at an early stage in the study that the DTp had three essential requirements of an Index of Disturbance by Aircraft Noise:

(a) The Index should enable decisions to be made on as equitable a basis as possible.

(b) It should be possible to substantiate the use of the Index by basing it on measured data.

(c) It should reflect the nature of disturbance around the DTp 'designated airports'* - Heathrow, Gatwick and Stansted.

The first two objectives would probably be common with those of administrators in other countries: the third is a peculiarity of the civil aviation arrangements in the UK. While the designated airports have been emphasized in this objective it is necessary that the study results should be generally applicable to airports with aircraft noise environments comparable to the London airports. The designated airports are not necessarily representative of the broadest variety of airports, in particular those airports with a relatively small number of movements at high noise levels. Therefore, for a generally applicable noise index it is necessary to include in the study one or more of these other airports.

4.3 It should be borne in mind that the extent of disturbance at Heathrow and Gatwick (and at a possibly developed Stansted) is of a different order from that at most of the UK airports (Manchester being the most comparable). This can be illustrated by the populations within NNI contours at these airports. Using the 1979 figures the numbers within NNI contours are:-

	Heathrow	Gatwick	Stansted	Total
55 NNI	73,000	1,000	0	74,000
45 NNI	311,000	3,000	0	314,000
35 NNI	1,610,000	31,000	2,000	1,642,000

(rounded to nearest 1000)

If the 1975/1976 DoT reports on Airport Strategy (Ref 5) are taken as a (rather dated) source for the population exposed at the rest of

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* 'Designated' refers to the DTp responsibility for certain matters, including aircraft noise, at these airports, which arises from Civil Aviation Legislation.

the public transport airports in the UK, then it can be shown that the percentage accounted for by the three London Airports is roughly:-

55 NNI	88%
45 NNI	80%
35 NNI	81%

4.4 Heathrow Airport can be seen to dominate aircraft noise exposure at every level and in particular for the highest NNI values - 55 and above. It is perhaps indicative of the severity of the noise problem at Heathrow that its air transport movements are less than one third of those for the UK as a whole. Because of the dominance of Heathrow in aircraft noise exposure the major part of any survey into aircraft noise in the UK needs to take place in its environs. The low density of population around Gatwick militates against the choice of areas there. Stansted, with present movements, offers little opportunity for reasonable statistical sampling. An examination of the airports in the UK indicates that at Luton an area can be found which does not have a counterpart at Heathrow. This area has a comparatively small number of movements but with high noise levels.

4.5 The general approach adopted here is to investigate annoyance caused by aircraft noise within a number of small communities, within each of which the exposure to external noise levels from aircraft overflights is approximately the same - these are known as 'common noise areas'. In practical terms a community has been defined as an area over which the external noise level from an aircraft does not differ by more than about 4dB at most, and more usually 3dB. The reported responses to a common external noise climate in any community are the average over a variety of conditions of attenuation, background noise and personal differences. This approach has been used in previous studies by DR (eg Refs 6, 7).

4.6 From the outset the study design centred on a matrix of noise level L and aircraft number N which covered a wide range of aircraft noise exposures. Table 4.1 presents an L - N matrix showing where survey areas could be located - only one of several possible areas has been given for filled cells of the matrix. The possible areas were determined in the main by examination of the output of the 1979 NNI computer contours. Thus an element of the study is the accuracy of the computer model used to predict exposure. (A useful by-product of the study was that it provided checks of the NNI computer model predictions.)

4.7 Determining such a matrix of areas is not enough; for example, the following additional questions need to be answered before a study can be designed:

: How many people should be sampled?

: Should all cells be sampled?

: Should some cells be sampled more than once? (Replicated sampling)

: What sort of questions should be asked in the social survey questionnaire - should they be the same as for previous surveys?

To respond to these questions it is necessary to focus on the purposes of the study. Probably the crucial aim of the work is to distinguish between the relative merits of NNI and Leq. The study needs to be of such a design and on such a scale as to provide a statistically satisfactory answer to this question. Too small a sample size would probably not provide these answers, too large would mean that money had been spent unnecessarily.

4.8 The results of the study might be crucial to development decisions for many years to come, so it is a major priority to substantiate an aircraft noise exposure index for use for probably the rest of the century. The study required careful design, particularly the noise measurement element, as one of the major problems with such surveys is too large a variation in noise climate over a common noise area.

4.9 Since the general aim of the survey was to uncover the relative merits of NNI and Leq it was necessary to retain the Guttman Annoyance Scale, otherwise comparisons with past studies could not be made. The problem then arises that the GAS responses may have shifted over the years. The need to know something of the variation in GAS scores before the survey sample size could be properly estimated suggested that trials needed to be carried out.

4.10 Another worthwhile reason for trials was to assess the accuracy of the NNI computer model. If it were inaccurate in certain regions of noise level and/or number this could mean that the planned cell coverage in Table 4.1 would be ineffective and hence impair the sampling design and the usefulness of the results.

4.11 The trials were carried out in the summer of 1980 and consisted of noise measurements and associated social surveys in five areas around Heathrow airport. The trials data are of nearly the same quality as the main fieldwork - the only deficiency is the omission of some questions (see Appendix A). Trials data are included with the main study data in description and analysis here. Note that about 80 people were interviewed in each area and that this cell sample size was repeated for the main fieldwork. These responses were helpful in answering a number of the questions (some raised earlier in the criticisms of the NNI) to be considered in the study design for ANIS, including:

: What is the likely statistical variation in annoyance responses for a common aircraft noise exposure?

: What is the likely statistical variation in external aircraft noise levels for respondents in a particular survey area?

: With what precision can average noise level (L) and number (N) be estimated from measurements?

: With what accuracy can L and N be predicted in possible survey areas?

(These statistical aspects are covered in Appendix E.)

: Should background noise levels be taken into account in the study? (No - this is the subject of complementary research using part of the ANIS data, Ref 8.)

: Which demographic factors need to be considered? (Areas were not matched for social or demographic factors, but social class, age, sex and marital status of respondents were recorded for statistical analysis.)

: Do worst mode effects need to be examined in addition to average mode effects? (Yes, and so does the time span for the most relevant 'stimulus' - whether people respond to the aircraft noise exposure in the last week or over the whole summer for example.)

: Should evening and/or night movements be measured? (Yes)

: Should cut-offs at different levels be used when analysing noise data? (70, 75 and 80 PNdB; no prescribed cut-off for Leq measurements.)

: Which scales should be used as measures of annoyance? (See Section 8.)

Area Matrix Design

4.12 Since the major aim of the study is to discover the best relationship between disturbance and components of noise exposure, the type of index I to consider would seem to be of the form

$$I \propto L + k\log N + C \qquad (C \text{ constant})$$

Here L is some average noise level and N the average number of aircraft.

4.13 This form of an index encompasses all those indices known to be in current use (para 3.11), the constant k being one of the values 10, 13.3 or 15. The aim of the survey is primarily to distinguish between the cases 10 (Leq-type) and 15 (NNI-type). The index would arise from an annoyance score (say A), which could be GAS, ANAS or some other attitude scale, so that

$$A \propto (L + k\log N + C)$$

the constant C in the case of NNI being chosen so that zero GAS score corresponds to approximately zero NNI.*

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* Technical note: The annoyance scores are not proper cardinal numbers in that they only rank disturbance on what is essentially an arbitrary scale. This causes problems for less noisy sites, e.g. less than 30 NNI, where many scores are zero, and the supposition of cardinality implicit in much of the statistical analysis becomes particularly tenuous: See Section 8.

4.14 Given some data on annoyance scores and on the corresponding L and N the value of k best suited to the data set can be estimated (the simplest method is by 'multiple regression analysis'). However, the crucial thing is the accuracy in the estimate of k as compared with the 'true' value of k, i.e. that which would give the best fit if the data were available on everyone who could be said to be exposed to aircraft noise. The precision of an estimate of k depends on the first three factors in para 4.11: if noise level and number could be estimated accurately for every individual and all individuals responded in the same way to aircraft noise, then the sample size necessary to determine k would be very small. It is the case, however, that the aircraft noise parameters are not perfectly estimated and there is also a considerable variation in response between individuals. Thus the estimate of k may differ from the best value by an amount depending on the number of people sampled. An analogy is a poll of political opinions: the larger the sample size the more likely an estimate is to correspond to the opinions of the whole population.

4.15 To determine the constant k a sufficient sample of the population is required: to reiterate, it need not be representative in a demographic sense of the population in the environs of an airport - rather it must cover the range of factors such as noise level and number of aircraft. An effective sampling plan is one which provides the most accurate and precise estimate of k for a given number of people sampled.

4.16 A sampling design may be effective in the above sense but it still may be more costly than necessary. One way in which costs can be reduced is that survey samples may in some cases be increased in size or replicated, e.g. two surveys of different sets of individuals could take place in the same area. This would then reduce the amount of noise measurement required because one set of noise data would serve to characterise a larger set of survey responses. This is particularly valuable for areas which 'test' the trade-off between L and logN, e.g. high L and small N and vice-versa.

4.17 A precise estimate of k in this context means one which possesses low variability as regards sampling fluctuations. To take a purely hypothetical example, suppose k was estimated to be 11.4 from the data set, and the variability was such that the true value of k could lie between 8 and 13 with high confidence. Such a result would indicate that Leq was a better fit to the results than NNI, as 10 would lie within the band of estimates for k and 15 would not. The concern here is perhaps more with establishing which of the values of k in use gives the best fit to the data, rather than in specifying some entirely new value of k - the latter would probably tend to add to the existing complexities as distinct from achieving some clarification.

4.18 The aim of the study can thus be stated in statistical terms as endeavouring to determine whether k = 10 or k = 15 provides the better description of the study data. This question is analysed in Appendix E in terms of the statistical modelling required and of various aspects of the accuracy and precision of noise measurement.

4.19 The end result of the analysis is shown in Table 4.1. It shows Heathrow locations which fall into particular cells of the L - N matrix. These areas have been annotated. The areas marked '(1980)' were studied in the trials work. The 'barred' cells - four of them - are eliminated from the design, essentially because they are near the average NNI and N values. The four areas marked with a double asterisk are sampled twice because they are nearer the extreme of NNI and N. In addition to the Heathrow areas a location at Luton was identified with high L and low N, i.e. a strong 'test' area.

4.20 The minimum survey programme to be carried out in addition to the five trial areas thus consisted of:

(a) Noise Measurement: 18 areas
(b) Social Survey: 18 sets of which 5 were replicated, making 23 in all.

During 1982, when the main study was carried out, opportunities arose to use measurements from other studies at Aberdeen and Manchester. These, together with the specifically designed study area at Luton (one area, two surveys) and extra areas at Gatwick (two areas, one survey each) were added. The addition of these areas was primarily in support of the application of the study results to other airports in addition to Heathrow.* At all (single) areas the target sample was 80 people - the preliminary statistical estimates indicated that this would be adequate to give a sufficiently precise figure for k.

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* These areas, with approximate L, N values, are listed in the footnote to Table 4.1.

5 EXECUTION OF THE STUDY

Noise Measurement Programme

5.1 The noise measurement programme is discussed in greater detail in Appendix B. At the time of the trials work, provisional locations were identified, having the required (L,N) combinations as described in the previous section. These were selected with the help of NNI contours for 1979 and the large amount of data available on actual noise measurements. Just prior to the main fieldwork the locations of some of the survey areas were changed as a result of more recent (1981) sets of NNI contours and further noise measurements. Once survey areas were finalised, measurements were made at a single site situated centrally within each of these common noise areas.

5.2 Measurement of aircraft noise was generally achieved by unattended automatic monitoring equipment being installed in the gardens of householders by prior arrangement. Attended monitoring was necessary in the four survey areas at Stanwell where L is relatively low and N relatively high, thus making it difficult to distinguish individual aircraft events when unattended equipment is used. At least 22 days of measurements were made at each site. Where necessary, recorded noise events were identified with help of Air Traffic Control runway logs.

5.3 In some survey areas extensive measurements of background noise were made by the Institute of Sound and Vibration Research as part of their complementary programme of research (Refs 8 and 9).

5.4 The five Heathrow trial sites had an NNI value of about 45, made up of different contributions from average noise level L and number N such that the greatest possible range, i.e. from 'high L-low N' to 'low L-high N', was achieved.*

5.5 Two measurement positions were chosen for each of cells 13/14 and 15/16 - originally planned as double sample areas - because of the difficulty in measuring high numbers of aircraft with a low average noise level. The resultant four areas were all in the Stanwell locality and are referred to in the Tables as Stanwell I to IV.

5.6 The target values of L and N displayed in Table 4.1 assume an 80PNdB cut-off (i.e. no noise level less than 80PNdB is included either in the averaging or totalling processes) and a modal split for operations at the airport of 70% westerly and 30% easterly. It should be borne in mind that the L - N matrix shown in Table 4.1 represents the target values, and, whilst every effort was made to achieve the target values, in practice some cells only fit into the matrix design by using cut-offs of 75PNdB and 70PNdB.

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* At one of these areas - Cranford - the noise exposure during the social survey was markedly atypical because of the use of the cross runway 23L. The results from this area have therefore not been used in analysis here, although survey responses are tabulated in Ref 13.

5.7 All the Heathrow measurement sites together with their survey areas are displayed in Figs 5.1A and 5.1B.

5.8 Five other measuring areas; two at Gatwick (Ifield and Horley) and one each at Luton, Manchester and Aberdeen were used. These enhance the Heathrow areas results, both by adding off-diagonal cells i.e. 'low L - high N' and 'high L - low N' and by surveying people's attitude to aircraft noise other than those residing around Heathrow.

5.9 The measurements made at Manchester and Aberdeen and used in this study were made primarily for other studies (Ref 10 for the latter airport). The measurement sites and survey areas for these additional five sites are shown in Figs 5.2 - 5.5.

The Questionnaire

5.10 The survey questionnaire was developed from the questionnaire used in the 1967 survey. The trials version differed only slightly from the main fieldwork questionnaire, Appendix A gives both. A major intention in this development was to reduce where possible the size of the questionnaire in order to cut the time taken to administer it to a respondent and hence save costs. Several questions were included in the 1967 survey only because they had been included in the pioneer survey of 1961. Those which do not contribute substantially to the understanding of disturbance through aircraft noise have been removed.

5.11 The questions in the survey can be divided into three basic types: the introductory questions which provide a general picture of attitudes to the area and lead the respondent gradually into the subject of aircraft (Q1-Q7 are of this type); the disturbance questions, which enquire explicitly about disturbance from aircraft noise; and the 'confounding' questions, which enquire about factors which might be expected to affect attitudes away from the 'true' response for a given exposure (such as the possession of double glazing, the socio-economic group, any business connections with the airport etc).

Comments on the questions:

Q1: This question was moved forward from Q7 in the 1967 survey, and the rest of the survey was administered only to those who had lived in their area at least three months - it is not the intention of the study to determine 'short-term' reactions.

Q5: This was a new question, asked before aircraft were mentioned by the interviewer. It was thought that expressions of acceptability might be better indicators of general attitude than annoyance or bother which might possibly be more related to recent noise events.

Q9: This question was introduced in the Sleep Disturbance study (Ref 6) and in the research work carried out by the MRC/DoT project on psychiatric affects of aircraft noise (Ref 11). It may give some indication of demographic shift as a result of aircraft noise, i.e. act as a 'reserve' explanatory factor.

Q11a: The phrase 'of aircraft' was substituted for 'of the aircraft' in the corresponding question in the 1967 survey (Q12a), to ensure that general experience of aircraft noise is elicited and not just attitudes to individual aircraft noise-events, emphasising that the respondent's general experience of aircraft noise is asked about and not their reaction to an individual aircraft.

Q11b: The frequency of annoyance is assessed as the number of occasions per time period, rather than in relative terms [see Q12b in 1967 survey].

Q12-Q14: This group of questions, corresponding to Q13-14a in the 1967 survey, has been considerably revised. The respondents were asked whether or not they were at home in the day, evening or night - the three periods of time into which noise measurements were divided. For those periods of time during which they were at home, they were asked if they were very much, moderately, a little or not at all annoyed. This assessment could then be compared to their general reaction to aircraft noise (Q11a). They are not asked about their reactions to noise elsewhere (for example at work) as noise measurements were only carried out in the survey areas around the respondents' homes. The emphasis placed on bother or annoyance at particular periods of time enables assessment of the relative impact of aircraft noise at different times.

Q15: [Q14b in 1967 survey]. The respondent is now only asked to assess his relative annoyance during the week and at the weekend and not to scale the two reactions separately.

Q16: This is a new question to assess to what extent double-glazing - which reduces noise levels indoors - modifies annoyance at a given noise level.

Q17: Three additional items have been added to this set of questions. Respondents were asked how bothered or annoyed they felt when i) their concentration was disturbed, ii) their rest and relaxation was disturbed, iii) they were made to shut their windows. These new items were included in the search for a new GAS scale (see Appendix D).

Q18: This new question was asked as a check on attitude. People may be annoyed by aircraft noise but nevertheless accept it to a certain degree because of their judgement of the economic or social benefits of aviation to the community.

Q20-Q22: This is a restricted set of questions on soundproofing, constructed from Q34-43 in the 1967 survey. The important aspect here is to determine whether the incidence of double-glazing moderated people's attitudes to noise at a given exposure.

Q23: A check question, designed to compare different types of scales for consistency.

Q24: The intention of this question was to detect whether worst mode or average mode matched better with reported disturbance.

5.12 The surveys were carried out using the questionnaire in August and Sepember 1980 (for the trials), and between July and September 1982 for the main study. Each respondent was given an introductory letter from the Department of Trade which introduced the survey as one which was examining people's attitudes towards the area in which they live; no specific mention was made of aircraft noise in this letter (see Appendix A). Further details of the social survey methodology is given in the report (Ref 12) by the contractors, Social and Community Planning Research (SCPR).

5.13 3140 addresses were selected for interview including those in the main study, the trials work and the Helicopter Disturbance Study area (at Aberdeen), 2178 successful interviews being carried out*, giving a response rate of 69.2% (see Table 5.1). If those addresses which were out of scope (i.e. premises vacant or derelict, used for business or industrial purposes only, untraceable) are excluded from the total number of addresses issued, the response rate is 71.6%. Of the original 3140 addresses, no contact with the person to be interviewed was established at 497 (15.8%), at 283 (9.0%) an interview was refused, and at 84 (2.7%) an interview was not possible because the potential respondent was ill, senile, incapacitated or unable to speak adequate English.

5.14 For the trials, interviewing took place over a period of at least 12 days in each survey area and in two cases (Ealing and Egham) it covered 27 days, 100 addresses being issued in each area. Such a long interview period means that some respondents might hear about the survey before they are interviewed. In the main study, therefore, the number of addresses issued in each area was increased to 120 and the interview period reduced to four days. Initially a three day period was used, covering Friday to Sunday, but this was extended to include Monday as response rates turned out to be lower than expected - the extra day boosted response rates noticeably. The response rate in the main study alone (67.3%) was lower than in the trials (74.8%) but the tactic of increasing the number of addresses issued while reducing the length of the survey period worked well. The response rate of 74.8% for the trials can be regarded as high for this type of social survey.

Survey Methodology

5.15 The sample design used was one in which several small geographical areas (say $1km^2$), known as 'common noise areas' were intensively sampled (cluster sampling); these areas were chosen to provide the greatest independent variation in loudness and number. Some areas, with a sufficiently high population, were sampled at twice the usual rate: these were 'statistically efficient' locations - such as those with high noise level and low number. This has the bonus of reducing costs of noise measurement.

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* Includes Cranford data.

5.16 SCPR were provided with the list of areas finally selected, with the boundaries of the common noise areas defined on large scale maps (1 in 10,000). Where an entire street lay within the area, the electoral register was used to provide a list of the addresses in the street. Where part of the street lay outside the area, larger scale Ordnance Survey maps were used to determine precisely which addresses lay within the area.

5.17 Given a sampling frame consisting of all addresses on the electoral register within the common noise area, a sampling method was designed to give equal probability of selection to all adults aged 18 or over living in the area. First every nth name in the electoral register was selected where n was chosen to give the same number of selected addresses in each single-sampled area, regardless of the number of addresses on the register. Thus the probability of a given address being selected was proportional to the number of registered electors living there. Then for each address thus selected, the interviewer randomly selected one resident aged 18 or over to be interviewed. This further selection process was designed to ensure (for all adults in any household with at least one member on the electoral register) an equal probability of being interviewed whether they were on the electoral register or not.

6 NOISE MEASUREMENTS

Method of measurement

6.1 The noise measurements for each of the twenty three survey areas shown in Figs 5.1 - 5.5 were made at a single measurement site, situated centrally within each common noise area. Most of the noise measurements were made using unattended equipment but some attended measurements were made at sites having minor modes of operation at low average noise energy. Attended measurements only were made at the sites Stanwell I-IV.

6.2 The noise measurement programme was designed to obtain an extensive sample of the values of LAmax and of the associated values of LAX of the aircraft noise events occurring at each selected site such that an estimate could be made of the noise exposure over various time periods.

6.3 This chapter explains how noise climates were estimated in terms of various noise metrics derived from the noise measurements. Technical details of the noise measurements shown in Appendix C are given in Appendix B.

Analysis of measured data

6.4 The noise exposure at any site is generally caused by one or more modes* of flight relative to a site. Since the noise levels and numbers in the various modes may differ substantially any attempt at estimation of the total noise climate of the site must initially consider all modes separately. The aim of the noise measurement programme was to produce, for each operating mode of the airport relevant to a site, various noise metrics relating to 'average' day (0700 - 1900LT), 'average' evening (1900 - 2300LT) and 'average' night (2300 - 0700LT). From these basic data estimates of noise metrics relating to 'average mode of operation' and 'worst mode of operation' could then be made.

6.5 To produce noise metrics for each operating mode for day, evening and night meant that days of different mode operation had to be 'stitched' together to form complete days of one mode. This was also true, albeit to a lesser extent, for the evening and night periods. The principal reason for this 'stitching'is the runway alternation scheme exercised during westerly operations at Heathrow. On every other week in the summer the day and evening operations will generally be as follows:-

0700 - 1500LT	take-off	28L
	landing	28R
1500 - 2400LT	take-off	28R
	landing	28L

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* Mode of operation generally refers to the direction of operation of the airport as a whole, i.e. either 'westerly' or 'easterly'. In the basic analysis of the data, mode of operation by runway was considered. For example at Woodham, there were four operating modes of noise exposure. These were:

West mode	take-off 28R
West mode	take-off 28L
East mode	take-off 10R
East mode	landing 10L

On the alternate weeks the operation will be:

0700 - 1500LT	take-off	28R
	landing	28L
1500 - 2400LT	take-off	28L
	landing	28R

This means that on any one day during westerly operations there will be, in many areas around Heathrow, two distinct modes of noise exposure. Moreover these two modes of exposure will occur on any day with westerly operation whether on the landing or take-off 'side' of the airport. Easterly operation normally assumes a fixed pattern (runway 10R is almost invariably used for take-off and 10L for landing) and thus produces only one mode of noise exposure. In order to keep these different modes of noise exposure separate measurements for all days during westerly operation have been separated into the two operational modes and recombined to form days of single, constant mode.

6.6 There is another, subsidiary, reason why the days are composites. There were some occasions on which a complete day's (i.e. 24 hrs) measurement was not obtained: this arose for several reasons. On some occasions the runway alternation scheme was modified or the operation of the airport changed from westerly to easterly. Invariably there was a period during each day when the instruments were switched off for servicing. This resulted in many days having small gaps in measurement during the 24 hour period. Since the original analysis had been devoted to examining the exposure on an hourly basis it was possible to fill whatever gaps existed with data from another day to achieve the desired number of full days at each site. Although the evening and night periods are not subject to a change of mode from runway alternation some gaps existed here and they were filled in a similar manner. The target was to measure, or be in a position to construct, a minimum of seven days (24 hours) for each operating mode relevant to a particular site. (Note: Attended measurements were analysed in a different manner, see section 6.7). Data for these 24 hour days were then averaged to produce values of various noise metrics for day, evening and night periods. From this data 'average mode' values of noise metrics were computed by examining the modal split of operations of the airport over the desired time periods. The periods presented in this report include the three summer months (mid June - mid September), the thirty days prior to the survey date and the week prior to the survey date for each particular site.

6.7 For sites where attended measurements were made the data were analysed in the following manner: distributions of LAmax, LAX and the numbers of aircraft 'heard' above 80PNdB, 75PNdB, 70PNdB, or not at all* were constructed for each <u>aircraft type</u> relating to a specific mode of operation of the airport. From these aircraft type distributions values of L for the three cut-off values were calculated. Also calculated were the percentages of aircraft types 'heard' above the

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* During attended measurement periods all relevant aircraft movements were noted even if the peak noise level was less than 70PNdB. These movements were classified under 'not at all' in the analysis.

three cut-off values. Values of LAX and the corresponding percentage of aircraft type registering on LAX value were also computed. As an example at Stanwell I 100 Tridents may have departed during a particular measurement session; 90 were measured as being above 70PNdB, 80 above 75PNdB, 70 above 80PNdB, and 90 had an associated value of LAX. The 90 above 70 PNdB have an average noise level of L70 and the number heard is 90% of the total; above 75PNdB the average noise level is L75 and the number heard is 80% of the total; above 80PNdB the average noise level is L80 and the number heard is 70% of the total. There is no implicit cut-off in the measurement of LAX but only those events for which it is possible to compute the duration (the interval between the '10dB down' points) are included, so the average value is LAX and the number heard 90%. In this study LAX values for events having LAmax of less than 67dBA were not computed. In practice, the contribution to the average Leq values of such events is less than 0.5dBA, and typically 0.1dBA. A separate analysis was made, from the ATC log books, of the numbers and types of aircraft operating during an 'average' day, evening and night. Using percentages 'heard' and the corresponding values of LAmax and LAX for each aircraft type the two analyses were combined to produce average noise metrics for day, evening and night for each operating mode of the airport. From these data average mode values of noise metrics were computed in the same manner as for the unattended measurements.

6.8 Although extensive attended measurements were made during the day, no attended measurements were taken during the evening and night periods. It was assumed that the values of LAmax, LAX and percentages 'heard' measured during the day for each aircraft type were applicable to the same aircraft types operating during the evening and night periods. Bearing in mind that the areas relying solely on attended measurements (areas Stanwell I - IV) were situated to the 'side' of the airport, and thus were exposed mainly to 'sideline' noise, this assumption was thought to be reasonable.

6.9 The various noise metric data used for computer statistical analysis (Section 8) is given in Appendix C, which includes definitions of the noise metrics. Data on noise levels and numbers of aircraft in the evening and night periods are given in Tables 6.1-6.4: these data are not used in the analysis of Section 8. Modal splits of operation for the airports studied are presented in Tables 6.5-6.18.

7 SOCIAL SURVEY RESULTS

7.1 In the subsequent discussion of the results of the survey the responses are treated as if the questionnaire used in the main study had been used in all areas. In fact there were several points of difference from the questionnaires used in the trials work (noted here as NIT for 'Noise Index Trials') and for Aberdeen, through questions being asked in a different order or omitted. Early in the analysis work, all the responses were recoded to fit into the format of the main study, with gaps in response due to missed questions flagged separately from responses missed by interviewees. However, for clarity the following paragraphs give a list of differences for each question in the main study, together with the corresponding question numbers in the other questionnaires, where these are different.

Q1 This question was the same at every area, but at the trial areas the response 'all my life' had been coded with '30 years or more'. Hence this category was swelled by a number of younger people who had not yet moved away from the area.

Q2a,b At the trial areas, no more than three answers could be given to these questions. At other areas, a theoretically unlimited number of answers could be given, but in practice few people gave more than two.
[NIT: Q2b,Q3]

Q3,4a No difference
[NIT: Q4,5a]

Q4b As for Q2 above
[NIT: Q5b]

Q5 This question was asked immediately after the length of residence question (Q1) at the trials areas.
[NIT: Q2a]

Q6 No difference.

Q7 This question was not asked at the trial areas.

Q8,9 No difference.
[NIT: Q7,8]

Q10a,b At Aberdeen, as well as being prompted about aircraft and road traffic noise, the respondents were asked if they ever heard helicopter noise.
[NIT: Q9a,b]

Q10c At Aberdeen, helicopters, as well as fixed wing aircraft and road traffic, were separately coded. In subsequent recoding for the present study respondents who reported either helicopters or fixed wing aircraft to be the most bothersome noise were grouped together.

Q11a,b	Fixed wing aircraft and helicopters were combined for this question at Aberdeen, so there was no effective difference from the main study. At the trial areas, the categories '3 or 4 times a day' and 'once or twice a day' were combined into 'a few times a day'. In recoding all respondents in this category have been arbitrarily assigned to 'once or twice a day'. [NIT: Q10a,b]
Q12-18	These were only asked of those who heard aircraft noise. At Aberdeen, this included those who heard helicopters but not fixed wing aircraft. (There was also an additional question here in the Helicopter Study that is not used in the main study.)
Q12-16	No difference. [NIT: Q11-15, ABERDEEN: Q13-17]
Q17	At the trial areas, items i,ii,iii were not asked. In particular, since Q17i on concentration did not appear, several respondents mentioned this in reply to the 'catch all' questions (NIT: Q16 vii,viii). [NIT: Q16, ABERDEEN:Q18]
Q18	At the trial areas this was asked of all respondents, irrespective of whether they had reported hearing aircraft noise. [NIT: Q17, ABERDEEN:Q19]
Q19	At Aberdeen, this was asked following several questions referring only to helicopters and referring to heliports as well as airports (which were asked only of those respondents who reported hearing helicopters). [NIT: Q18, ABERDEEN:Q27]
Q20-22	These questions on sound proofing were not asked at Aberdeen. [NIT: Q19-21]
Q23,24	These were not asked at Aberdeen. [NIT: Q22,23]
Q25a,b	No difference. [NIT: Q24a,b, ABERDEEN: Q28a,b]
Q26	No difference. [NIT: Q25, ABERDEEN: Q29]
Q27a,b	At Aberdeen these were asked after the questions on marital status and age of the respondent. [NIT: Q26a,b, ABERDEEN: Q31a,b]
Q28a,b	No difference (but note change in order as above). [NIT: Q27a,b, ABERDEEN: Q30a,b]
	At the trial areas there was an additional question about bus routes at the end of the interview.

7.2 Because of the very large quantities of data involved in this study, the description of the results and the subsequent analysis in this main report are based on a compact data base using the tabulations of the social survey results (Ref 13). Responses from each of the twenty-six survey areas have been aggregated, and statistics of the form 'percentage responding by -' or 'sample mean' have been calculated: see the text Table of variable names that follows.

Variable(s) derived from response to questions

Question Number	Variable Name	Variable Title*	Data Base No.	Paragraph No.
1	LRES	Av length of residence	27	7.35
2a				(7.4)
2b				(7.4)
3	ARCLIV3	% A-C Item least liked	15	7.22
4				(7.4)
5	AXGOOD	% Rated Area less than Good	21	7.28
6	ANOISY	% Rated Area at least Noisy	20	7.27
7	NSEAL2	% At least a Little Annoyed: GNL	3	7.11
8	NSENA	% Gnl Noise Levels Unacc.	1	7.09 7.10
9				7.31
10ab				7.22
10c	ARCBOTH	% A-C Most Bothersome Noise	16	7.22
11a	AVANAS	Av ANAS Scores	8	7.18
	VMANN	% Very Much Annoyed: A-C	5	7.13
	ARCAL2	% At Least a Little Annoyed: A-C	4	7.12
11b				(7.4)
12	NEWEVE	Net % More Bothered Evenings	17	7.23-7.25
	NEWNGT	Net % More Bothered Nights	18	7.23-7.25
13	NEWEVE	Net % More Bothered Evenings	17	7.23-7.25
14	NEWNGT	Net % More Bothered Nights	18	7.23-7.25
15	WKEBOTH	Net % More Bothered Weekends	19	7.26
16				(7.4)
17	AVOGAS	Av GAS Scores on 1967 Scale	6	7.13-7.19
	AVNGAS	Av GAS Scores on New Scale	7	7.19
	OGASPOS	1967 GAS Scores Gt than 0	12	7.19
	OGASHI	1967 GAS Scores 3-6	11	7.19
	NGASPOS	New GAS Scores Gt than 0	10	7.19
	NGASHI	New GAS Scores 3-6	9	7.19
18	ARCNA	% Aircraft Noise Unacc.	2	7.10
19	WORKAP	% Work Connected with A-Port	25	7.33
20	DGL	% With Double-Glazed Homes	22	7.29-7.31
21				7.29-7.31
22				(7.4)
23	SCALE7	Av Satisfaction on 7 pt Scale	13	7.20
24	WORSTM	% Scaling in Worst Mode	14	7.20
25a				(7.4)
25b	SHIFT1	% in Work and on Shift	24	7.33

* Abbreviations explained in Appendix C

Variable(s) derived from response to question

Question Number	Variable Name	Variable Title	Data Base No.	Paragraph No.
Cont'd				
26				(7.4)
27a				(7.4)
27b	NONMAN	% Non Manual	23	7.32
28a	FEMALE	% of Females	28	7.36
28b				(7.4)
28c	AVAGE	Av Age of Respondents	26	7.34

7.3 Note that results for Cranford are not included in this report because exceptionally heavy use of runway 23L during the summer of 1980 made it difficult to estimate exposure accurately and makes it possible that the response is distorted: see Appendix B. The survey results, however, are given in Reference 13.

7.4 The responses to certain questions are not included in this aggregated database, either because they were included in the questionnaire largely as introductory questions to channel the respondents thoughts into 'environmental' matters, or because the information elicited is in similar form elsewhere. (Slightly variant forms of some questions were used partly as checks, and partly to enable the detection of possibly subtle effects.) The excluded questions are:

Q2a,b: These two are introductory, probing the respondent's feelings towards the area he or she lives in. Negative reaction to aircraft noise is similarily picked out in Q3.

Q4: The responses to this question are overwhelmingly concerned with location of the home with respect to work, leisure facilities, public transport etc.

Q9: This question was included in a study investigating the psychiatric effects of exposure to aircraft noise (Ref 11). The respondent's answer is, necessarily, a subjective rating against others, a factor which might contribute to the response. In fact the distribution of responses did not vary markedly from area to area, or with the annoyance expressed, so since more 'physical' variables are available from the survey results, this was not included in the data base.

Q10,11: The responses to questions about road traffic and other noise were not included in the data base. These questions were asked primarily to show aircraft noise in the context of other noises heard by the respondent.

Data on noises other than from aircraft are available for those areas included in the ISVR study on background noise (Refs 8 & 9). Responses to these questions are analysed there. Only the reported 'most bothersome noise' is used in the aggregated data base.

Q11b: The frequency of reported disturbance is correlated with the degree of disturbance expressed through ANAS. (See Table 7.1.)

Q16: This question was included to test whether the attenuating effect of double glazing moderated people's attitudes to the noise. The response is measured more physically in Q20. (But see Ref 1.)

Q21,22: The extent of a possible moderating effect of double-glazing is taken to be adequately measured by Q20.

Q25,26: The extent of a possible moderating effect of socio-economic group is chosen to be measured by Q27b. This avoids the problem of a large, undifferentiated 'housewife' group.

Q28b: Preliminary examination of the data showed no marked effect of marital status as a factor in reaction to aircraft noise. (See Table 7.2.)

Note that all the response variables used in this report are chosen so that larger numerical values correspond to greater disturbance.

7.5 In considering the results of this study, it is important to realize that, whereas in the previous UK studies in 1961 and 1967 (Refs 3, 14) the aim was to produce a complete picture of aircraft noise disturbance around Heathrow. In this case the survey areas have been chosen solely on a statistical basis, to test more efficently the validity of the Noise and Number Index (NNI) and other candidate noise indices.To do this the noise level (L) and number (N) must be varied independently through the choice of survey areas. That is to say, a selection of areas giving a good mixture of noise level and number areas is required, with, very roughly, a preference for areas with high noise and low number, and low noise and high number. The statistical background of this approach is discussed in Appendix E. The data gathered are therefore generally representative of the whole range of noise exposure for airport-related disturbance in the UK. Thus, aircraft noise index contours, based on these data, provide a valid picture of the pattern of disturbance around each airport.

7.6 The explanation of the calculation of the statistics in the data base, based on the responses to the social surveys is given in full in Appendix C. A brief description of these data base statistics, rather than the details of individual responses to the questions in each area, is given in this section. This data base of aggregated statistics was in part designed as a compact way of presenting the very large amount of data gathered in the survey. Section 8 uses the data base in assessing community response. Note that whereas

Stanwell I, II, III and IV are distinct areas experiencing different noise exposures, Feltham A&B, Harlesden A&B and Luton A&B are single areas split into two by fractional sampling after the surveys were carried out. For statistical purposes they are treated as separate areas with identical noise exposure. (It had been hoped that the Stanwell areas could be 'replicated' in a similar fashion, but the noise exposure throughout the areas showed too much variation.)

7.7 In the Figures referred to in this section the variables are shown plotted against three month, twenty-four hour Leq (M3LQ24)*. This variable is used in this section purely as a descriptive tool: it is not intended to imply that this is in any sense a 'best' noise measurement or index of annoyance. The analysis of noise measurement data in the assessment of annoyance follows in section 8. It is worth noting, however, that Leq-type noise measures underpin many of the community annoyance indices in use round the world. (See Ref 2.)

7.8 The data base - Table C2 - is ordered so that overt measures of community reaction to noise precede covert measures (that is, response to questions where reaction to aircraft noise has not been explicitly asked for) which in turn precede the confounding factors (those factors which, while not measuring reaction to noise, may nevertheless influence that reaction). The exceptions to this are NSENA and NSEAL2. These are covert measures (derived from questions about general noise environment) that have direct parallels with overt measures (ARCNA and ARCAL2 respectively) and are listed with these variables.

Summary Survey Results

% THINK GNL NOISE UNACC (1)** [Figure 7.1]

7.9 The percentage of respondents finding levels of general noise unacceptable range from 4.0% at Aberdeen to 53.7% at Hounslow. A large number of people qualified their response in some way, particularly at Colnbrook where 14.5% of responses were qualified. Interestingly none of the four trial areas returned any qualified responses. This may be due to differences in the detailed instructions given to interviewers for the trials work and for the main study. Qualified responses are counted in the data base as finding noise exposure unacceptable (see Appendix C). Examination of these responses (listed by SCPR) reveal that many people have aircraft in mind already, although they had not been mentioned by the interviewer at this point.

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* For explanation of data base names see Appendix C.

** These titles and numbers are those used in the main data base which is listed immediately prior to the Appendices. The abbreviations are explained in the glossary in Appendix C.

% THINK A-C NOISE UNACC (2) [Figure 7.2]

7.10 The percentage of respondents who felt aircraft noise exposure was unacceptable was markedly higher than the 'general' response. At Feltham A&B, Hounslow, Isleworth and Colnbrook around 60% found noise levels unacceptable. At a further seven areas more than 40% expressed dissatisfaction. At the other extreme, at Woodham only 5.3% found noise from aircraft to be unacceptable, and at Aberdeen 7.9%. Qualified answers are again treated as equivalent to a reply of 'unacceptable'. Once more, Colnbrook returned a particularly high percentage of qualified answers - this time 18.1%. A number of people in some areas had reported not hearing aircraft noise at all so they were never asked this question: it being assumed - for consistency - when this statistic was calculated that they found the noise exposure acceptable.

% AT LEAST A LITTLE ANNOYED: GNL (3) [Figure 7.3]

7.11 Respondents were asked to say if they were 'very much annoyed', 'moderately annoyed', 'a little annoyed' or 'not at all annoyed' with the levels of general noise around them. The percentage of respondents reporting that they were 'a little annoyed' or worse varied from 32.7% at Aberdeen to 92.1% at Feltham A. Note that this question was not asked in the trials work. See below for a discussion of this question in comparison with the equivalent question specifically on aircraft.

% AT LEAST A LITTLE ANNOYED: A-C (4) [Figure 7.4]

7.12 As well as the question referring to general noise in the environment discussed above, the respondents were asked the same form of question but referring specifically to aircraft (the aircraft noise annoyance question leading to the ANAS scale). The levels of annoyance expressed are generally very similar, in contrast to the other matched pair of questions on acceptability of general and aircraft noise, where there was a sharp rise in dissatisfaction expressed when the focus was on aircraft. The highest proportion of people expressing a little annoyance or worse was 97.7%, again at Feltham A, and the lowest 42.3% at Stanwell II. The largest increase in the proportion expressing annoyance with aircraft over that expressed with general noise was 23.9% at Aberdeen, where 32.7% were annoyed with general noise, 56.6% by aircraft noise. In contrast, at Stanwell II there was a drop in annoyance expressed from 66.0% with general noise to 42.3% with aircraft noise. It should be pointed out that at Aberdeen the survey was conducted on a new housing estate some way from the centre of the city, overflown by aircraft but in 'semi-rural' conditions with respect to road traffic and industry. Hence other noise is exceptionally low, particularly in comparison with what might be expected of the past experience of many residents, and aircraft noise tends to predominate to a large degree - see Figure 7.7 for comparison. If Figures 7.3 and 7.4 are considered together, it appears that the difference between the two responses is determined by the exposure to aircraft noise relative to other noise, but without detailed measurements of non-aircraft noise it is impossible to confirm this. In particular it appears that, whereas for Leq values around 60-65dBA aircraft are thought of as a more serious source of annoyance when seen isolated from other noise problems, for Leq greater than 65dBA aircraft noise dominates other noise problems to such an extent that there is little difference in response between the two questions.

% VERY MUCH ANNOYED: A-C (5) [Figure 7.5]

7.13 This variable corresponds to the common annoyance measure in use in the USA, known there as the percentage 'highly annoyed'. (This is in fact an amalgam of their percentage 'very much annoyed' with the additional sub-category 'extremely annoyed'.) At areas with Leq below 60dBA, less than 20% are 'very much annoyed'. For Leq in the range 60 - 65dBA, the percentage varies from less than 5% at Stanwell I and II to more than 50% at Feltham A&B. It is interesting that after the very high response at Feltham, the percentage 'very much annoyed' drops to around 40% at Hounslow and Isleworth, then markedly again to 29% at Colnbrook, the area of highest Leq. Various factors may be at work here, including the very high incidence of double glazing following the introduction of the Government Grant Scheme, and the large number of people whose work is connected with the airport. (The next section examines those aspects statistically.) There may also be a certain degree of 'demographic shift'; thus in areas exposed to such high noise exposure residents who have not yet moved away may be there either because they can tolerate the noise, or because for one reason or another they cannot move.

GAS RESPONSES (6,7, 9-12) [Table 7.3]

7.14 The variation in response to Question 17, the GAS question, can be exemplified by reference to extreme areas. If the area with lowest Leq (Woodham) is considered along with the areas with lowest average community OGAS* score (Stanwell II), highest average community OGAS score (Isleworth) and highest Leq (Colnbrook), it can be seen that the priority given to the various factors in the annoyance score varies very little. In general, the largest contributions to annoyance are from disturbance to television viewing and disturbance to conversation. The next largest contributions are from vibration of the house, and being forced to shut their windows. Disturbance of rest and of concentration rank next, followed by being woken or being startled by aircraft. (In areas of high exposure, there appears to be a large drop in the percentage bothered between those woken by aircraft and those startled by aircraft.) Annoyance with television disturbance is the most erratic factor - giving the 3rd highest proportion in Stanwell II, but 7th in Colnbrook. Woodham fits this pattern least well - house vibration being said to cause the greatest annoyance, being forced to shut windows the least - but apart from these two factors the pattern is still much as in other areas.

7.15 Annoyance with interference to television viewing is 88.7% in Isleworth, 24.5% in Woodham; interference with conversation produces 79.5% annoyance in Colnbrook, 23.4% in Woodham. At Isleworth, all factors (except the 'catch all' 17xi) produce 25% or more at least a little annoyed, whereas at Stanwell II only interference to television viewing produces more than 25%. Compare

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* See Appendix D for definitions and discussion on Guttman Annoyance Scales, referred to here as OGAS - the scale used for the NNI - and

this with the response to the general question (ANAS) where the lowest percentage was 42.3% at Stanwell II. At Woodham, the highest response to a particular question was 29.8% - the response to the ANAS question was 59.6%. At Isleworth the highest response to a particular question was 88.7% at least a little annoyed, whereas for ANAS 95.8% were at least a little annoyed. At Colnbrook there is a maximum response to an individual item of 81.9%, whereas for the ANAS question 85.5% were at least a little annoyed.

Annoyance Scales

7.16 The questionnaire results permit the construction of a large number of disturbance scales. In the next section a theoretical and statistical examination is carried out with particular reference to the construction of an aircraft noise index. In the following paragraphs a preliminary, partly graphical, comparison of data base scales is made. In the data base there are two annoyance scales in which the respondent directly assesses his or her own annoyance - the ANAS scale and the 7 point scale of satisfaction SCALE7, and two versions of the GAS scale (the original scale - OGAS, and a new scale incorporating different elements - NGAS), where the annoyance score is derived indirectly from a composite of several responses. From these four basic scales, several measures of community annoyance can be derived. An average of the respondents' scores within one common noise area can be taken; percentile measures such as the percentage recording any annoyance at all can be used, as can the percentage recording high annoyance. The average of the OGAS scores is of particular importance as it enables direct comparisons to be made with previous work.

7.17 Since OGAS and NGAS are in the range 0 to 6, SCALE7 in the range 1 to 7 and ANAS in the range 0 to 3, it is useful to have some idea, for the data here, what a score in one scale corresponds to in another. Note that these procedures are inherently approximate owing to the nature of annoyance scales - see the next section. It may be done roughly by averaging, for example, the OGAS scores for all the population with a given ANAS score: see Table 7.4 for the results. The results are compatible with the commmunity average OGAS scores for areas with an average ANAS score near 1 or 2. (No community has an average ANAS score of 0 or 3.)

7.18 Average ANAS scores range from 0.64 of Stanwell II to 2.35 at Feltham A. Seven sites had average community ANAS scores under 1.0 and five above 2.0.

7.19 Average OGAS scores range from 1.2 at Stanwell II to 4.0 at Isleworth. The percentage of people with positive (non-zero) OGAS score range form 45.7% at Stanwell II to 98.7% at Ealing. The percentage with OGAS scores between 3 and 6 ranged from 18.2% Stanwell I to 88.2% at Feltham B. The new GAS scale NGAS produced scores that were consistently lower than on the original scale. The average score ranges from 0.7 at Ifield to 3.2 at Feltham A. The percentage scoring more than 0 ranged from 46.4% at Stanwell II to 97.7% at Feltham A. The percentage scoring between 3 & 6 ranged from 4.3% at Woodham to 67.1% at Feltham A. The new GAS scale could not be calculated for the trial areas, as it incorporates three items (on disturbance of concentration, disturbance of rest and relaxation, and on annoyance at being made to shut windows) that were not asked in the original set of Guttman questions.

AV SATISFACTION ON 7PT SCALE (13)
% SCALING IN WORST MODE (14)

7.20 Average satisfaction on a 7 point numerical scale (where 1 represented highly satisfied, 7 highly dissatisfied) ranged from 2.3 at Woodham to 5.2 at Feltham B. This was coupled with a question which endeavoured to ascertain whether people made their judgements on the basis of average exposure to noise, or of occasions when the disturbance was greatest and thus whether average or worst mode noise measures (see Glossary) were likely to be the best predictors of annoyance. The responses varied from 13.6% scaling in worst mode at Stanwell III to 47.7% at Feltham B. (It should be pointed out that Feltham A, which was exposed to the same noise as Feltham B, had only 30.7% scaling in worst mode).

PLOTS OF ANNOYANCE SCALES [Figures 7.2, 7.5, 7.6]

7.21 Figures 7.6, 7.5 and 7.2 show AVOGAS, VMANN and ARCNA respectively (see Glossary), plotted against Leq. The last two are the variables which correlated least well with average OGAS. All three show a portion with lower values and little or no increase, to about 60dBA and a portion of higher responses at 65dBA and above, but which shows a slight decrease at higher Leq values. There is a fairly substantial jump between the two portions. At 60 to 65dBA there is a region of uncertainty, where points may align with either the upper or the lower portions.

% AIRCRAFT ITEM LEAST LIKED (15) [Figure 7.7]
% A-C MOST BOTHERSOME NOISE (16)

7.22 Aircraft are mentioned as the most bothersome noise by considerably more people than those who say they are what 'they like least about the area'. At five areas no-one felt it was what they liked least. At Feltham A, Feltham B and Isleworth, between 45% and 50% disliked aircraft noise most. The next highest percentage, however, was 31% (Colnbrook). The smallest percentage saying aircraft was the most bothersome noise was 19.4% at Woodham, the highest was 90% at Isleworth. Except at Stanwell I-IV, areas with aircraft Leq over 60dBA had more than 50% who felt aircraft was the most bothersome noise. Figure 7.7 shows the net percentage who felt air traffic was more bothersome than road traffic. Road traffic is seen as the greater problem for most areas with Leq less than 60dBA. (Aberdeen is an exception - see para 7.13 and Figures 7.3 & 7.4). There is a sharp increase in the net percentage response between 60 and 65 dBA. It is interesting to compare areas with a similar percentage reporting aircraft were the most bothersome noise with their average OGAS scores. Consider for example the areas Hounslow W, Horley, Luton A, Ealing and Sheen, all reporting between 68% and 72% finding aircraft the most bothersome noise. They have average OGAS scores between 2.7 and 3.2. Similarly for Harlesden A, Chiswick and Ifield, with between 33% and 35% finding air traffic the most bothersome noise. They have OGAS scores of between 1.30 and 1.65. The reverse is not true. The percentage finding air traffic the most bothersome noise is sensitive to the degree of reported exposure to other noise, whereas the OGAS score appears less so.

NET % MORE BOTH'D EVENINGS (17) [Tables 7.5, 7.6]
NET % MORE BOTH'D NIGHTS (18)

7.23 After the ANAS question (see para 7.12 and 7.13), respondents were once again asked to say if they were 'very much', 'moderately', 'a little' or 'not at all' annoyed, this time by aircraft noise during the specific time periods: 0700-1900 (day), 1900-2300 (evening) and 2300-0700 (night). The reaction to noise in the different time periods was compared. A difficulty is that nearly half the sample reported that they were usually out during the day, and therefore could not record any annoyance. It was decided that annoyance could only be compared for those respondents who were usually in during all periods of time, rather than assign 'no annoyance' or the same annoyance to those not in during one time period. Table 7.5 shows that annoyance expressed, during evening and night, by those out during the day does not differ greatly from that expressed by those who are in; so the given statistic can reasonably be used to represent the feelings of the population as a whole. For the exact definition of these statistics see Appendix C.

7.24 The greatest evening noise exposure is 71.1dBA* at Hounslow, in fact an increase of 0.2dBA over daytime exposure, and here a net 11.5% were more annoyed in the evening. The largest net percentage more annoyed in the evening was at Horley (32.7%) where the evening noise was 60.9dBA (a decrease of 2.4dBA from daytime). However, in contrast, at Colnbrook a net percentage of 32.6% were more annoyed in the day, despite an evening Leq of 69.6dBA, a decrease of 3.5dBA from the day. Altogether nine areas showed a net percentage more annoyed during the evening.

7.25 The greatest night exposure was also at Hounslow (63.0dBA, down 7.9dBA from day-time exposure), but nevertheless a net 52.9% were more bothered in the day. Only Horley and Luton A show a net percentage more bothered at night. At Horley a net 10% were more bothered by 54.3dBA (down 9dBA from day time levels). At Luton A, a net 13.6% were more bothered by 57.4dBA (down 3.9dBA from day time, the smallest decrease). The largest net percentage more bothered in the day was at Feltham (79% and 78% respectively at the two sites) where the noise was down 15.3dBA to 50.0dBA at night. Note that there were no night time aircraft movement at Aberdeen.

NET % MORE BOTH'D WEEKENDS (19)

7.26 Except at Aberdeen, where there is a large drop in traffic rates over the weekend, there is little difference in noise exposure from weekday to weekend. At Heathrow there is an estimated 0.4dBA drop, at Luton 0.4dBA, at Manchester 0.1dBA. At Gatwick there is a 0.3dBA increase in noise exposure at weekends. At all sites except Aberdeen there is a net percentage more bothered at weekends. (Note that unlike the previous statistics on net percentages bothered at different times of day, this statistic is not calculated from comparing two scores. Respondents were asked directly when they felt they were more bothered.) The net percentage varied from 1.2% at

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* Note that these figures refer to three month, 24 hour Leq: M3LQ24.

Stanwell III to 49.4% at Colnbrook. Although Gatwick actually increases its traffic rates at weekends, the response at Horley and Ifield were not exceptionally high: 31.1% at Horley and 22.5% at Ifield. It would seem that the net increase in annoyance over the weekend is more a function of people's habits and way of life than of the noise exposure.

% RATED AREA AS AT LEAST NOISY (20)

7.27 The results at the three double sampled areas show that this response is subject to considerable sampling fluctuation. At Harlesden 43.9% in one sample and 25.8% in the other rated the area noisy or very noisy; at Feltham A & B the percentage were 46.0% and 29.6% respectively, and at Luton A & B 20.0% and 32.1% respectively. The lowest response was 3.0% at Aberdeen, the highest was 57.9% at Hounslow West.

% RATED AREA LESS THAN GOOD (21)

7.28 Respondents were asked if they considered their area was 'excellent', 'good', 'fair', 'poor' or 'very poor'. All those who rated the area neither excellent nor good are included here. The smallest percentage rating their area less than good was at Aberdeen (8.9%) and the highest (68.2%) at Harlesden A. The indications are that even in areas with very high aircraft noise exposure, aircraft do not figure very markedly in this very general assessment of the area.

% WITH DOUBLE-GLAZED HOMES (22) [Table 7.7]

7.29 Incidence of double-glazing varies considerably from site to site. No information was obtained about Aberdeen, as this question was omitted in that area. The lowest incidences apart from this are 6.5% at Manchester and 7.6% at Willesden Green. The highest percentages are 92.8% at Colnbrook and 84.0% at Stanwell III.

7.30 Certain areas, because of the noise exposure they were subject to, were eligible for Government double-glazing grants. Nearly all those with double-glazing in Colnbrook had had grants, and there was a high proportion also in Hounslow, Hounslow West, Hounslow Central and Stanwell I, III and IV. It is not clear what effect double-glazing might have on people's general reaction to noise. Although it should muffle the sound in the house and would therefore be expected to moderate people's annoyance, it has no effect in the garden and also means that windows have to be shut in the summer for the double-glazing to be effective.

7.31 Table 7.7 shows the distribution of responses to the question 'How sensitive are you to noise compared with other people?', comparing the total sample in an area with those who stated that they had put double-glazing in because of aircraft noise. Only those areas are considered where a sufficient number had put in double-glazing because of aircraft noise to give a significant result. The bottom row gives the results for all twenty six areas together. Considering the full sample first it is apparent that there is very little difference in distribution between those who had put in double-glazing who feel themselves to be more sensitive are more likely to put in double-glazing. Looking at the individual areas, only six had more than 50 respondents who put in double-glazing because of aircraft noise. Of these, Colnbrook has a greater than average proportion throughout who feel they are less sensitive. Stanwell I and Horley show a small increase in the number of people who believe they are less sensitive among those who put in double-glazing. Only Stanwell IV shows an increase in those who feel they are more sensitive among those who put in double-glazing.

% NON-MANUAL (23)

7.32 From the original 16 point classification of socio-economic group carried out by SCPR, an 8 point classification was formed. This present statistic combines the classifications 'professional, managerial' and 'other white collar'. The smallest percentage nonmanual workers was at Luton B, with 21.5%, the highest at Isleworth 67.6%. In the Helicopter Study (Ref 10) a marked tendency was demonstrated for areas with a high proportion of professional, managerial and other non-manual workers to express higher annoyance than was typical at a given noise level. In considering the results of our analysis in a later chapter, it should be noted that such a wide a range of percentage non-manual workers was not found in this study. In particular, none of the areas exhibit a very high number of professional and managerial people.

% IN WORK & ON SHIFT (24)
% WORK CONNECTED WITH THE AIRPORT (25)

7.33 These two variables are connected, since in many areas close to the airport this is the chief source of shift work. The percentage of those in work doing shift work varies from 2.1% at Sheen to 34.0% at Stanwell IV. As would be expected, the percentage whose work is connected with the airport increases with proximity to the airport, the highest percentages being 35.4% at Stanwell IV and 22.2% at Stanwell III. No-one at Willesden Green was connected with the airport. Roughly two-thirds of those who say their work is connected with the airport actually work there; the remaining third work for companies doing business at the airport. 36% of those usually on shift work have jobs at the airport, compared to 6% of the whole sample.

AVERAGE AGE OF RESPONDENTS (26)
AVERAGE LENGTH OF RESIDENCE (27)

7.34 The average age of the respondents varies very little with area. The youngest group is at Aberdeen, where the average age is 39.3 and the oldest at Chiswick, where the average age is 51.7. Only three areas have average ages outside the range 40 to 50.

7.35 The average length of residence is slightly more variable. The shortest period is 3.1 years at Aberdeen, where the survey area was a new housing estate. Next to that is Colnbrook, with 15.4 years (and four other areas have average lengths of residence less than 16 years). The highest is 29.2 years at Egham.

% FEMALES (28)

7.36 The largest percentage of females sampled was 62.1% at Willesden Green, the smallest 44.4% at Slough. At all but eight areas, more than half were women, and of eleven areas lying outside the range 48-54%, all but two lay above it.

DISTURBANCE AND NOISE EXPOSURE*

Introduction

8.1 The object of this study is, using the words of the Wilson Report (Ref 1), to define 'the total noise exposure which causes annoyance' from aircraft noise: here 'annoyance' includes any sort of disturbance reaction. Noise exposure is to be measured by some sort of index, composed of measurable variables such as the number and loudness of the aircraft heard, which matches most closely with the disturbance reaction. There are thus two distinct questions to answer:-

(i) How should disturbance be assessed from the social survey results?

(ii) What combination of measured physical variables gives the best match to the disturbance measure?

8.2 In the Wilson Report disturbance was determined by an annoyance measure called the Guttman Scale after the originator of the concept. This scale has been called OGAS (for Old Guttman Annoyance Scale) in this report. (For convenience the database variable names are used frequently throughout this chapter so reference to the database Glossary in Appendix C is necessary.) OGAS is a six point scale, a respondent's disturbance being measured by an integer from 0 to 6 on OGAS (the scoring method is listed in Figure D4). The NNI was chosen by the Wilson Committee as matching well with OGAS, NNI being defined by -

$$NNI = L + 15\log N - 80$$

where L is the logarithmic average noise level in PNdB (from dBA+13) and N the number of aircraft noise events of more than 80PNdB on an average summer day (0700-1900 LT). The choice of OGAS and the choice of NNI to match OGAS correspond to the answers to questions (i) and (ii) in the above paragraph. In the following paragraphs these questions are examined for the Aircraft Noise Index Study data. Three points need to be made here. First, different results from those given by the Wilson Committee may be a product of the changes in annoyance responses over two decades rather than deficiencies in the Wilson analysis. Second, the aircraft noise environments used for this study were chosen for their 'statistical efficiency', i.e. because they would help in the identification of an index, not to represent in some sense the broad picture of disturbance around an airport. Third, the Wilson Committee only examined the environs of Heathrow, whereas this study includes other airports.

Disturbance

8.3 The reaction to an adverse stimulus can be called the degree of disturbance. The fact that it is possible to name this concept does not mean that it is intrinsically well-defined. Disturbance through aircraft noise incorporates a wide variety of very real emotional

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* This section, in particular paragraph 8.17 et seq, assumes a knowledge of statistical hypothesis testing and multiple regression methods: the main results are described more fully in Section 9.

states occurring in different circumstances such as: anger at intrusion when relaxing in a garden, irritation when concentration is broken during work or leisure, fear when startled by a flyover. An individual's reaction at a particular time will, no doubt, vary in extent with the airport runway in use, the weather (suitable for gardening or sunbathing?), the other stresses of the day and so on. Even for people in very similar circumstances reaction can differ markedly; some are phlegmatic about noise, while others are more anxious. In addition, differing education and jobs and degree of awareness about society can all affect reaction, in particular the overt response through complaints or other actions.

8.4 An attitude such as disturbance is thus an intrinsically complex concept (Ref 15). It is also the case that is not possible to guarantee that a measure of an attitude has so called 'cardinal' qualities. Cardinal properties are those generally found in basic physical variables. The ordinary measure of length possesses such properties e.g.:

(i) Different objects can be arranged in order of length;
(ii) Objects of length dimension 1,2,3 .... units all differ by the same length;
(iii) An object of (say) length 4 is equal in length to two objects of length 2.

These all seem quite trivial properties for a measure to possess, for the reason that they are those of the ordinary operations of arithmetic. An attitude measure does not, however, inherently possess such qualities and it does not seem possible, with existing methodological techniques, to demonstrate conclusively that an attitude measure does in fact have cardinal properties. A disturbance measure with cardinal properties would be one which essentially allowed one to discuss 'units of annoyance', so that an increment of annoyance between people would be well defined and an individual could be said to have (say) twice the annoyance of another individual.

8.5 The 'non-provability' of cardinal properties may seem a minor matter but it provides a particular constraint on any statistical testing which uses the powerful techniques of 'Multiple Regression Analysis' - MRA. While this approach can still be used - as it is in later paragraphs and in Appendix F - to examine the data set in an organised fashion in a search for a good disturbance/physical variable relationship - results have to be examined with caution and re-tested, if possible, through methods ('nonparametric') which are not dependent on ordinary arithmetic operations.

8.6 The lack of an objective 'unit of annoyance' does, however, have an even more serious consequence, in that it is not possible to establish a logical mechanism which will ensure that the 'best' disturbance measure can be found from social survey responses. Discrimination between disturbance scales can only be through special argument or, for similarly constructed scales, through internal consistency analysis. Fortunately the degree of commonality between aircraft noise disturbance scales turns out here to be rather high so it seems quite possible to examine different scales selected from the whole 'spectrum'.

8.7 The analysis in this section uses - in the main - the compact database formed from the study results. The various measures of disturbance in the database cover all of the main features brought out in the social survey questionnaire plus noise metric data. An almost infinite number of possible distinct disturbance measures could be produced from the survey results, but the database (which includes the established measures, such as OGAS) is an effective representative for the whole set. Any other measure of interest can still be calculated from the database, the survey tabulations (Ref 13) or the whole data tape.

8.8 The database uses the 'single sample' survey area. Data from all the respondents in each area are collected together because:

(i) Noise measurement is by survey area so all the respondents in an area are identified as having the same noise climate.
(ii) The grouping of respondents in a community gives a stability to the measure of disturbance estimated for that noise exposure. Thus, for example, an individual's OGAS scores would be subject to the sort of individual variations mentioned before, whereas an average OGAS score taken from a group of people would more easily reflect community disturbance.
(iii) Single area groupings are used so that the degree of statistical variability implicit in each community assessment is about the same.

The second point here needs some enlargement as it has already been pointed out that scales such as OGAS do not, 'as of right', permit arithmetic operations such as arithmetic averaging. The latter has, however, been done frequently in the past for convenience: an argument for continuing this treatment is that the 'average community score' is a simple and stable measure which matches well with other statistical measures such as the median score (Ref 2).

8.9 Disturbance measures in the database may be categorised in a number of ways : it is particularly important to focus on these different approaches in the analysis of measures. A crucial breakdown is:

(a) Covert measures arising from questions about disturbance where 'aircraft' is one of several possible answers, or where aircraft noise contributes, perhaps unspecifically, to the response.

(b) Overt measures which arise from questions explicity related to aircraft noise.

Examples of type (a) are ARCBOTH* - the percentage of area respondents who say aircraft are the most bothersome noise, and NSENA - the percentage who think general noise levels unacceptable. An example of type (b) is AVOGAS, the average OGAS score, as people are specifically asked to indicate disturbance reactions arising from aircraft noise. The latter type of measure has tended to be preferred in past analyses because the respondent's mind is focussed on aircraft and he or she is given a clear opportunity to comment on disturbance from aircraft noise.

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* Explanation of the variable names can be found in Appendix C, Table C1.

In the former type of question there may be a doubt as to the extent to which aircraft are identified as part of the external environment in the same scheme as, for example, road traffic and noise from neighbours : aircraft may be seen as an 'external' feature while the examples mentioned would be seen as more local.

8.10 Another important categorisation is that between 'average' and 'percentile' measures. In the former some disturbance measure provides a score for all the respondents in a community which is then averaged, eg the individual OGAS scores are averaged to give AVOGAS, which thus includes contributions from the whole community in proportion to the severity of the individual's response. An example of the latter is VMANN, the percentage who say they are very much annoyed by aircraft noise. Such a variable does not weight the response of all the individuals in the community, but estimates the strength of attitude by a count of those respondents with at least a certain response. There is no guarantee that a high average response will always entail a high percentile response, but it turns out in practice that the measures move quite closely together. Thus, for example, the four areas in the database with AVOGAS scores greater than 3.5 are the only areas with VMANN percentages in excess of 40%, while all the sites with AVOGAS less than 2.0 all have VMANN less than 17%. Measures such as AVOGAS have tended to be used in the UK studies, whereas in USA work VMANN has become a foremost measure. VMANN as the 'highly annoyed' percentage (equal to 'very much annoyed' plus a more emphatic 'extremely annoyed', subsumed in the UK categorisation) has in fact been recommended in the USA as a measure for the assessment of community response to aircraft noise (Ref 16), following research on worldwide aircraft noise disturbance results by Schultz (Ref 17).

8.11 A third division which should be noted is that between overt numerical scales and constructed numerical scales. The only overt numerical scale used here is SCALE7 (a seven point scale of satisfaction/dissatisfaction), all others being constructed 'naturally' from responses (eg for AVANAS, 'very much bothered' being given a score of 3 down to 'not at all bothered' a score of 0) or through some construction mechanism, as in the case of the Guttman Annoyance Scales. In the case of the overt scales the individual respondent interprets the meaning of the numerical values, whereas for constructed scales the researcher's method decides the respondent's score. Neither method quarantees cardinal properties, but it has been argued (Ref 2 and the references therein to the research by Ollerhead et al) that the roughly constant spread of scores about the community average as exposure increases for OGAS and ANAS indicates that their scale values are well chosen.

8.12 One method of assessing different scales of an attitude is to examine the degree of agreement between them. If different scales are intended to measure the same thing, then they should tend to agree on the relative rankings by respondents and, more likely, for communities of respondents. If they do not agree, then it is not possible to make any deduction : either or none of the scales may be appropriate. Agreement of scales in the assessment by the respondent does not by itself guarantee that the scales measure the intended attitude appropriately. It is desirable that the mechanism for scale scores is intrinsically connected with the attitude. Agreement of scales does not, of itself, guarantee that the scales do in fact measure the attitude appropriately. However, in the present case all the scales in the compact database are constructed so as to lend credence to the scales as measures of aircraft noise disturbance, even though the attitude may not be explored overtly by the interviewer's mention of aircraft.

8.13 Table 8.1 shows the 'Spearman rank correlation' matrix for the database disturbance scales. For convenience the first row of the matrix is listed here, showing the correlation between AVOGAS and the other scales in decreasing order of correlation coefficient, the overt aircraftrelated scales coming first. (Note that correlation coefficients are for all 26 areas, except for those connected with the new GAS calculation, NGAS, which are for the first 22 areas in the database only.)

Scale	Correlation with AVOGAS
AVNGAS	0.98
OGASHI	0.97
NGASPOS	0.95
AVANAS	0.95
SCALE7	0.94
ARCAL2	0.94
OGASPOS	0.93
NGASHI	0.91
VMANN	0.91
ARCNA	0.91
ARCBOTH	0.87
NSEAL2	0.87
ARCLIV3	0.78
NSENA	0.76
ANOISY	0.27
AXGOOD	-0.06

The rank correlation coefficients displayed here are measures of concordance between the scale and AVOGAS, used here as the 'traditional' measure. A value of +1 would indicate complete agreement, a value of zero would indicate no measured association, while a value of -1 would show that the scales were measuring the same thing but in an opposite fashion. 'Rank' here refers to the fact that these coefficients are estimated by ranking the survey areas 1,2,3... for each scale and then matching the ranking of AVOGAS and the scale in question. Thus the top ranked area for AVOGAS is no. 8, Isleworth, and the bottom ranked (i.e. 26th) is no. 14, Stanwell II; for AVANAS the same areas are ranked 3 and, again, 26. This similarity of ranking holds over all of the areas, giving a coefficient of 0.95. Note that because rankings are used the actual scale values of the measures are not of major importance (however, as the community averages are used for some scale measures the scoring mechanisms are not completely absent).

8.14 The scales listed in the above table are all, in one way or another, measures of the total disturbance caused by aircraft operations (note that at this point variations in disturbance, eg day versus evening, are not being examined). The correlation coefficients indicate a good degree of consistency among the scales. All the coefficients, bar the last two, are statistically significant at better than 0.1%, i.e. such high values would only be achieved through chance fluctuations less than one in a thousand occasions. The ANOISY coefficient is significant at 10%, i.e. could occur by chance one time in ten, while AXGOOD shows no significant correlation with AVOGAS. These are non-specific scales for aircraft disturbance : one - perhaps obvious - inference may be that aircraft noise is not immediately identified as a reason for thinking an area poor, while other noises (particularly road traffic) have a strong effect on the perceived noisiness of the area : Figure 7.7 shows that the association of a 'noisy area' with aircraft is most marked for the higher levels of aircraft noise exposure.

8.15 Which of the scales above should be considered as measures of disturbance in statistical analysis to determine the major 'stimulus' factors such as noise level and number? There is little to be gained from carrying out detailed calculations on similarly ranking scales - differences in regression analysis results could easily result from differences in the numerical values of the scales. Examining the Table above:-

AVOGAS: The 'traditional' measure - which must be examined if only for comparison purposes.

OGASHI, NGASPOS, AVANAS, SCALE7, ARCAL2, OGASPOS: All these scales have correlation coefficients of 0.93 or better and need not substitute for AVOGAS in the analysis. This is an arbitrary, but high, dividing line. Note that SCALE7, which arises independently of the GAS or ANAS question, has a high correlation coefficient with such scales. Note also that the new GAS scales are highly correlated with AVOGAS, i.e. no markedly improved structure has been found by the heuristic analysis of Appendix D.

NGASHI, VMANN, ARCNA: These scales do not match AVOGAS quite so closely. The rank correlation coefficients of NGAHI and ARCNA with VMANN are 0.93 and 0.92 respectively (only slightly better than with AVOGAS) and the NGASHI/ARCNA correlation is 0.97. VMANN is essentially the USA 'highly annoyed' scale and is therefore a good candidate for examination. ARCNA is a particularly important scale to decision-makers, as the degree of acceptability of aircraft noise expressed by representative populations is of major significance, so the choice is to examine ARCNA, but not the similar NGASHI.

Covert Scales: For covert scales the degree of agreement between scales will tend to be less because the focus on aircraft disturbance has to be identified by the respondent. Neither ANOISY nor AXGOOD seem particularly good scales for aircraft disturbance as it appears that the responses are significantly confounded by other environmental factors. NSENA may also be affected, but as ARCNA focuses on the aircraft aspect of non-acceptability, NSENA has a lower importance. ARCLIV3 has a comparatively high correlation coefficient (0.88) with ARCBOTH and the questions from which they are derived have similar intent. NSEAL2 has as high correlation as ARCBOTH with AVOGAS and does not seem to offer a particularly distinctive character. Therefore, of the covert measures, ARCBOTH is chosen for examination.

8.16 From the 'long list' in the database the following scales are thus selected for detailed statistical analysis: AVOGAS, VMANN, ARCNA, and ARCBOTH. To summarise: the first scale enables comparison with past work, the second with USA research, the third has particular relevance for decision-makers, and the fourth is a measure of a respondent's spontaneous reaction to aircraft as a feature of environmental noise. The other scales in the database - and other possible scales which could be constructed from the survey results - are unlikely to demonstrate markedly different results as regards the derivation of an aircraft noise index. Aside from AVOGAS, the scales here also have the advantage that they are percentile scales which have good statistical properties in terms of regression analysis.

Statistical Analysis

8.17 Because of the large amount of noise data in the database,* statistical analysis of the results could be overwhelming. The approach followed here is to proceed from some simple analysis, supplemented by graphical examination and alternative statistical testing methods, to more full analyses. In the earlier stages AVOGAS is the only scale examined. The examination uses forward selection multiple regression analysis (MRA) in the search for sound statistical relationships (Ref 18 Chapter 6), but note the caveats on this technique specified earlier. MRA is a method for finding the 'best' relationship between a 'response' variable - so far AVOGAS has been used with the stimulus variables noise level and number. If Y is the response value and X_1, X_2...the values of stimulus variables 1,2... for a particular area then MRA finds constant coefficients a_0, a_1,a_2,..so as to yield an expression:-

$$Y = a_0 + a_1X_1 + a_2X_2 + \dots$$

The coefficients a_0, a_1 etc are determined from the data so as to give a 'best match' between the observed responses and the predicted response calculated from the above equation. Each survey area is treated as having the same importance, i.e. there is no 'weighting' of data points (Ref 18, Chapter 2).**

8.18 For the NNI the variables and coefficients are (using the earlier symbols):-

Y	AVOGAS times a constant
X_1	L
X_2	log N
a_2/a_1	15
a_0/a_1	-80

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* The compact database does not include the noise levels and number of movements for the evening and night periods. The decision was taken to use only the Leq values for day, evening and night. The evening and night data is given in Tables 6.1-6.4.

** This is not too dangerous an assumption given percentage, i.e. binomial responses.

This sort of linear relation - a non-linear form could also be used - enables the relative importance of the stimulus variables to be seen, the ratio of a_2 and a_1 giving the 'trade-off' between the variables. In the case of NNI, the ratio of 15 implies that an increase of 1dB in noise level has about the same impact on disturbance as a 17% increase in the number of aircraft, or, even more dramatically, that a 4.5dB increase in noise level equates to a doubling of the number. The logarithmic form for the number variation is a common feature of all indices in use throughout the world so initially this form will be retained.

8.19 In the previous section several 'confounding' variables were discussed. These represent factors which could affect response but which are not physical stimuli as discussed above. An obvious example of a confounding variable is WORKAP, the percentage of respondents in the area whose work is closely connected with the airport. The views of such respondents on the disturbance caused by aircraft noise may be coloured by their knowledge that their livelihood is dependent on the continued existence of the airport. These people's views are quite valid, but it would be wrong to use their responses as an indication of the possible effects of a new or developed airport on a previously unaffected population without a existing interest in airport-related employment. However, it is not correct merely to eliminate these responses from statistical analysis: neighbours of airport workers or respondents whose businesses depend heavily on local economic activity may be just as involved with the operations at the airport. WORKAP is used as a surrogate to account for this involvement.

8.20 Of the other confounding factors (used here as extra stimulus variables in MRA) LRES, NONMAN and FEMALE are socio-demographic in nature. SHIFT1 is needed to cope with the possible distortions in response because interviewees are not exposed to the 'standard pattern' of aircraft noise. DGL is included because both noise-related double-glazing, with possible Government Grants, and (to a lesser extent) heat-related doubleglazing reduce external noise levels. Here, again, it is not correct to analyse the different respondents' answers separately. First, it is not possible to determine in such a social survey the physical efficiency of each respondent's double-glazing. Second, respondents with and without double-glazing are not necessarily equally representative of the general population - the people with double-glazing might, for example, be more concerned about noise than the population as a whole.

8.21 Confounding factors can generally be one of two types: those which are 'neutral' and those which are influenced by different levels of aircraft noise exposure. In practice mechanisms can be thought of which would indicate at least a partial influence on an apparently neutral factor. For example, NONMAN might decrease with noise exposure because an airport tends to provide a source of non-manual jobs and also because, the generally better paid, white-collar workers might be more likely to move to areas with a better aircraft noise climate. If a confounding factor turns out to be a significantly contributing variable in MRA, it is of particular importance that it is not merely a substitute for noise-related variables which have been omitted from the analysis. Thus, if DGL were to be necessary in a MRA with noise level and number variables already in the equation, a positive coefficient - implying an increase in disturbance with the percentage of respondents having double-glazing - would be suspect (although not necesarily invalid): a negative coefficient would be less dubious, indicating some effect due to amelioration by double-glazing rather than the omission of some noise variables.

8.22 Details of the MRA and other statistical analyses are given in Appendix F. The discussion here summarises these results in a less technical fashion: a summary of the results is given in the final paragraphs of this section. The term correlation coefficient is used in the same fashion as in earlier paragraphs, except that it is also used to indicate the match between the response variable and the combination of variables derived by MRA - the 'multiple' correlation coefficient. To understand fully the analysis it may be necessary to refer also to the Database Glossary (Appendix C), which indicates conventions and assumptions in calculation.

8.23 An obvious first question is that of the efficiency of the NNI as an index of disturbance. The variables in the NNI expression are, in database notation, M3L80 and LM3N80 with a relative weighting of 15. MRA I shows that for the data set the correlation between these two stimulus variables is very low (- 0.10), indicating that there is a good likelihood of discriminating between the effects of the two variables. MRA I (in the notation of Appendix F) gives

$$\mathrm{AVOGAS} = -13.04 + \underset{(0.023)}{0.148\ \mathrm{M3L80}} + \underset{(0.310)}{0.952\ \mathrm{LM3N80}}$$

(The numbers in brackets are 'standard errors of estimate' for the coefficient immediately above: these indicate the statistical confidence in the coefficient. Very roughly, a ratio between coefficient and standard error of more than 2, as in both cases here, shows that the coefficient is a sound estimate.) The 'trade-off' between the variables is 0.952 ÷ 0.148 = 6.43. Statistical testing shows that it is very unlikely that this ratio is merely a statistical fluctuation from a true value of 15. Examination of rank correlation in the Appendix F (which, as noted before, does not require explicit knowledge of scale values) agrees with the MRA I analysis, the best trade-off from the data being about 8. Note that the rank analysis, because it does not use explicit scale values, allows for non-linearity in response.

8.24 The next examination MRA II extends the analysis by allowing the confounding variables to come into the equation. (In MRA II the 'F-test' criterion for inclusion of variables is 2.92: this allows 'chance' variables to enter the regression on about 10% of occasions, higher values of F - see final column of MRA II - being more unlikely to correspond to such statistical fluctuations.) SHIFTI is the variable to be included in the regression set. It is included 'negatively', i.e. not as an apparent substitute for noise exposure.

The equation is

$$\text{AVOGAS} \;=\; 14.34 + \underset{(0.021)}{0.165}\ \text{M3L80} + \underset{(0.276)}{1.128}\ \text{LM3N80} + \text{confounding contribution.}$$

i.e. with a coefficient ratio of 6.84. The added variable has changed the noise variable coefficients, but has not shifted the trade-off markedly. The MRA II has an (unadjusted) correlation coefficient ('Multiple R') of 0.871, compared with 0.817 for the two noise variables indicating a good, but certainly not perfect, match of the stimulus combination with the response.

8.25 In MRA III the 70 and 75 PNdB cut-offs are examined by including in the regression six analogous noise variables - noise level and number at 80, 75 and 70 PNdB cut-offs. Note that the data used still refer to the three month summer average period used in constructing the NNI. The noise variables chosen are M3L70 and LM3N75; including the confounding variable (SHIFT1) the trade-off is 1.071 ÷ 0.1568 = 6.82. The regression correlation coefficient for the whole regression set is 0.880 (cf 0.871). Thus the use of noise variables with a lower cut-off has improved the quality of the regression analysis slightly: the small difference in quality could, however, be merely a result of statistical fluctuations.

8.26 Many of the noise indices in use throughout the world are based on Leq, which is a physical noise scale - essentially the A-weighted noise energy recorded - combining noise levels and numbers intrinsically (Ref 19). Leq thus has useful properties as a starting point for a noise <u>index</u> . In MRA IV the Leq variable chosen (M3LQ24) is measured over the three month summer period analogous to the NNI, but covers the whole 24 hours, as opposed to NNI which uses the 12 hour day period. Note that Leq includes an element corresponding to the <u>duration</u> of noise events (in succeeding analyses Leq is used as a combination of noise level, number and duration which can then if necessary be improved in explanatory power by noise level and number factors). M3LQ24 by itself has a correlation of 0.773 with AVOGAS. With the addition of noise variable (LM3N70) and confounding variables the correlation coefficient rises to 0.885, (cf para 8.25). As Leq has, roughly, an implicit 10 times the logarithm of the number of aircraft factor, the number variable here leads to a 8.53 trade-off - similar to the previous figures. The variable WORKAP is included as a confounding factor : note that WORKAP is highly associated - for a socio-demographic surrogate variable - with SHIFT1.

8.27 Reviewing the analysis: the NNI trade-off is not confirmed, a value of around 8 gives a much better match than 15; Leq appears as a possible candidate on which to build. However, on examination of the match between response and the prediction by the stimulus variables it is apparent that the linearity assumption used so far may be suspect. Figure F4 in Appendix F shows the residuals - the difference between response and prediction - for MRA IV. The areas are rank ordered by the values of M3LQ24. The residuals do not show the random pattern of plus and minus signs which would be expected if a valid relationship was merely being masked to some degree by chance or extraneous effects. The grouping of error signs is in accord with an underlying non-linear relationship: essentially a curve is being fitted by a straight line. There appears to be a comparatively sharp rise at about the middle of the range of Leqs here. To model this new variables are included. A set of 'jump' variables - STEP60 etc, - is constructed so that, for example, STEP60 is unity for areas with M3LQ24 greater than 60 and zero elsewhere. Thus the position of the step or jump is determined by an Leq value. This set of variables, with the step at values between 56 and 64, serves to characterise the apparent sharp increase in response. It is not to be supposed that this step exactly matches people's changes in disturbance response, which would generally be assumed to follow a more smooth pattern: the purpose here is to fit the data with as simple a form as possible. The step variables turn out to be very useful in fitting the data, as shown in MRA V, in which the best step variable - on an F-test criterion - is added to the MRA V regression set. STEP58 is chosen and shows a marked improvement in the multiple regression coefficient from 0.885 to 0.937. (See Table F2 for MRA V correlation matrix.)

8.28 All the analysis so far, with AVOGAS as the response variable, has been carried out the 'three monthly' variables - the averages of the various noise variables during the standard NNI months. It has been argued (Ref 4) that the use of such an average does give the best match with the response variable. The suggestion is that people's responses are determined in some way by either recent experience of noise exposure or by the worst conditions of aircraft noise to which they are exposed. In the database there are, as well as the three month variables, the corresponding one month and one week variables, referring to the period ending just prior to the social survey. There is also a set of worst mode variables, which does not necessarily correspond to 'real' days of exposure in that they estimate the value of the noise variable by supposing the airport to be using the runway mode of operation which results in the highest Leq value in each area. In the case of Heathrow, westerly take-offs are usually changed between runways during the 24 hours, so 'worst mode' is not necessarily heard throughout any of the day, evening or night. Note that worst mode as regards NNI values is not necessarily identical for runway operations with that for worst mode Leq operations as used here. Previous analysis here has also not examined the variation in noise climate throughout the 24 hours which is described in the database by the evening and night Leq values. Many aircraft noise indices in use in other countries are constructed from a weighted combination of the Leq values in these or similar time periods, so the day, evening and night Leq variables should be incorporated.

8.29 A statistical analysis with the response data points has all of the following variables as possible candidates for inclusion as stimulus variables:

: noise level: for 3 cut-offs and 4 durations i.e. 12 possibilities.
: number of events: for 3 cut-off and 4 durations x 2 *
i.e. 24 possibilities.
: Leq: for 4 durations and 4 periods i.e. 16 possibilities.

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* The '2' comes in because both number and logarithm of numbers are allowed.

Duration here refers to 'three months' etc, period to 'day' etc, including 24 hours. There is also the possibility of step variables in Leq. In addition there are the six confounding variables, making a total of 58+ variables. An MRA with such a set of possibilities has a deficiency in that the best regression fit may not be the 'true' representation of the data, but merely a good approximation which has been chosen as a result of measurement or sampling fluctuations. This is of particular concern when several groups of variables are highly intercorrelated. In this instance the data in each of the the three groups above are all highly associated - the correlation matrix has a high proportion of coefficients in excess of 0.99.

8.30 Forward selection multiple regression analysis with many intercorrelated variables - and indications of non-linearity through the STEP variables - is rather a 'blunderbuss' technique. The benefit of the approach is probably that it enables 'good fits' to the data set to be obtained, so it is possible to determine the potential of the 'stimulus' data set in explaining the observed responses. An advantage of the data set here is that as well as covering the range and variety of noise exposures which exist at present in the UK, it is also appropriate for future conditions - in view of the high number/'low' noise level areas. This means that prediction in general will tend to require interpolation rather than need to expose the regression analysis to the problems associated with extrapolation. A good fit is of substantial benefit, even though there may be a measure of statistical uncertainty in terms of functional relationships valid outside the data set parameters.

8.31 In paragraph 8.27 the different Leq variables are noted, in particular the possibility of further STEP variables. Previous MRAs used M3LQ24 alone in constructing the latter, the Leq 'jump' showing strongly at M3LQ24 = 58, but being markedly less appropriate at other Leq values (eg compare the AVOGAS correlation co-efficients for these STEP variables in MRA V). There is little to be gained in incorporating all the analogous STEP variables for the other time periods because of the high correlation with the M3LQ24 STEPs, as can be seen from inspection of the database. Thus the STEP variables are very similar for the 3 month and 1 month 24 hours period and very nearly the same variable for the 3 month and 1 week period. It is interesting that the STEP58 variable is again very similar for the three month and worst mode 24 hour Leqs. There is also, as would be expected, a high degree of concord between the 24 hour and daytime variables. Evening and night data again show similarity for STEP variables compared with the 24 hour choice although there is somewhat less of a match in the latter case. None of this is unexpected given the general pattern of airport movements through the 24 hours. The choice of STEP variables is therefore a difficult one, as there is little apparent theoretical reason for preferring one scheme to another, while graphical analysis is unlikely to be definitive in such an assessment. As a working hypothesis the STEP variables form is kept as the M3LQ24 'variety' with 2dBA steps from 56 to 64dBA. (Reference to the database will show that this produces a set of quite distinct STEP variables.) In MRA the 'onus' is therefore on other candidate variables to force any reappraisal of this STEP choice, either directly or through examination of residuals.

8.32 As mentioned earlier, most attention is generally focussed on the logarithm of the number of noise events, but here the actual number will also be included as a variable in each case. Thus the full recipe for MRA VI is:

: Four response variables *AVOGAS*, *VMANN*, *ARCBOTH* and *ARCNA*
: 12 noise level parameters
: 24 number parameters and their logarithms
: 16 Leq parameters
: 5 step variables
: 6 confounding factors

The Appendix gives the final analysis of variance tables and regression equations for MRA VI.

8.33 The MRA VI results are summarised in the following lists which give the variables included in each final regression in order of entry to the step-wise process, plus the final multiple regression coefficient (R). Variables above the line drawn on the list have added more than 0.025 (an arbitrary figure) to the value of R^2.

(A) AVOGAS : W1LQ24 R = 0.980
WORKAP
STEP58
STEP64
M3N70 (-ve)
NWMLEQ
STEP60
LRES

(B) VMANN : W1L70 R = 0.978
NW1LEQ
NONMAN
STEP64(-ve)
WMN75
WORKAP
STEP56

(C) ARCNA : W1LQ24 R = 0.989
WORKAP
NWMLEQ
M1L80
W1N80
STEP56(-ve)
STEP64(-ve)
SHIFT1
NONMAN

(D) ARCBOTH : W1LQ24 R = 0.968
WORKAP
STEP58
M1L70
NONMAN

The annotation (-ve) indicates that a noise-related variable is included with a negative coefficient, i.e. there is some sort of noise variable 'cancellation' implicit in the regression equation.

8.34 In this regression process a very loose inclusion parameter has been used - in the general sense that a purely random variable would be included in the regression equation on about 10% of occasions (i.e. the F-test significance level has been set at about 10%). With more than 60 possible variables this means that several of the variables actually chosen could in fact be incorporated - at least in part - merely as 'chance' variables. This appears to have happened, very badly, with (B) above - this fitting of regression equations that involve more independent variables than are necessary to obtain a satisfactory fit to the data is called overfitting . The regression (B) is also rather dubious because six variables contribute markedly (i.e. above the 0.025 threshold) to the correlation. An inspection of the whole set, 'above the line', shows that WORKAP appears in all four analyses, W1LQ24 in three of them and STEP58 in two. As the correlation coefficient of W1LQ24 with VMANN is 0.792, not much less than the W1L70/VMANN figure of 0.805, it could well be that the poor regression (B) is merely a result of an inappropriate choice at the outset of the step-wise process.

8.35 To investigate the possibility of a 'unified' variable set for all of the four scales, W1LQ24 and WORKAP are now forced in as independent variables (MRA VII). For consistency with the Leq variable 'STEP' is now transformed to 'JUMP' referring to W1LQ24 rather than M3LQ24. The JUMP variables still go from 56 to 64 Leq but this time 1dB increments are allowed. The JUMP variable is only allowed in the regression if significant at about the 1% level (F=7.82), thus reducing the likelihood of 'chance' variables. After W1LQ24, WORKAP and any JUMP variable any other variable is included if better than significant at the 1% level; in summary:

(A)	AVOGAS :	W1LQ24 WORKAP JUMP57	R = 0.941
(B)	VMANN :	W1LQ24 WORKAP	R = 0.935
(C)	ARCNA :	W1LQ24 WORKAP	R = 0.941
(D)	ARCBOTH :	W1LQ24 WORKAP JUMP57	R = 0.953

In all four regressions every coefficient is statistically significant at the 0.5% level or better. There is no definite requirement for any further explanatory variable at the 1% level. In fact, given the large candidate variable list, the possible variables for inclusion next have F-test levels of significance of the same order as chance statistical fluctuations in the data. The multiple regression coefficients resulting from the restriction of variables to be included are typically 0.04 less than the 'open search' values in MRA VI (para 8.34). This can readily be attributed to the 'chance' benefits of using two or three times the number of independent variables.

8.36 Some general features of MRA VII need comment. First, the JUMP57 variable : it is required for AVOGAS, which is a constructed scale, so it might be argued that its presence could be due to some flaw in that construction. However, the same variable is required for ARCBOTH, which is probably the least 'artificial' scale examined. It may be that the requirement for the JUMP57 component in a scale is dependent on the influence of other noise sources on people's reactions: the decision on a best scale to use here is an open question. Another point of interest is that the number variation appears to be adequately represented through the Leq variable, i.e. the response to number through an implicit '10logN' factor is satisfactory - there is no 'dramatic' increase with number resembling in any way a linear relationship. An examination of the residuals for MRA VII shows no marked 'airport-dependence' on response, an aspect discussed earlier in this section *. Taking AVOGAS, for example, Aberdeen (residual no.5, as they appear in order of increasing W1LQ24), Luton(nos. 11 and 12), Gatwick (nos. 4 and 15) and Manchester (no.9) do not show significant differences from the regression pattern. The only extreme residual is for no.13 (Stanwell I) but this area does not stand out as an extreme on the other three residual plots, i.e. it could merely show a sampling fluctuation. A final point is that it was noted earlier that some indices in use in other countries 'weight' movements outside the day-time period. In other words, an index might add the day-time Leq to the evening and night Leqs increased by 10dB, i.e. movements at these (more adverse?) times would be treated as producing noise levels which, from the point of view of response are effectively 10dBA more than measured physically. The regression analysis MRA VII does not reveal the need for such additions, in that the 24 hour Leq value is not modified by extra evening or night terms eg EW1LEQ, NW1LEQ. As a variant on this approach; a set of difference variables, M3DE = M3LEQ - EM3LEQ, etc were tried in MRA again the levels of significance for inclusion generally were at around 10% to 5% (MRA not listed).

8.37 Another way of examining the need for these weightings is to take the results of the Aircraft Noise Annoyance questions restricted to the day, evening and night time periods (Q12-14). These are summarised as percentages of the whole data sample in Table 7.5 together with the ANAS percentages. The evening figures are divided into two classes, IN and OUT, depending on whether the respondent was in or out during the day-time period; similarly for the night responses. At the bottom of the table are the average values of W1DE (-3.1) and W1DN (-13.1). A number of inferences can be drawn from this data. First, the ANAS response is stronger - in 'very much' and 'moderately annoyed' - than any of the responses for restricted time-periods, indicating perhaps that reaction has been cumulated in ANAS, rather than focussing on a worst time period, or being 'averaged' over the whole exposure. The IN and OUT reactions are not markedly different, i.e. reaction in evening and night is not much affected by absence or

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* Note that the residuals are listed here by increasing value of W1LQ24, not as in the data base. See Figures F10 - F13.

presence at home during the day. The day and the evening responses show very similar percentages, the night response is much less marked than either. If Leq is a proper measure this indicates that the evening weighting, if required, cannot be greater than 3.1 dBA, while a night weighting, if required, is much less than 13.1 dBA.

8.38 It is possible to place tighter restrictions on possible evening and night weightings. This is done by examining the Aircraft Noise Annoyance responses for those survey areas where there is little difference between the day and evening Leq, and evening and night Leq values. Table 8.2 shows the former, for the areas Isleworth, Colnbrook, Hounslow Central, Ifield, Manchester, Slough and Sheen. Here the average difference is 0.6dBA in a range from -0.6dBA to 1.2dBA. There is not much difference in the day and evening responses, particularly when possible statistical fluctuations are taken into account. If the percentage highly annoyed is taken as a true guide the difference of about 0.8% in response between day and evening is not large. As a change in VMANN of 1% corresponds roughly to an Leq increase of about 2 units, an average value of 0.7% might correspond to an evening weighting of 1.5 dB.

8.39 For the evening/night analysis (Table 8.3) the areas Hounslow, Ifield and the two Luton cases are used. Here the Leq average difference is 1.1dBA in a range 0.3dBA to 3.1dBA. The night responses are considerably less than the evening reactions. There seems no justification for any positive weighting. Thus, to summarise, an evening weighting - if required is of the order of perhaps 1.5dBA; there is no evidence for a night weighting - indeed there are indications that movements at night are rather less annoying than day or evening ones.

8.40 In MRA VII the one week Leq variable gives a good unitary fit to the four scales examined. That this one week period is found to be the best match for these data probably confirms that community response depends more strongly on recent experience when this reinforces general experience. If, however, recent exposure had been greatly atypical, longer term exposure might well have been found to correlate better with responses.

8.41 As Leq is essentially a combination of noise level and number, there is a likelihood that a combination of noise level and number variables analogous to NNI, but designed to approximate Leq, will match the data rather well. MRA VIII examines this; it is essentially the same as MRA VII except that the Leq variables are not used, apart from the JUMP variables (which can enter only after noise level/number). In summary*:

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* For consistency WORKAP is forced in as the confounding variable.

(A)	AVOGAS :	WORKAP W1L70 LW1N75 JUMP57	R = 0.953
(B)	VMANN :	WORKAP W1L70 LW1N70	R = 0.922
(C)	ARCNA :	WORKAP W1L70 LW1N70	R = 0.950
(D)	ARCBOTH :	WORKAP W1L70 LW1N80 JUMP57	R = 0.959

The regressions show that a combination of level and number performs better than Leq; but, in fact, some of this improvement results from the use of two variables rather than one, so it is probably more true to say they perform at about the same level. Note too, that the level/number variables refer, as with NNI, only to the daytime movements.

8.42 It is apparent in MRA VIII that a 70 PNdB cut-off is preferred in all cases for noise level. As a 70 PNdB cut-off also occurs for two of the number variables it is appropriate to see how well a combination of 70 PNdB cut-off variables performs for ARCBOTH and AVOGAS. MRA IX presents these regressions, i.e. substituting the 70 PNdB cut-off variables for the 75/80 PNdB cut-offs in MRA VIII

(A) AVOGAS : R = 0.952
(D) ARCBOTH : R = 0.958

The performance, in fact, improves slightly - indicating, inter alia, that the forward regression process will by no means always produce the very best variable set. The 70 PNdB combinations do not, however, all correspond to the same trade-off between level and number, thus:

(A) AVOGAS : k = 8.49
(B) VMANN : k = 8.52
(C) ARCNA : k = 10.1
(D) ARCBOTH : k = 8.51

ARCNA, perhaps for sampling reasons, is the only one out of line. On the basis of these results a suitable level/number index might be, aside from constants;

$$L70 + 9\log N70$$

as compared with the NNI:

$$L80 + 15\log N80 .$$

The levels of cut-off are shown by the '70' and '80'. However, the performance of this 'pseudo-NNI' is not markedly different from that of 24 hour Leq.

8.43 The analysis in section have, apart from the JUMP/STEP variables, used linear multiple regression. Non-linear forms can also be explored. For example, 'sigmoid'-type curves can be used, in which the response is at first slowly increasing with stimulus, then increases rapidly, and then back to a slow increase and final 'flattening-off'. The use of such forms might well increase the degree of fit somewhat, even though the simple fits here (eg, para 8.35) explain most of the data variation.

9 CONCLUSIONS

9.1 In the two previous sections the results from the noise measurement and social survey work have been described and analysed. This section presents some conclusions from the results in regard to the various questions discussed in Section 3. First, two points need to be emphasised:

(i) The study has been successful within the terms of its design - in particular the aim of 'disentangling' the effect of the aircraft noise level and the number of aircraft has been achieved

(ii) These conclusions are scientific and technical in their nature; the study does not prescribe guidelines or recommendations for government policy as regards airport planning, development criteria, or possible compensatory schemes.

9.2 In previous studies annoyance and disturbance arising from aircraft noise have been measured by a scale called the Guttman Annoyance Scale - GAS, synthesized from the responses to questions about general annoyance and interference with activities. This study confirms that GAS is a good measure of such disturbance. If variations on the construction method for GAS are explored, the resulting 'best scale' is little different from GAS. If other scales, such as the degree of 'acceptability' of aircraft noise or the proportion of the population very much annoyed by aircraft noise, are constructed they match very well with GAS. None of these other scales show statistically marked differences from GAS in the variation of responses with any of the noise 'stimuli' or other factors examined.

9.3 The major conclusion from the statistical estimation of Section 8 is that the use of the NNI expression places too much weight on the number of aircraft heard. In past studies the NNI expression was put forward as a combination of physical factors which matched well with the disturbance measured, i.e.

$$NNI = L + 15\log N - 80$$

with L the average noise level and N the number of aircraft heard. The two important features are the use of the logarithm of N - so proportionate increases in N give equal changes in NNI - and the coefficient '15' indicating the relative importance of the noise level and number terms. In this study no evidence has been found for a need for any stronger variation in N - such as a term linear in N. The 'trade-off' of 15 is not confirmed by the study results: a value of 9 or 10 gives a better match of disturbance responses to the physical variables. Statistical hypothesis testing shows that this best trade-off of 9 or 10 is very unlikely to be merely a product of sampling fluctuations from a true value nearer 15.

9.4 A good fit to the disturbance responses is found to be given by Leq, a measure of noise energy (see Glossary). This corresponds approximately to a trade-off of 10 between noise level and (logarithm of) number of aircraft. Of many Leq variables examined, the best - consistently over a number of disturbance scales - is the Leq averaged over the week prior to the social survey, measured over the whole 24 hours.* Note that the NNI uses movements over the day-time hours averaged over three months of the summer. This averaging of Leq was preferred statistically over 'worst-mode' estimates, i.e. focussing only on the exposure when the airport runway operations were at their 'worst' for the location in question.

9.5 Leq-based indices are in use in many other countries. In several cases the movements at certain times of the 24 hours are 'weighted', i.e. their noise energy is artificially adjusted up or down, with the idea of matching more closely with the relative intrusion of the aircraft noise. Thus, for example, the USA uses Day-Night Sound Level (L_{dn})in which all night movements are counted as 10dB higher than measured, because it is argued that night movements are more disturbing. The study results do not confirm the need for such major weightings; movements at night appear, if anything, less disturbing than daytime or evening movements (i.e. require a negative weighting); movements during the evening _might_ require a weighting of 1 or 2 dBA, but, when sampling fluctuations are taken into account, the rejection of any weighting at all is consistent with the study data.

9.6 A number of 'non-noise' factors have been incorporated in the statistical analyses of response and noise stimuli. These factors - known to statisticians as 'confounding factors' - affect response through economic, social or demographic means. The most important of these factors is found statistically to be the percentage of respondents in each area who either work at the airport or whose business is dependent on the airport. Other somewhat similar variables in their effect are the percentage of people with double-glazing and the percentage of shift workers. The airport-related percentage has particularly marked effects; for example in some of the study areas it can change the percentage of people who say the aircraft noise is 'not acceptable' by of the order of 25%.**

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* The fact that the disturbance response _at a particular time_ is best correlated with the previous week's Leq does not of course specify over what period of time an airports _annual_ noise exposure contours should be calculated. A summer period of high traffic (cf NNI) or the whole year (cf Ldn para 9.5) might be appropriate. That the prior week is the best match probably only confirms that response depends strongly on recent experience when this is not atypical (as applies in this study).

** It is not the intention that these confounding factors should generally be incorporated into an aircraft _noise_ index. Such factors have been included in the analysis to provide some explanation for _anomalies_ in response. The use of Leq would give a cautious estimate of disturbance, i.e. overestimates its magnitude, if the airport work factor discussed in para 9.6 is disregarded.

9.7 In this study localities near five airports have been examined, with the bulk of the respondents coming from areas near Heathrow. There is no strong evidence of any marked airport-dependent factor in disturbance, i.e. one resulting from people's reaction to a particular airport rather than a noise or (measurable) confounding factors. The responses from the non-Heathrow areas fall into the general pattern, given the necessary allowances for sampling fluctuations.

9.8 Given that Leq is preferred over NNI in the study results, what incorrect decisions may have been made through the use of NNI in the past? Figure 9.1 shows a plot of NNI against Leq for the study areas. The match is very good. In fact the match between the two measures will historically have been even better than that shown because the values of noise level and number of aircraft will have tended to be associated around airports, whereas in this study, by the artifices of area selection, the two factors are almost independent variables. Figure 9.2 shows the results for the average GAS score against the original NNI relationship.

9.9 NNI contours will have mis-stated the true pattern of disturbance in the following aspects:

(i) NNI contours will have exaggerated the effect of an increase in the number of aircraft, all other things being equal.

(ii) NNI calculations will not have taken into account the effects of movements producing less than 80 PNdB - the 'cut-off' in the count of aircraft movements - whereas for Leq there is no explicit cut-off.

(iii) NNI estimates will not have taken into account disproportionate increases in evening and night traffic.

(iv) NNI values do not include an allowance for the duration of noise events.

9.10 Are these in any cases major distortions? It has to be borne in mind that the accuracy of NNI contour estimates is 1 or 2 NNI units at best, and that this assumes a perfect ability to estimate traffic mix and numbers at an airport. Some part responses, keeping the same sub-paragraphs as above are:

(i) A doubling of traffic would produce an increase of 3 Leq units and 4.5 NNI units: the use of the NNI for a 'relative case' could therefore lead to an overestimate of effects.

(ii) The statistical examination of Section 8 of the relative merits of the L and logN combination with different cut-offs does not reveal much, if any, improvement through a lower threshold than 80 PNdB. Leq counts everything, but the dominant contribution is most usually by movements above 80 PNdB.

(iii) Without an evening/night weighting, movements in these periods generally contribute much less than half the total 24 hours noise energy. A doubling in the proportion of such movements is likely to add, at most, of the order of 1 dBA to the 24 hour Leq value. Such a doubling is probably not the general experience at major airports.

(iv) Changes in the duration of noise events will generally produce shifts of less than 1 dB in Leq values.

These are not complete responses to the issues raised, but do perhaps serve to indicate something of the magnitude of 'erroneous' effects.

9.11 Paragraph 9.10 (ii) does indicate where a major problem in the use of NNI might arise in the future. The introduction of a higher proportion of quieter aircraft (i.e. in terms of the L value measured at a location) could, over time, produce a drastic drop in the N value in NNI and hence NNI would also drop markedly, whereas Leq would not show such a dramatic drop in value*. The future pattern of civil transport operations is likely to be an increased number of comparatively less noisy aircraft. Continued use of NNI could therefore have serious consequences in the future as the NNI would provide an underestimate of disturbance.

9.12 The NNI contours which are most frequently used in development assessment are for NNI values of 35, 45 and 55; these values being taken by the Wilson Committee (Ref 1) to indicate low, moderate and high annoyance. For 24 hour Leq these correspond to about 56, 63 and 70 units (Figure 9.1) for the areas surveyed. The analysis of Section 8 indicates that for some choices of disturbance measure there is a 'step' in response at a value of Leq around 57. For example, the average community GAS score (which ranges from 0 to 6) has a jump of about 0.74 units just above this value. The percentage of people who say that aircraft are the most bothersome noise jumps by about 20% at around this value.

9.13 The jumps in response indicate a rapid increase in disturbance over a short Leq range. Figures 9.3 and 9.4 display these steps; but interestingly other response measures - see Figures 9.5 and 9.6 - do not show such a non-linear effect**. It may be conjectured that a Leq of around 57 is at about the magnitude of typical road traffic noise, so that at this point aircraft noise is becoming particularly noticeable as an environmental noise source. The fits to the data in the figures above are generally very good: there is no strong indication of anything but a smoothly increasing, nearly linear, variation of response against Leq, apart from the step already noted at around 57 Leq.

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* For example: 200 aircraft at 85 PNdB gives an NNI of 39.5. If 150 of these are replaced by quieter variants, so as to produce less than 80 PNdB, the average noise level of those aircraft above 80 PNdB would remain at 85 PBdB. The NNI would therefore drop to 30.5, i.e. by 9 units, whereas the Leq would decrease by about the same as the average peak noise level, i.e. by about 3 dBA.

** The response measures in these Figures have been adjusted to take account of the effect due to respondents working at the airport - see paragraph 9.6 and Section 8. The corresponding 'unadjusted' data are shown in Figures 9.7 to 9.10.

9,14 A linear variation does not lend itself to 'natural' statements regarding 'most relevant' annoyance levels - the Wilson Committee choices for NNI values (where response was approximately linear with NNI) are 'reasonable' but essentially arbitrary. In the following Table Leq values appropriate to certain reactions by specified proportions of the population are given as an illustration. The estimates are taken from the fitted lines to the Figures referred to above. (Note degree of extrapolation.)

		Most Bothersome Noise	Not Acceptable	'Very Much' Annoyed
	25%	49	55	57
Percentage of population agreeing	50%	58	62	67
	75%	61	69	77
	90%	67	74	83

Leq values for certain responses

As an example, the Table above shows that 50% of the population would say that aircraft noise exposure was 'not acceptable' at a Leq value of 62. The table shows the pronounced jump at around 58 Leq for the 'most bothersome' noise - a 25% increase in response by 61 Leq.

9.15 What values of Leq could be used on which to base planning/ development criteria and possible compensatory schemes? To reiterate, apart from the jump in response at about 57 Leq, there is a smooth, almost linear, variation of disturbance with Leq - no other natural values are presented for significant Leq levels for use as policy tools. These are facts which further research work, of even greater scope, is *not* likely to change. A decision on Leq values for policy tools must therefore be judgemental, albeit consistent with the pattern of results found here.

9.16 One suggestion, which has the merits of consistency with the present study results and a minimum of discontinuity from past methods, is to use Leq approximations to 35 and 55 NNI, thus

- Onset of Community Disturbance - 55 Leq

This approximates to 35 NNI. It is just below the jump in disturbance detected for some measures of response. The value of 55 Ldn is used in airport assessment in the USA.

- High Disturbance - 70 Leq

This approximates to 55 NNI. It represents an aircraft noise exposure which is,

(i) 'Very Much' annoying to around 2/3 of the population,
(ii) 'Not Acceptable' to 3/4 of the population, and
(iii) the 'Most Bothersome Noise' to 9 out of 10 of people.

It should be emphasised that these suggestions would be guideline figures for application, not rigid prescriptions.

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TABLE 4.1: Target L - N matrix of sites around Heathrow*

L (PNdB) N	80-85.9 (83)	86-91.9 (89)	92-97.9 (95)	98-103.9 (101)
23.7-42.1 (31.6)	Woodham 4 NNI = 25.5	Willesden Green 3 NNI = 31.5	Harlesden 1 & 2 NNI = 37.5 **	Ealing 23 NNI = 43.5 (1980)
42.2-75 (56.2)	Chiswick 5 NNI = 29.3	NNI = 35.3	Egham 24 NNI = 41.3 (1980)	NNI = 47.3
75.1-133.4 (100)	NNI = 33	NNI = 39	Slough 10 NNI = 45 (1980)	Feltham 6&7 NNI = 51 **
133.5-237.1 (177.8)	Stanwell I,II 13 & 14 NNI = 36.8	Sheen 26 NNI = 42.8 (1980)	Isleworth 29 NNI = 48.8	Hounslow 8 NNI = 54.8
237.2-421.7 (316.2)	Stanwell III IV, 15 & 16 NNI = 40.5	Hounslow Central 12 NNI = 46.5	Hounslow West 11 NNI = 52.5	Colnbrook 10 NNI = 58.5

area name
data base no.
target NNI
(trials site)
double sampled site

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* Non Heathrow Sites , with actual L,N from Appendix C:

Ifield: (Gatwick)	17	L = 83.4 N = 76.5	NNI = 31.7
Horley: (Gatwick)	18	L = 90.3 N = 111.0	NNI = 41.0
Luton:	21 & 22 **	L = 97.2 N = 32.4	NNI = 39.9
Manchester:	19	L = 91.8 N = 46.6	NNI = 36.8
Aberdeen:	20	L = 95.0 N = 17.6	NNI = 33.7

TABLE 5.1: Response rates and dates of surveys

SURVEY AREA	DATES OF SURVEY	ADDRESSES ISSUED	COMPLETED QUESTION-NAIRES	RESPONSE RATE
HEATHROW				
(N) SLOUGH	6th-27th August 1980	100	72	72.0%
(N) EALING	6th-27th August 1980	100	77	77.0%
(N) EGHAM	6th August-1st September 1980	100	77	77.0%
(N) SHEEN	19th August-3rd September 1980	100	72	72.0%
(N) CRANFORD	19th August-3rd September 1980	100	76	76.0%
(A) CHISWICK	2nd-4th July 1982	120	75	62.5%
(A) HOUNSLOW CENTRAL	2nd-4th July 1982	120	71	59.2%
(A) WILLESDEN GREEN	2nd-4th July 1982	120	66	55.0%
(A) HARLESDEN	9th-11th July 1982	240	132	55.0%
(A) HOUNSLOW WEST	9th-11th July 1982	120	76	63.3%
(A) ISLEWORTH	9th-11th July 1982	120	71	59.2%
(A) FELTHAM	16th-19th July 1982	240	176	73.3%
(A) COLNBROOK	23rd-26th July 1982	120	83	69.2%
(A) STANWELL I & II †	23rd-26th July 1982	240	177	73.8%
(A) HOUNSLOW	30th July-2nd August 1982	120	82	68.3%
(A) STANWELL III & IV †	30th July-2nd August 1982	240	180	75.0%
(A) WOODHAM	30th July-2nd August 1982	120	94	78.3%
GATWICK				
(A) IFIELD	16th-19th July 1982	120	90	75.0%
(A) MORLEY	23rd-26th July 1982	120	90	75.0%
(A) LUTON	16th-19th July 1982	240	159	66.3%
(A) MANCHESTER	3rd-6th September 1982	120	76	63.3%
(H) ABERDEEN	20th-23rd August 1982	120	101	84.2%
		3140 *	2173	69.2%

(A) indicates a survey area from the Aircraft Noise Index Study

(H) indicates a survey area from the Helicopter Disturbance Study

(N) indicates a survey area from the noise Index Trials

*Of the 3140 addresses issued, 103 were 'out of scope' (premises vacant or derelict, used for business or industrial purposes only, untraceable). Based on this reduced sample of 3037, the response rate was 71.6%

†Stanwell I and II and Stanwell III and IV were each split into two separate areas after the surveys were carried out; Stanwell is therefore tabulated as four distinct areas.

TABLE 6.1 Noise Levels - Evening

AREAS WITH DOUBLE SAMPLES SPLIT	THREE MONTH L80	ONE MONTH L80	ONE WEEK L80	WORST MODE L80	THREE MONTH L75	ONE MONTH L75	ONE WEEK L75	WORST MODE L75	THREE MONTH L70	ONE MONTH L70	ONE WEEK L70	WORST MODE L70
HARLESDEN A	91.9	91.4	91.2	93.4	90.7	90.2	90.1	92.5	89.6	88.9	88.6	92.4
HARLESDEN B	91.9	91.4	91.2	93.4	90.7	90.2	90.1	92.5	89.6	88.9	88.6	92.4
WILLESDEN	90.1	90.2	87.1	90.3	88.2	88.6	83.0	89.5	86.9	87.5	80.2	89.4
WOODHAM	86.7	86.7	86.6	86.6	84.6	84.4.	84.3	85.0	83.7	82.9	82.0	84.5
CHISWICK	85.9	85.9	85.7	86.0	83.7	83.6	83.9	84.0	83.1	82.9	83.3	83.7
FELTHAM A	94.0	93.8	95.2	96.1	92.6	92.5	94.2	95.4	91.9	91.7	93.8	95.1
FELTHAM B	94.0	93.8	95.2	96.1	92.6	92.5	94.2	95.4	91.9	91.7	93.8	95.1
HOUNSLOW	105.1	103.4	96.6	106.6	105.0	103.3	96.5	106.5	105.0	103.3	96.5	106.5
ISLEWORTH	98.7	98.7	98.9	99.8	98.0	98.0	98.3	99.8	97.7	97.7	98.0	99.8
COLNBROOK	97.7	97.3	97.1	100.9	97.7	97.2	97.1	100.9	97.7	97.2	97.1	100.9
HOUNSLOW W	91.6	91.2	91.0	95.2	90.6	90.1	89.9	95.1	90.4	89.9	89.7	95.0
HOUNSLOW C	90.6	90.6	91.5	92.4	89.8	89.8	90.7	91.8	89.7	89.7	90.6	91.8
STANWELL I	86.9	86.8	86.1	87.4	85.3	85.3	84.4	86.7	84.5	84.5	83.4	86.5
STANWELL II	87.2	87.5	89.9	86.1	84.0	84.0	84.8	83.3	82.1	82.1	82.1	82.3
STANWELL III	89.4	88.9	89.0	90.6	88.0	87.5	87.7	90.1	87.4	86.9	87.2	89.8
STANWELL IV	88.2	87.7	87.6	88.9	86.8	86.4	86.5	88.2	85.6	85.3	85.8	87.8
IFIELD	83.4	83.3	84.1	85.0	82.0	82.0	82.4	82.9	81.7	81.7	81.9	82.3
HORLEY	89.4	89.3	88.9	89.6	87.5	87.6	87.7	87.5	86.6	86.7	87.1	86.5
MANCHESTER	89.6	89.4	89.4	89.4	89.0	88.8	88.8	88.8	88.7	88.5	88.5	88.5
ABERDEEN	91.9	91.9	91.7	92.0	90.6	90.7	90.6	91.1	90.2	90.3	90.2	90.9
LUTON A	95.2	95.0	93.6	97.3	94.0	93.9	92.7	96.1	93.5	93.4	92.1	95.6
LUTON B	95.2	95.0	93.6	97.3	94.0	93.9	92.7	96.1	93.5	93.4	92.1	95.6
EALING	97.7	97.7	97.7	97.7	97.7	97.7	97.7	97.7	97.7	97.7	97.7	97.7
EGHAM	96.5	96.7	95.0	98.1	96.2	96.4	94.7	97.8	96.0	96.2	94.5	97.5
SLOUGH	94.6	94.1	95.8	96.4	94.3	93.8	95.5	96.2	93.7	93.2	94.9	95.6
SHEEN	89.9	89.9	90.5	90.9	89.3	89.3	90.0	90.5	89.1	89.1	89.8	90.3

* NOTE The definitions of the noise metrics used in this table are completely analogous to the day metrics in the compact database (Appendix C), only the time period is changed.

TABLE 6.2 Noise Levels - Night

AREAS WITH DOUBLE SAMPLES SPLIT	THREE MONTH L80	ONE MONTH L80	ONE WEEK L80	WORST MODE L80	THREE MONTH L75	ONE MONTH L75	ONE WEEK L75	WORST MODE L75	THREE MONTH L70	ONE MONTH L70	ONE WEEK L70	WORST MODE L70
HARLESDEN A	84.1	83.8	83.4	85.7	83.0	82.7	82.3	84.2	81.2	80.7	80.1	84.2
HARLESDEN B	84.1	83.8	83.4	85.7	83.0	82.7	82.3	84.2	81.2	80.7	80.1	84.2
WILLESDEN	84.7	84.2	85.4	87.1	82.7	82.7	82.9	83.0	80.5	80.5	80.3	80.2
WOODHAM	85.8	85.8	85.8	85.8	84.5	84.1	84.0	84.8	83.3	82.2	81.8	84.4
CHISWICK	84.1	84.1	84.1	84.1	83.0	83.0	83.0	83.1	82.4	82.7	82.1	83.0
FELTHAM A	91.9	92.0	94.0	95.0	90.9	90.9	93.4	94.6	89.9	89.9	93.0	94.6
FELTHAM B	91.9	92.0	94.0	95.0	90.9	90.9	93.4	94.6	89.9	89.9	93.0	94.6
HOUNSLOW	105.7	105.5	105.5	106.1	105.5	105.4	105.5	106.1	105.5	105.4	105.5	106.1
ISLEWORTH	96.8	97.9	96.9	98.9	95.6	97.2	95.6	98.9	95.3	97.0	95.4	98.9
COLNBROOK	94.7	94.8	94.4	96.2	94.7	94.8	94.4	96.2	94.7	94.8	94.4	96.2
HOUNSLOW W	87.6	87.1	86.9	92.0	87.3	86.9	86.6	91.7	87.3	86.9	86.6	91.7
HOUNSLOW C	89.1	88.0	89.9	91.1	88.8	87.7	89.6	90.8	88.8	87.7	89.6	90.8
STANWELL I	86.6	86.6	86.4	86.9	85.3	85.5	85.4	86.3	84.4	84.6	84.6	85.9
STANWELL II	87.3	87.0	86.9	87.7	84.1	84.0	83.1	84.8	82.4	82.3	81.0	83.8
STANWELL III	89.7	89.8	89.9	90.9	88.3	88.5	88.8	90.2	87.9	88.0	88.4	90.0
STANWELL IV	87.9	87.8	87.9	88.8	86.9	86.7	86.8	88.3	85.7	85.9	86.2	88.0
IFIELD	84.5	84.5	85.6	86.8	83.3	83.4	84.5	85.9	83.0	83.1	84.1	85.4
HORLEY	89.6	89.5	89.1	90.0	88.6	88.6	88.5	88.7	88.1	88.1	88.2	88.0
MANCHESTER	89.3	87.8	87.8	96.0	88.7	87.1	87.1	95.5	88.5	86.9	86.9	95.5
ABERDEEN	-	-	-	-	-	-	-	-	-	-	-	-
LUTON A	95.6	95.7	94.5	97.5	94.4	94.5	93.5	96.0	94.0	94.1	93.2	95.7
LUTON B	95.6	95.7	94.5	97.5	94.4	94.5	93.5	96.0	94.0	94.1	93.2	95.7
EALING	95.2	95.2	95.2	95.2	95.2	95.2	95.2	95.2	95.2	95.2	95.2	95.2
EGHAM	94.7	94.6	94.5	95.5	94.6	94.3	94.2	95.3	93.9	93.9	93.9	94.7
SLOUGH	89.2	89.2	89.2	89.3	88.4	88.4	88.4	88.8	87.8	87.7	87.8	88.1
SHEEN	90.8	90.9	91.0	91.4	90.7	90.7	90.8	91.3	90.5	90.5	90.7	91.1

* See note Table 6.1.

TABLE 6.3 Number of Aircraft - Evening

AREAS WITH DOUBLE SAMPLES SPLIT	THREE MONTH N80	ONE MONTH N80	ONE WEEK N80	WORST MODE N80	THREE MONTH N75	ONE MONTH N75	ONE WEEK N75	WORST MODE N75	THREE MONTH N70	ONE MONTH N70	ONE WEEK N70	WORST MODE N70
HARLESDEN A	5.6	5.0	4.7	16.6	7.4	6.5	6.2	20.6	9.9	9.2	9.0	21.8
HARLESDEN B	5.6	5.0	4.7	16.6	7.4	6.5	6.2	20.6	9.9	9.2	9.0	21.8
WILLESDEN	4.1	5.3	0.4	17.1	6.9	8.1	3.0	20.6	9.7	10.8	6.2	21.9
WOODHAM	4.1	2.9	2.0	6.5	7.5	5.6	4.0	10.1	9.6	8.2	7.3	12.0
CHISWICK	10.5	9.1	10.2	22.6	20.1	18.3	17.7	41.4	24.9	23.1	21.6	48.2
FELTHAM A	15.8	15.3	22.8	43.3	22.5	21.8	29.1	51.3	26.8	26.1	32.2	55.0
FELTHAM B	15.8	15.3	22.8	43.3	22.5	21.8	29.1	51.3	26.8	26.1	32.2	55.0
HOUNSLOW	28.5	29.4	24.6	55.4	29.0	29.7	24.9	55.7	29.0	29.8	25.0	55.8
ISLEWORTH	30.0	29.0	30.8	57.3	35.5	34.5	36.0	57.5	38.6	37.9	39.2	57.6
COLNBROOK	51.7	50.9	48.0	60.2	52.6	51.7	48.6	60.7	52.6	51.8	48.7	60.8
HOUNSLOW W	38.8	38.2	38.1	52.2	49.9	49.7	49.8	53.4	54.2	54.3	54.2	54.7
HOUNSLOW C	39.9	40.5	41.0	46.6	48.4	48.6	49.5	52.9	51.5	51.7	52.5	54.9
STANWELL I	24.5	25.0	22.4	37.5	36.6	37.1	35.3	45.0	45.2	45.6	46.1	48.0
STANWELL II	8.9	8.3	4.0	14.7	21.4	20.9	14.9	32.8	34.6	34.0	28.9	43.3
STANWELL III	29.0	28.0	30.3	43.4	42.5	41.5	42.2	49.9	48.3	47.2	47.2	52.8
STANWELL IV	24.1	25.5	30.8	39.5	34.0	35.9	40.8	46.3	45.1	46.1	48.5	50.5
IFIELD	15.7	15.8	14.2	12.2	25.4	25.5	24.3	22.8	29.0	29.0	29.0	28.9
HORLEY	25.2	25.2	24.9	25.4	41.3	39.6	33.7	45.2	53.4	50.6	40.4	60.2
MANCHESTER	14.4	18.3	18.0	18.8	16.3	20.8	20.3	21.2	17.9	22.6	22.1	23.1
ABERDEEN	2.1	3.3	2.1	4.6	4.5	4.5	3.4	6.0	4.9	5.1	4.0	6.4
LUTON A	6.6	6.9	8.2	5.0	8.9	9.2	10.5	6.8	10.3	10.8	12.0	7.8
LUTON B	6.6	6.9	8.2	5.0	8.9	9.2	10.5	6.8	10.3	10.8	12.0	7.8
EALING	3.1	6.0	3.7	26.8	3.1	6.0	3.7	26.8	3.1	6.0	3.7	26.8
EGHAM	14.5	13.5	13.5	17.5	15.5	14.6	14.2	19.0	17.4	16.4	15.5	22.1
SLOUGH	19.9	17.0	21.0	25.7	21.5	18.5	22.3	27.0	24.5	21.2	25.4	30.7
SHEEN	44.2	41.8	47.8	58.5	50.9	48.1	53.3	63.5	54.7	51.7	56.9	67.5

* See note Table 6.1.

TABLE 6.4 Number of Aircraft - Night

AREAS WITH DOUBLE SAMPLES SPLIT	THREE MONTH N80	ONE MONTH N80	ONE WEEK N80	WORST MODE N80	THREE MONTH N75	ONE MONTH N75	ONE WEEK N75	WORST MODE N75	THREE MONTH N70	ONE MONTH N70	ONE WEEK N70	WORST MODE N70
HARLESDEN A	0.8	0.8	0.8	1.0	1.2	1.2	1.2	1.6	2.1	2.0	2.1	1.7
HARLESDEN B	0.8	0.8	0.8	1.0	1.2	1.2	1.2	1.6	2.1	2.0	2.1	1.7
WILLESDEN	0.3	0.3	0.2	0.1	1.1	1.0	1.0	1.0	1.9	1.8	1.9	2.0
WOODHAM	0.6	0.4	0.4	0.7	1.0	0.9	0.8	1.2	1.6	1.6	1.6	1.5
CHISWICK	4.3	6.3	3.4	12.8	5.9	8.4	4.7	16.8	7.1	9.5	5.9	18.2
FELTHAM A	2.9	3.0	3.7	5.0	3.6	3.6	4.1	5.5	4.6	4.7	4.6	5.6
FELTHAM B	2.9	3.0	3.7	5.0	3.6	3.6	4.1	5.5	4.6	4.7	4.6	5.6
HOUNSLOW	8.1	7.3	7.7	16.8	8.3	7.4	7.8	16.8	8.3	7.4	7.8	16.8
ISLEWORTH	9.1	11.8	10.9	16.8	12.5	14.1	14.9	16.8	13.8	14.9	16.4	16.8
COLNBROOK	4.8	3.5	2.5	4.0	4.8	3.5	2.5	4.0	4.8	3.5	2.5	4.0
HOUNSLOW W	11.3	11.8	13.0	4.9	12.1	12.7	13.8	5.2	12.3	12.9	13.9	5.3
HOUNSLOW C	13.2	12.7	14.1	15.2	14.3	13.8	15.2	16.3	14.5	13.9	15.5	16.5
STANWELL I	2.2	2.4	2.6	3.3	3.2	3.2	3.2	3.9	4.1	4.1	4.1	4.3
STANWELL II	0.8	0.9	0.6	1.3	2.0	2.0	1.8	2.9	3.1	3.2	3.0	3.8
STANWELL III	2.8	2.8	3.0	3.9	4.1	3.8	4.0	4.7	4.4	4.3	4.3	4.9
STANWELL IV	2.2	2.4	2.6	3.4	3.0	3.3	3.6	3.9	4.0	4.0	4.1	4.2
IFIELD	10.5	10.6	11.2	12.1	15.1	15.1	15.3	15.6	17.2	17.2	17.4	17.8
HORLEY	12.2	12.5	13.4	11.6	16.0	15.9	15.6	16.2	18.7	18.2	17.0	19.5
MANCHESTER	11.3	14.1	14.0	3.4	13.5	16.7	16.7	3.9	14.3	17.8	17.8	4.0
ABERDEEN	-	-	-	-	-	-	-	-	-	-	-	-
LUTON A	12.1	12.6	11.8	10.7	16.4	17.3	14.9	15.6	18.6	19.6	16.6	17.6
LUTON B	12.1	12.6	11.8	10.7	16.4	17.3	14.9	15.6	18.6	19.6	16.6	17.6
EALING	0.2	0.3	0.2	2.2	0.2	0.3	0.2	2.2	0.2	0.3	0.2	2.2
EGHAM	2.4	2.1	2.3	2.6	2.5	2.4	2.5	2.8	2.9	2.7	2.7	3.2
SLOUGH	1.1	1.0	1.1	1.6	1.4	1.3	1.4	1.8	1.6	1.5	1.5	2.0
SHEEN	19.2	17.4	19.2	21.2	19.7	18.3	19.6	21.3	20.5	18.7	20.3	22.3

* See note Table 6.1

TABLE 6.5 Modal splits of operation for three months mid June to mid September 1982

AIRPORT	% of movements 'west'	% of movements 'east'
	DAY 0700-1900LT	
Heathrow	72.5	27.5
Gatwick	70.0	30.0
Luton	74.1	25.9
Manchester	75.5	24.5
Aberdeen	38.0 (runway 35)	62.0 (runway 17)
	EVENING 1900-2300LT	
Heathrow	77.8	22.2
Gatwick	76.0	24.0
Luton	74.2	25.8
Manchester	74.0	26.0
Aberdeen	33.7	66.3
	NIGHT 2300-0700LT	
Heathrow	79.0	21.0
Gatwick	76.5	23.5
Luton	73.1	26.9
Manchester	70.2	29.8
Aberdeen	No Night Movements	

TABLE 6.6 Modal splits of operation for the period 0700-1900LT 30 days prior to the surveys conducted in 1982

Measurement Site	% of movements 'west'	% of movements 'east'
Harlesden	77.5	22.5
Willesden	64.5	35.5
Woodham	53.8	46.2
Chiswick	64.5	35.5
Feltham	70.9	29.1
Hounslow	53.8	46.2
Isleworth	77.5	22.5
Colnbrook	64.8	35.2
Hounslow West	77.5	22.5
Hounslow Central	64.5	35.5
Stanwell I	64.8	35.2
Stanwell II	64.8	35.2
Stanwell III	53.8	46.2
Stanwell IV	53.8	46.2
Ifield	68.2	31.8
Horley	53.7	46.3
Manchester	97.4	2.6
Aberdeen	30.4 (runway 35)	69.6 (runway 17)
Luton	71.2	28.8

TABLE 6.7 Modal splits of operation for the period 1900-2300LT 30 days prior to the surveys conducted in 1982

Measurement Site	% of movements 'west'	% of movements 'east'
Harlesden	82.8	17.2
Willesden	70.7	29.3
Woodham	53.7	46.3
Chiswick	70.7	29.3
Feltham	79.2	20.8
Hounslow	53.7	46.3
Isleworth	82.8	17.2
Colnbrook	69.2	30.8
Hounslow West	82.8	17.2
Hounslow Central	70.7	29.3
Stanwell I	69.2	30.8
Stanwell II	69.2	30.8
Stanwell III	53.7	46.3
Stanwell IV	53.7	46.3
Ifield	77.1	22.9
Horley	66.3	33.7
Manchester	97.5	2.5
Aberdeen	31.1 (runway 35)	68.9 (runway 17)
Luton	72.5	27.5

TABLE 6.8 Modal splits of operation for the period 2300-0700LT 30 days prior to the surveys conducted in 1982

Measurement Site	% of movements 'west'	% of movements 'east'
Harlesden	87.4	12.6
Willesden	73.8	26.2
Woodham	61.5	38.5
Chiswick	73.8	26.2
Feltham	78.8	21.2
Hounslow	61.5	38.5
Isleworth	87.4	12.6
Colnbrook	69.4	30.6
Hounslow West	87.4	12.6
Hounslow Central	73.8	26.2
Stanwell I	69.4	30.6
Stanwell II	69.4	30.6
Stanwell III	61.5	38.5
Stanwell IV	61.5	38.5
Ifield	74.9	25.1
Horley	65.9	34.1
Manchester	94.3	5.7
Aberdeen	No Night Movements	
Luton	71.4	28.6

TABLE 6.9 Modal splits of operation for the period 0700-1900LT 7 days prior to the surveys conducted in 1982

Measurement Site	% of movements 'west'	% of movements 'east'
Harlesden	85.7	14.3
Willesden	87.9	12.1
Woodham	43.8	56.2
Chiswick	87.9	12.1
Feltham	32.5	67.5
Hounslow	43.8	56.2
Isleworth	85.7	14.3
Colnbrook	32.3	67.7
Hounslow West	85.7	14.3
Hounslow Central	87.9	12.1
Stanwell I	32.3	67.7
Stanwell II	32.3	67.7
Stanwell III	43.8	56.2
Stanwell IV	43.8	56.2
Ifield	25.8	74.2
Horley	31.7	68.3
Manchester	99.7	0.3
Aberdeen	42.2 (runway 35)	57.8 (runway 17)
Luton	49.3	50.7

TABLE 6.10 Modal splits of operation for the period 1900-2300LT 7 days prior to the surveys conducted in 1982

Measurement Site	% of movements 'west'	% of movements 'east'
Harlesden	84.3	15.7
Willesden	100.0	0
Woodham	31.2	68.8
Chiswick	100.0	0
Feltham	57.4	42.6
Hounslow	31.2	68.8
Isleworth	84.3	15.7
Colnbrook	29.4	70.6
Hounslow West	84.3	15.7
Hounslow Central	100.0	0
Stanwell I	29.4	70.6
Stanwell II	29.4	70.6
Stanwell III	31.2	68.8
Stanwell IV	31.2	68.8
Ifield	42.6	57.4
Horley	30.4	69.6
Manchester	95.4	4.6
Aberdeen	56.4 (runway 35)	43.6 (runway 17)
Luton	52.1	47.9

TABLE 6.11 Modal splits of operation for the period 2300-0700LT 7 days prior to the surveys conducted in 1982

Measurement Site	% of movements 'west'	% of movements 'east'
Harlesden	98.2	1.8
Willesden	88.6	11.4
Woodham	52.9	47.1
Chiswick	88.6	11.4
Feltham	45.0	55.0
Hounslow	52.9	47.1
Isleworth	98.2	1.8
Colnbrook	39.3	60.7
Hounslow West	98.2	1.8
Hounslow Central	88.6	11.4
Stanwell I	39.3	60.7
Stanwell II	39.3	60.7
Stanwell III	52.9	47.1
Stanwell IV	52.9	47.1
Ifield	47.8	52.2
Horley	36.4	63.6
Manchester	94.0	6.0
Aberdeen	No Night Movements	
Luton	43.5	56.5

TABLE 6.12 Modal splits of operation at Heathrow for three months mid June to mid September 1980

% movements 'west'		% movements 'east'
	DAY 0700-1900LT	
88.0		12.0
	EVENING 1900-2300LT	
88.3		11.7
	NIGHT 2300-0700LT	
91.0		9.0

TABLE 6.13 Modal splits of operation for the period 0700-1900LT 30 days prior to the surveys conducted in 1980

Measurement Site	% of movements 'west'	% of movements 'east'
Ealing	82.6	17.4
Egham	82.6	17.4
Slough	82.6	17.4
Sheen	78.6	21.4

TABLE 6.14 Modal splits of operation for the period 1900-2300LT 30 days prior to the surveys conducted in 1980

Measurement Site	% of movements 'west'	% of movements 'east'
Ealing	77.7	22.3
Egham	77.7	22.3
Slough	77.7	22.3
Sheen	82.5	17.5

TABLE 6.15 Modal splits of operation for the period 2300-0700LT 30 days prior to the surveys conducted in 1980

Measurement Site	% of movements 'west'	% of movements 'east'
Ealing	85.9	14.1
Egham	85.9	14.1
Slough	85.9	14.1
Sheen	82.5	17.5

TABLE 6.16 Modal splits of operation for the period 0700-1900LT 7 days prior to the surveys conducted in 1980

Measurement Site	% of movements 'west'	% of movements 'east'
Ealing	90.1	9.9
Egham	90.1	9.9
Slough	90.1	9.9
Sheen	86.1	13.9

TABLE 6.17 Modal splits of operation for the period 1900-2300LT 7 days prior to the surveys conducted in 1980

Measurement Site	% of movements 'west'	% of movements 'east'
Ealing	86.3	13.7
Egham	86.3	13.7
Slough	86.3	13.7
Sheen	86.1	13.9

TABLE 6.18 Modal splits of operation for the period 2300-0700LT 7 days prior to the surveys conducted in 1980

Measurement Site	% of movements 'west'	% of movements 'east'
Ealing	91.6	8.4
Egham	91.6	8.4
Slough	91.6	8.4
Sheen	90.7	9.3

TABLE 7.1 : ANAS Scores by Frequency of Annoyance*

FREQUENCY		many times a day	3-4 times a day	1-2 times a day	a few times a week	a few times a month	less often	total
ANAS SCORE								
1	%	7.6	25.5	34.9	52.5	66.7	87.0	
	no.	39	49	103	155	98	60	504
2	%	30.0	54.2	49.5	36.6	27.2	11.6	
	no.	155	104	146	108	40	8	561
3	%	62.4	20.3	15.6	10.8	6.1	1.4	
	no.	322	39	46	32	9	1	449
TOTAL		516	192	295	295	147	69	1514

NOTE: Respondents scored 0 on the ANAS scale if and only if they did not hear aircraft or were not bothered by aircraft. If they gave one of these responses to question 10, or question 11a, they were not asked about frequency of annoyance (9.11b).

* In some of the following tables, percentages refer to column data; e.g. in Table 7.1, 7.6% of 516 is 39.

TABLE 7.2 : Marital Status vs ANAS Score

ANAS Score	Married	Single	Other	
0 %	25.2	26.2	35.9	26.7
no.	352	112	94	558
1 %	23.6	29.3	22.5	24.6
no.	329	125	59	513
2 %	27.6	30.0	19.1	27.0
no.	386	128	50	564
3 %	23.6	14.5	22.5	21.6
no.	330	62	59	451
TOTALS	1397	427	262	2086

(Other = widowed, divorced)

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* In this Table, and some of the following, percentages refer to the column data, eg in Table 7.1, 7.6% of 516 is 39.

TABLE 7.3 : Response to Guttman question for four 'extreme' sites

Question		Woodham	Stanwell II	Isleworth	Colnbrook
17i	Concentration	11.7%	11.3%	56.3%	34.9%
17ii	Rest & Relaxation	19.2%	13.4%	56.2%	39.8%
17iii	Shutting Windows	4.3%	14.4%	66.2%	69.9%
17iv	Startled	6.4%	5.2%	25.4%	15.7%
17v	Awoken	8.5%	7.2%	46.5%	20.5%
17vi	Television/Radio/ HiFi Viewing and Listening	24.5%	26.8%	88.7%	81.9%
17vii	Television Flicker	12.8%	15.5%	33.8%	33.7%
17viii	House Vibrates	29.8%	13.4%	71.8%	63.9%
17ix	Conversation	23.4%	23.7%	78.9%	77.5%
17x	Other Activity	4.3%	2.1%	28.2%	21.7%
17xi	Other	0.0%	1.1%	9.9%	9.6%

TABLE 7.4 : Comparison of Scales

ANAS	OGAS	NGAS	SCALE7
0	0.4	0.1	1.8
1	2.2	1.4	2.9
2	3.3	2.2	4.3
3	4.3	3.6	5.9

OGAS	ANAS	NGAS	SCALE7
0	0.0	0	1.6
1	0.9	0.8	2.3
2	1.4	1.3	3.3
3	1.9	2.1	4.3
4	2.2	2.7	4.9
5	2.5	3.7	5.6
6	2.7	4.6	6.2

TABLE 7.5 : Comparison of responses to Q12, 13, 14 for those in and those out during day *

	DAY	EVENING		NIGHT		ANAS	
		IN	OUT	IN	OUT		
Very Much Annoyed	18.6	19.7	17.7	7.3	6.0	23.4	%
	185	190	143	72	54	481	No.
Moderately Annoyed	23.7	21.6	27.7	8.7	7.3	28.8	%
	235	208	224	86	65	592	No.
A Little Annoyed	26.5	26.4	26.9	17.7	18.7	25.8	%
	263	254	218	174	167	529	No.
Not At All Annoyed	31.0	32.0	27.7	65.4	67.6	21.8	%
	308	308	224	644	604	448	No.
Don't Know	0.2	0.3	0.1	0.9	0.3	0.1	%
	2	3	1	9	3	2	No.
TOTAL	993	963	810	985	893	2052	

* Average difference in one week day/evening Leq (WIDE) is -3.1

Average difference in one week day/night Leq (WIDN) is -13.1

TABLE 7.6 : Evening and Night Disturbance and Exposure, relative to daytime

		NET % MORE BOTH'D EV'NGS	DROP IN dBA DAY TO EV'NG*	NET % MORE BOTH'D NIGHTS	DROP IN dBA DAY TO NIGHT *
1	Harlesden A	-23.3		-54.8	
2	B	-28.8	4.1	-47.2	22.0
3	Willesden Grn	- 9.1	3.9	-36.2	19.3
4	Woodham	-16.3	3.7	-43.2	15.3
5	Chiswick	- 4.7	1.2	-29.6	10.0
6	Feltham A	- 4.4	3.5	-78.7	15.3
7	B	- 8.2		-78.0	
8	Hounslow	+11.5	-0.2	-52.9	7.9
9	Isleworth	+14.6	1.0	-48.8	11.5
10	Colnbrook	-32.6	3.5	-72.7	19.1
11	Hounslow West	-22.0	3.5	-61.0	15.9
12	Hounslow Cen	-11.8	1.3	-55.6	10.5
13	Stanwell I	- 4.0	3.7	-22.0	6.8
14	Stanwell II	0.0	3.1	-14.3	15.7
15	Stanwell III	+12.1	3.1	-31.4	15.2
16	Stanwell IV	- 1.9	3.3	-23.6	16.3
17	Ifield	+ 7.3	1.3	- 1.8	4.7
18	Horley	+32.7	2.4	+10.0	9.0
19	Manchester	+12.2	2.9	-14.3	6.4
20	Aberdeen	- 8.8	8.1	-39.0	58.6
21	Luton A	+18.2	4.0	+13.6	3.9
22	B	+25.6		- 9.5	
23	Ealing	0.0	3.0	-75.9	21.3
24	Egham	+13.2	2.8	-56.1	15.6
25	Slough	-14.3	2.2	-62.9	12.5
26	Sheen	0.0	0.4	-46.0	6.5

* Three Month Average Mode Leq

TABLE 7.7 : Sensitivity vs Double-glazing

	Colnbrook		Hounslow West		Stanwell I	
	*	% of Total	*	% of Total	*	% of Total
more	17.9	15.7	12.5	13.2	6.2	12.7
same	29.9	32.5	53.1	46.1	59.4	64.6
less	50.7	50.6	31.2	38.2	34.4	20.3
don't know	1.5	1.2	3.1	2.6	0.0	2.5

	Stanwell III		Stanwell IV		Horley	
	*	% of Total	*	% of Total	*	% of Total
more	20.6	19.8	23.1	17.2	17.1	15.6
same	35.3	30.9	42.3	39.4	40.0	53.3
less	35.3	44.4	32.7	42.4	42.9	31.1
don't know	8.8	4.9	1.9	1.0	0.0	0.0

	Total Sample	
	*	% of Total
more	17.5	17.7
same	46.9	48.8
less	33.7	31.5
don't know	1.9	1.9

* Percentage of those who put in double-glazing because of noise

TABLE 8.1: spearman rank correlations

	AVOGAS	AVNGAS	OGASHI	NGASPOS	AVANAS	SCALE7	ARCAL2	OGASPOS	NGASH1	VMANN	ARCNA	ARCBOTH	NSEAL2	ARLVI3	NSENA	ANOISY	AXGOOD
AVOGAS	——																
AVNGAS	.9808	——															
OGASHI	.9720	.9616	——														
NGASPOS	.9497	.9576	.9322	——													
AVANAS	.9453	.9718	.9275	.9718	——												
SCALE7	.9446	.9636	.9577	.9383	.9469	——											
ARCAL2	.9391	.9537	.9036	.9859	.9638	.9085	——										
OGASPOS	.9338	.9616	.9178	.9780	.9373	.9059	.9550	——									
NGASHI	.9130	.9404	.9368	.8667	.9311	.9416	.8735	.8803	——								
VMANN	.9114	.9407	.9292	.9387	.9631	.9352	.9162	.8880	.9282	——							
ARCNA	.9050	.9458	.9316	.8831	.9221	.9592	.8441	.8648	.9729	.9169	——						
ARCBOTH	.8735	.8645	.8496	.8356	.8591	.9223	.8379	.8025	.8351	.8307	.8844	——					
NSEAL2	.8732	.8743	.8952	.8658	.8642	.8652	.8585	.8884	.8579	.8632	.8275	.7916	——				
ARCLIV3	.7825	.7683	.7818	.7017	.7729	.7969	.7249	.7226	.8206	.7564	.8223	.8799	.7879	——			
NSENA	.7608	.8625	.7762	.8393	.7345	.7521	.6870	.7124	.8935	.6983	.7926	.6254	.8274	.6433	——		
ANOISY	.2671	.4038	.3485	.3526	.2377	.3205	.1741	.2538	.5162	.2723	.4005	.1570	.5209	.2574	.6944	——	
AXGOOD	-.0591	.0536	-.0284	-.0175	-.0756	-.1031	-.1296	-.0185	.1248	-.0636	.0913	-.2157	-.0367	-.2768	.2773	.5581	——

TABLE 8.2 Response in areas (Isleworth, Colnbrook, Hounslow Central, Ifield, Manchester, Slough & Sheen) with small day/evening shifts *

		DAY	EVENING		NIGHT	
Annoyance			IN	OUT	IN	OUT
Very much	%	19.9	21.0	20.3	5.8	7.1
	no	54	56	46	16	17
moderately	%	26.8	21.7	31.7	11.7	8.4
	no	73	58	72	32	20
a little	%	23.9	27.0	25.6	18.6	22.6
	no	65	72	58	51	54
not at all	%	29.4	30.0	22.5	63.5	61.5
	no	80	80	51	174	147
Don't know	%	0.0	0.4	0.0	0.4	0.4
	no	0	1	0	1	1
TOTAL		272	267	227	274	236

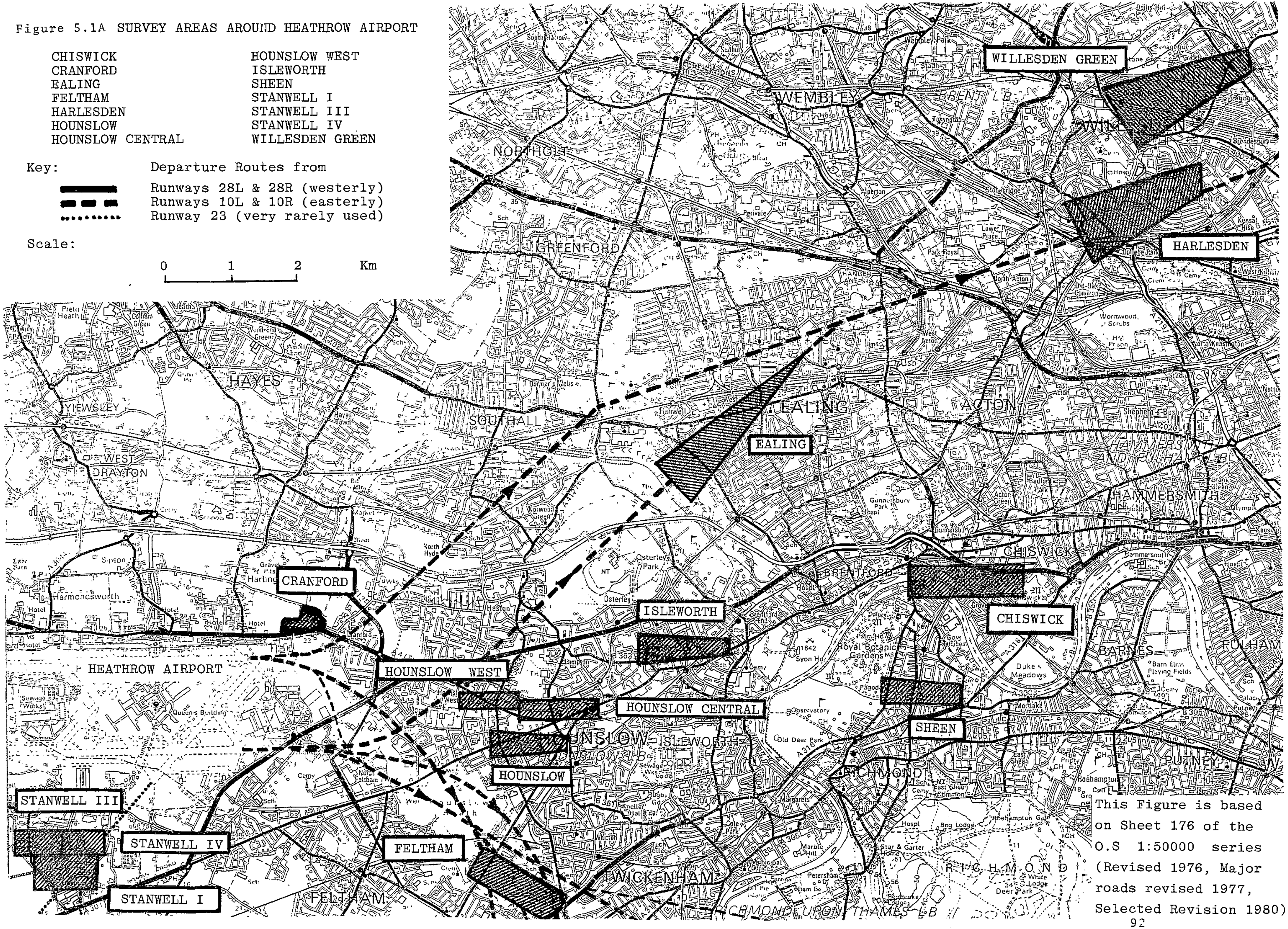
* compare with Table 7.5

TABLE 8.3 Response in areas (Hounslow, Ifield, Luton A&B) with small evening/night difference *

		DAY	EVENING		NIGHT	
Annoyance			IN	OUT	IN	OUT
Very much	%	24.7	25.0	20.3	7.8	9.2
	no	41	41	25	13	12
moderately	%	21.7	22.0	31.7	11.4	8.4
	no	36	36	39	19	11
a little	%	21.7	25.0	25.2	17.5	23.7
	no	36	41	31	29	31
not at all	%	31.3	26.8	22.8	62.7	58.0
	no	52	44	28	104	76
DK	%	0.6	1.2	0.0	0.6	0.8
		1	2	0	1	1
TOTAL		166	164	123	166	131

* compare with Table 7.5

Figure 5.1A SURVEY AREAS AROUND HEATHROW AIRPORT



CHISWICK	HOUNSLOW WEST
CRANFORD	ISLEWORTH
EALING	SHEEN
FELTHAM	STANWELL I
HARLESDEN	STANWELL III
HOUNSLOW	STANWELL IV
HOUNSLOW CENTRAL	WILLESDEN GREEN

Key: Departure Routes from

━━━━ Runways 28L & 28R (westerly)

▬ ▬ ▬ Runways 10L & 10R (easterly)

•••••••• Runway 23 (very rarely used)

Scale:

This Figure is based on Sheet 176 of the O.S 1:50000 series (Revised 1976, Major roads revised 1977, Selected Revision 1980)

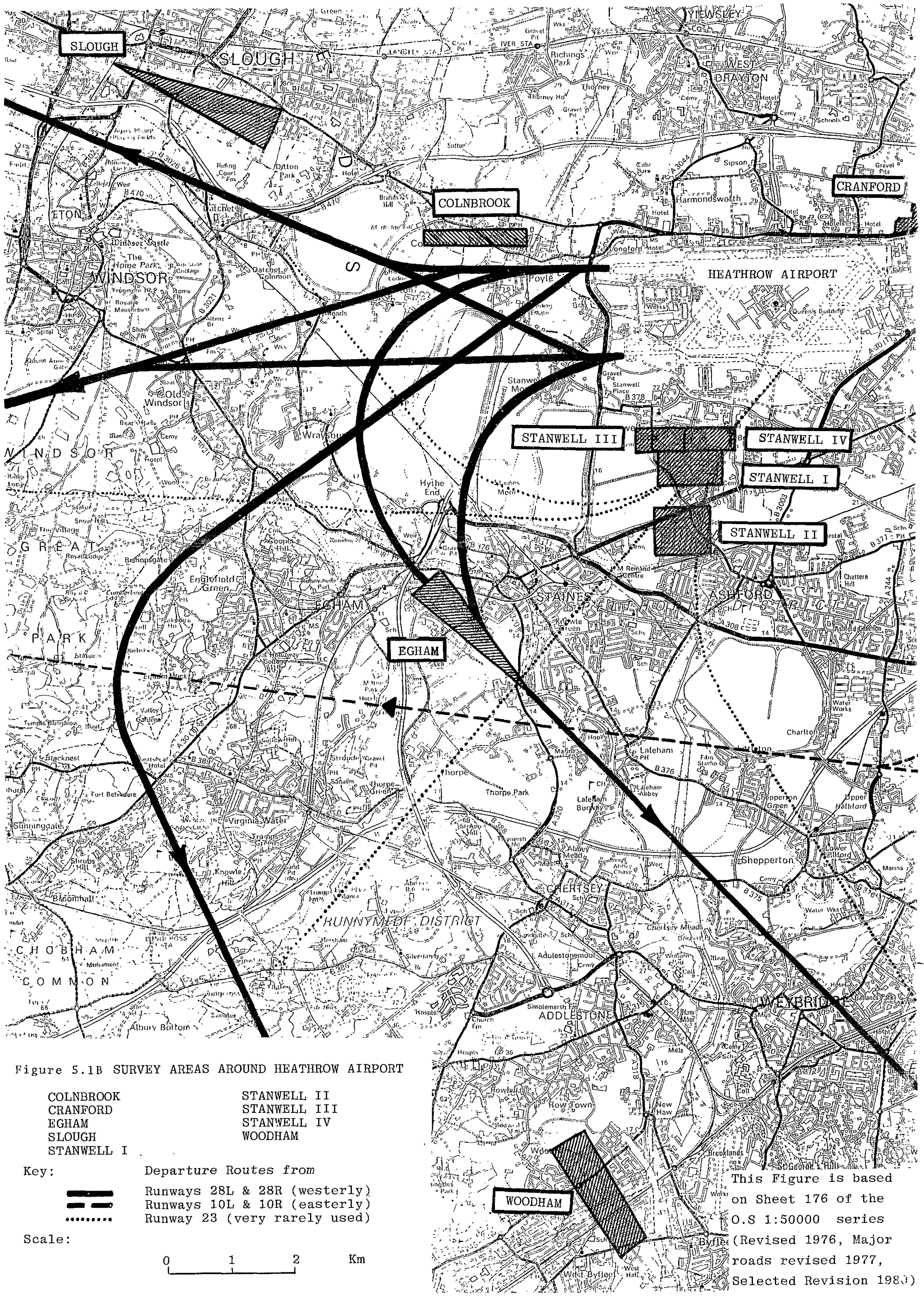


Figure 5.1B SURVEY AREAS AROUND HEATHROW AIRPORT

COLNBROOK
CRANFORD
EGHAM
SLOUGH
STANWELL I
STANWELL II
STANWELL III
STANWELL IV
WOODHAM

Key: Departure Routes from

━━ Runways 28L & 28R (westerly)
╍╍ Runways 10L & 10R (easterly)
⋯⋯ Runway 23 (very rarely used)

Scale: 0 1 2 Km

This Figure is based on Sheet 176 of the O.S 1:50000 series (Revised 1976, Major roads revised 1977, Selected Revision 1980)

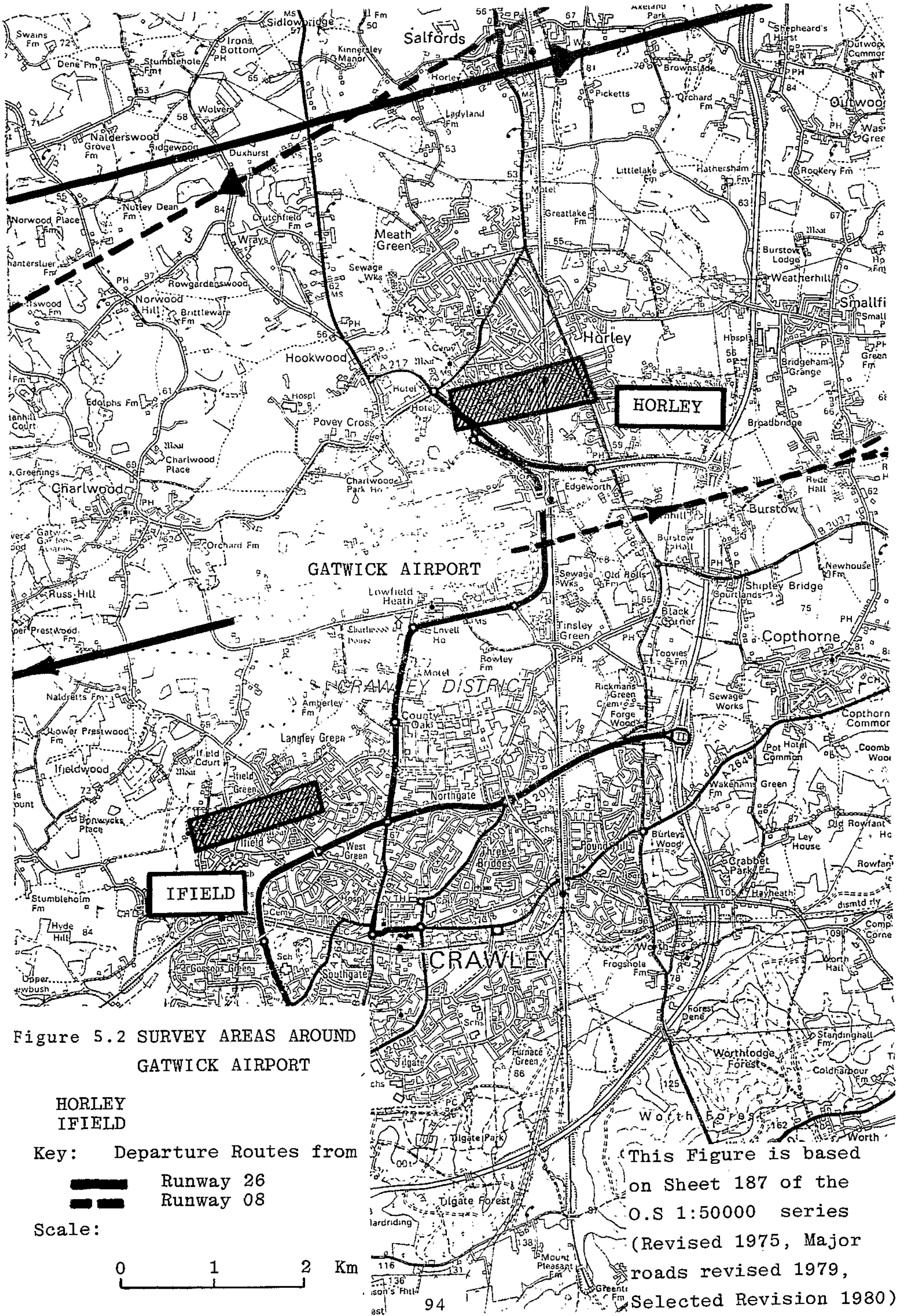


Figure 5.2 SURVEY AREAS AROUND GATWICK AIRPORT

HORLEY
IFIELD

Key: Departure Routes from

▬ Runway 26
▬ ▬ Runway 08

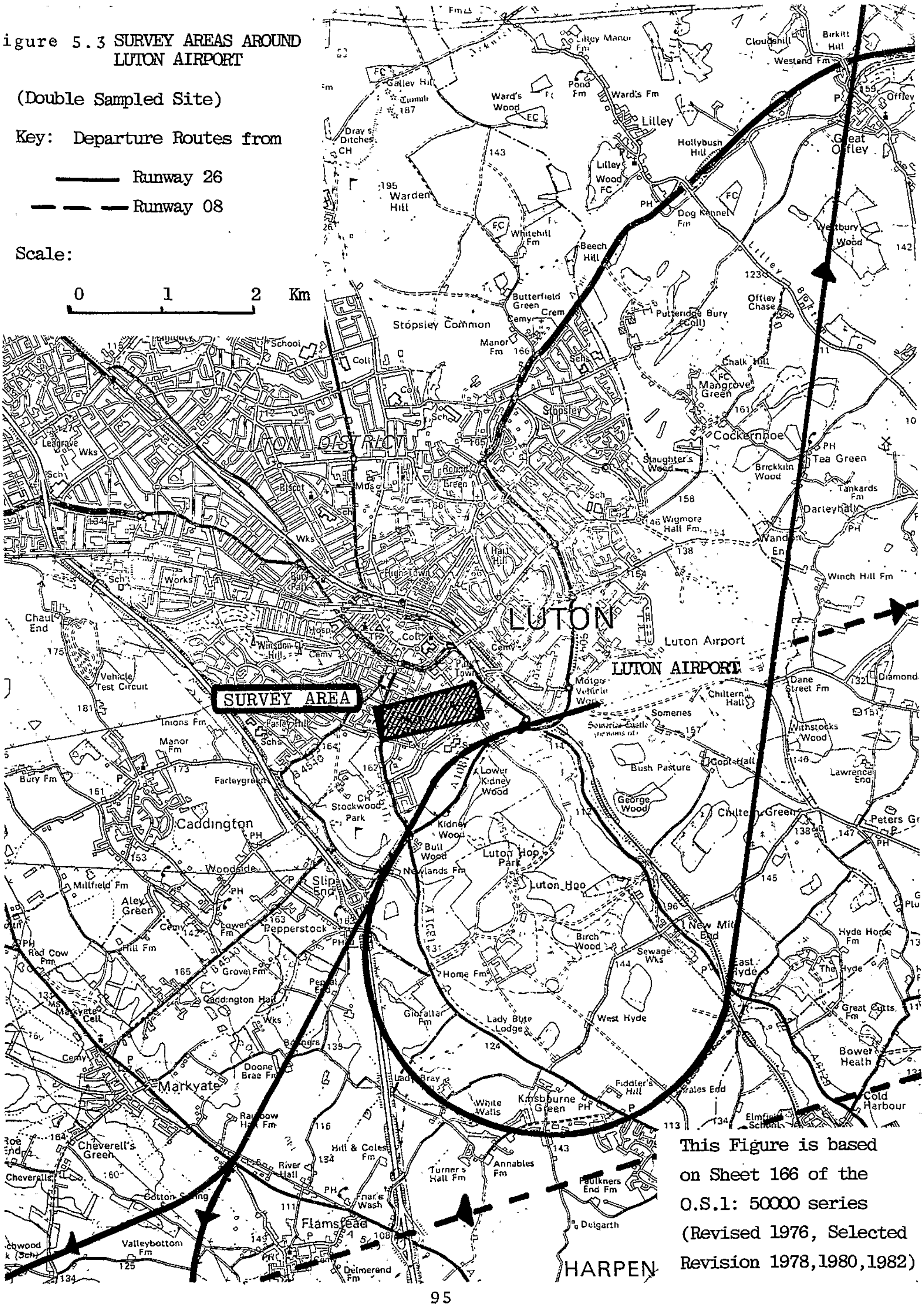
Scale:

0 1 2 Km

This Figure is based on Sheet 187 of the O.S 1:50000 series (Revised 1975, Major roads revised 1979, Selected Revision 1980)

Figure 5.3 SURVEY AREAS AROUND LUTON AIRPORT

(Double Sampled Site)



This Figure is based on Sheet 166 of the O.S.1: 50000 series (Revised 1976, Selected Revision 1978,1980,1982)

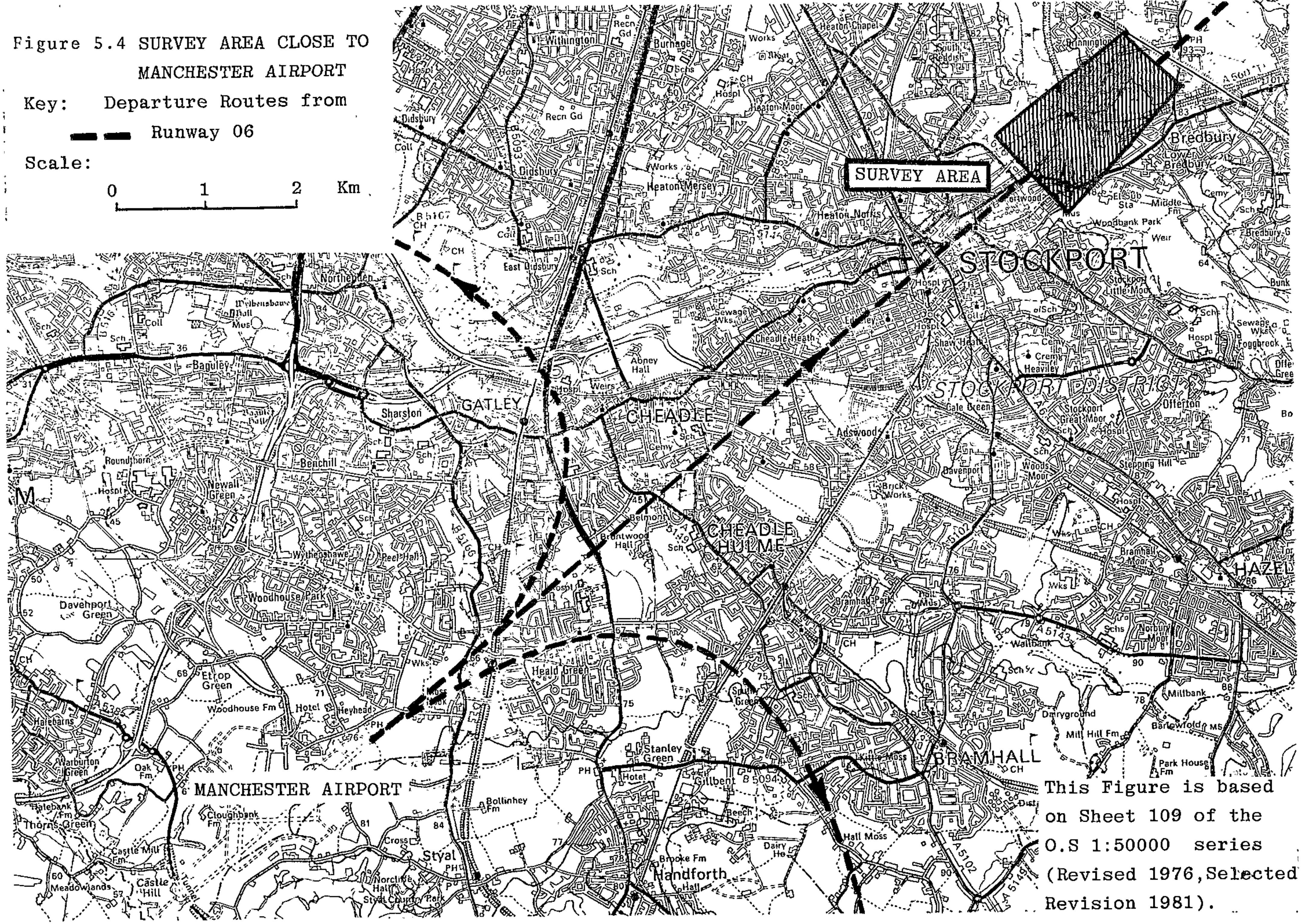
Figure 5.4 SURVEY AREA CLOSE TO MANCHESTER AIRPORT

Key: Departure Routes from

▬ ▬ Runway 06

Scale:

0 1 2 Km

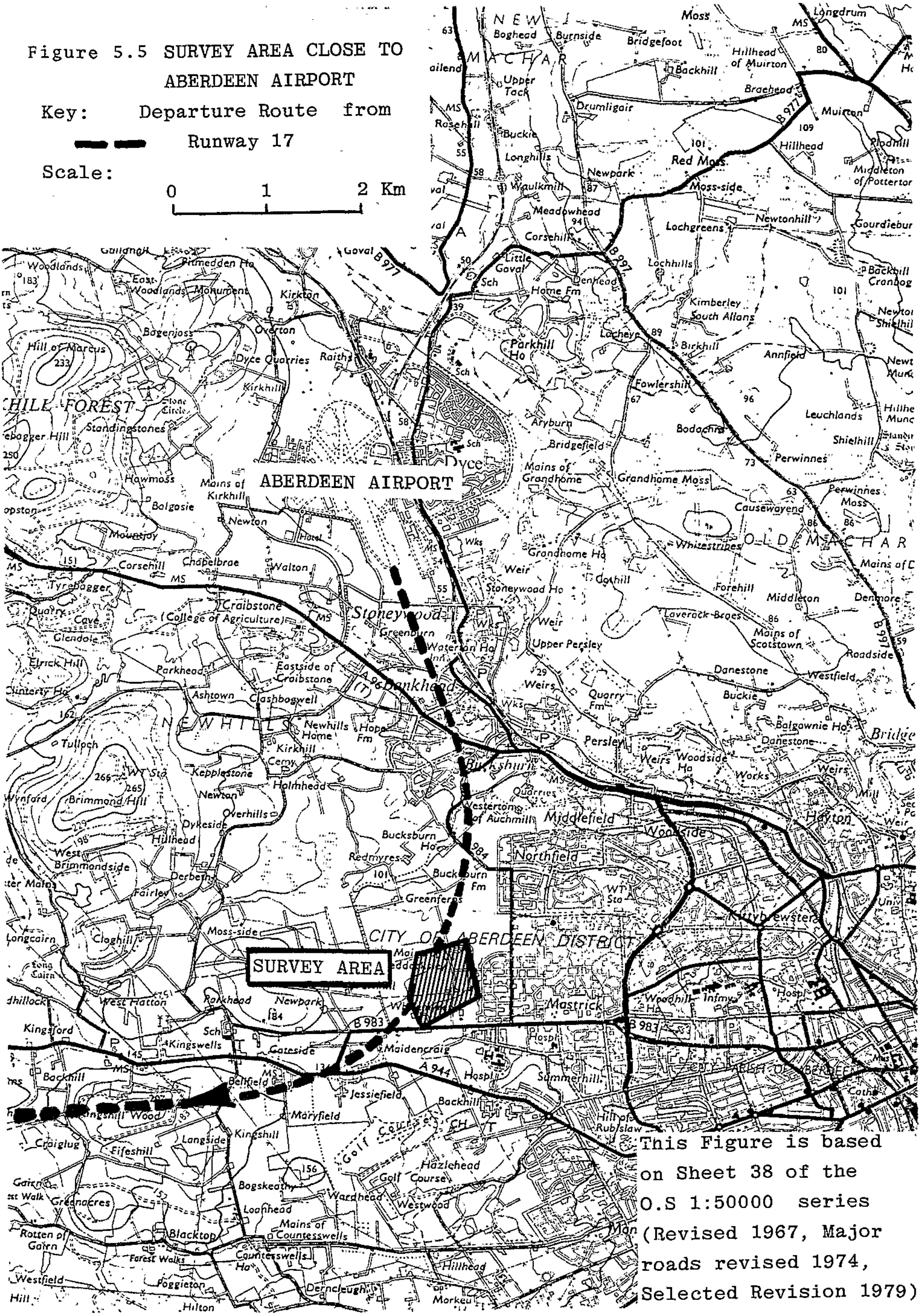


This Figure is based on Sheet 109 of the O.S 1:50000 series (Revised 1976, Selected Revision 1981).

Figure 5.5 SURVEY AREA CLOSE TO ABERDEEN AIRPORT

Key: ▬ ▬ Departure Route from Runway 17

Scale: 0 1 2 Km



This Figure is based on Sheet 38 of the O.S 1:50000 series (Revised 1967, Major roads revised 1974, Selected Revision 1979)

Figure 7.1: Percentage finding noise levels unacceptable plotted against 3 month 24 hour Leq (NSENA vs M3LQ24)

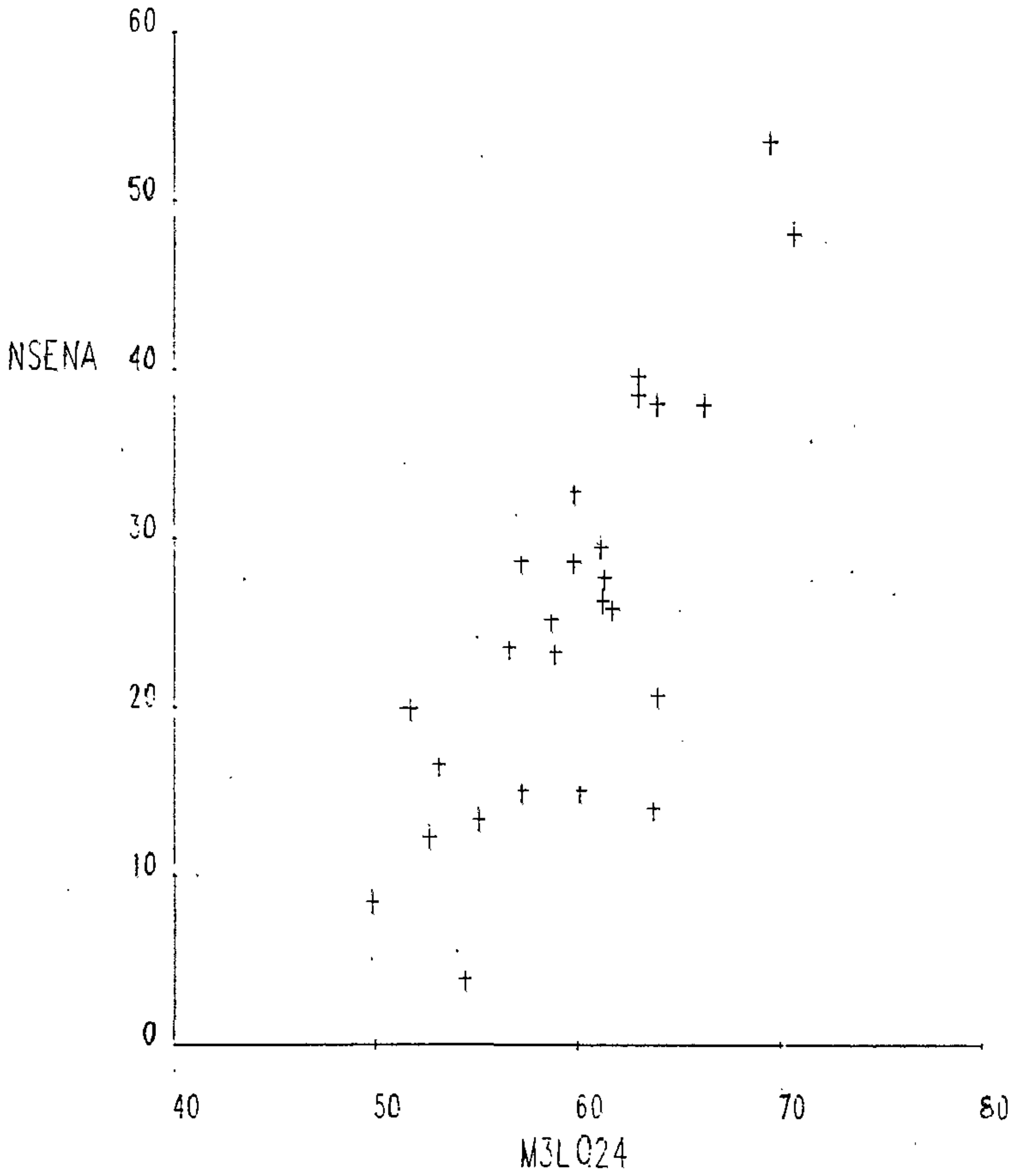


Figure 7.2: Percentage find aircraft noise levels unacceptable plotted against 3 month 24 hour Leq (ARCNA vs M3LQ24)

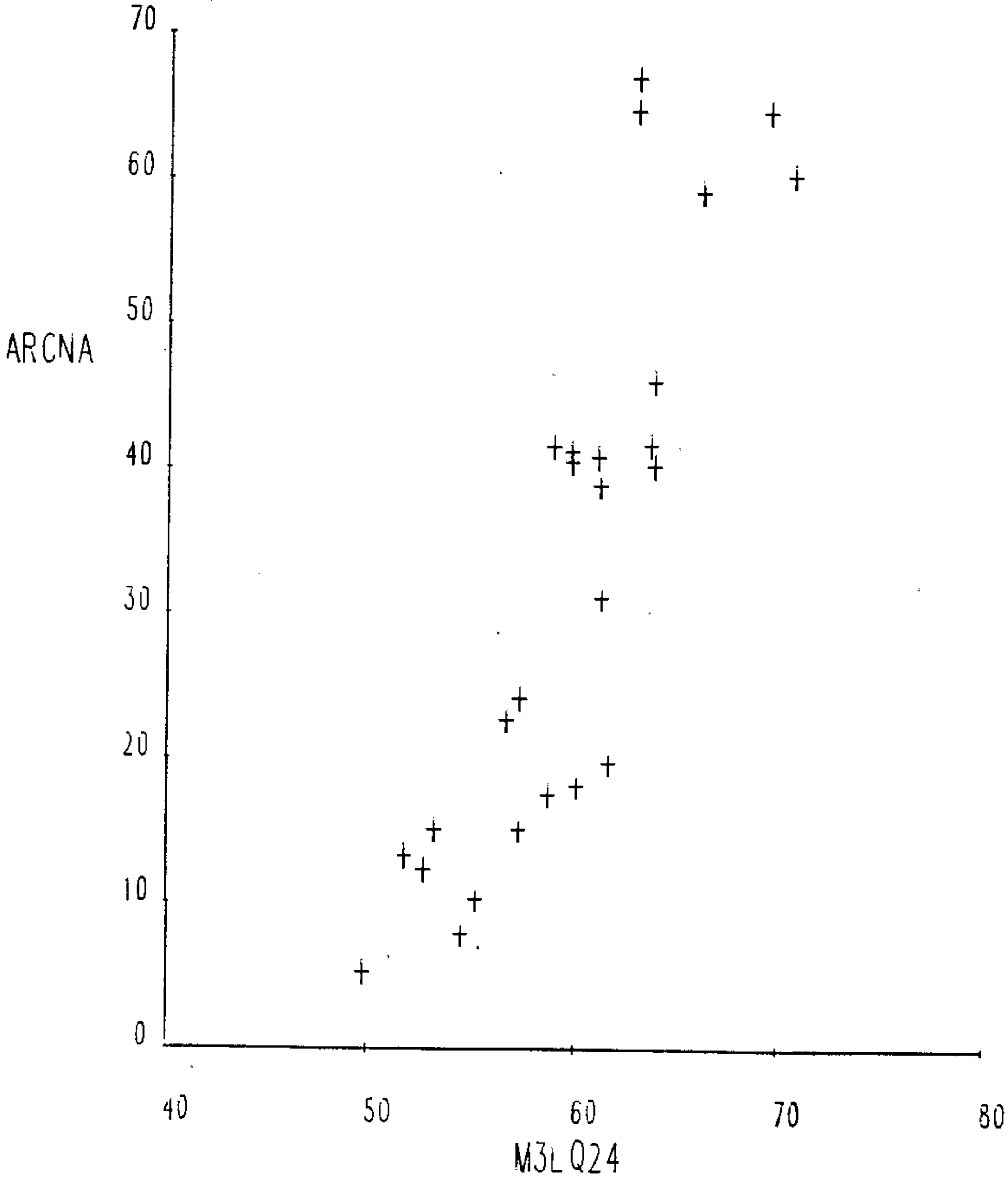


Figure 7.3: Percentage at least a little annoyed with aircraft noise levels plotted against 3 month 24 hour Leq (NSEAL2 vs M3LQ24)

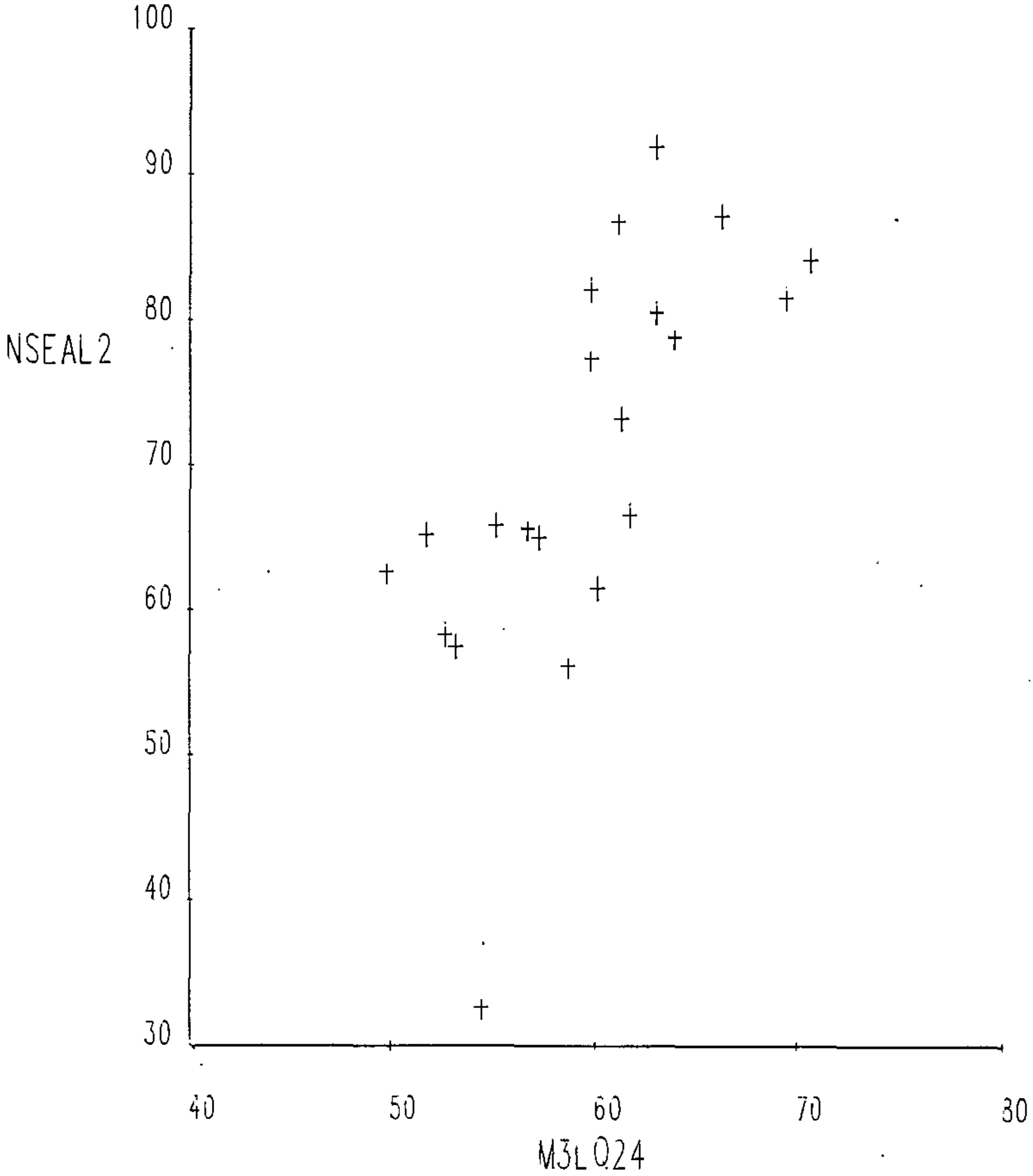


Figure 7.4: Percentage at least a little annoyed with aircraft noise levels plotted against 3 month 24 hour Leq (ARCAL2 vs M3Q24)

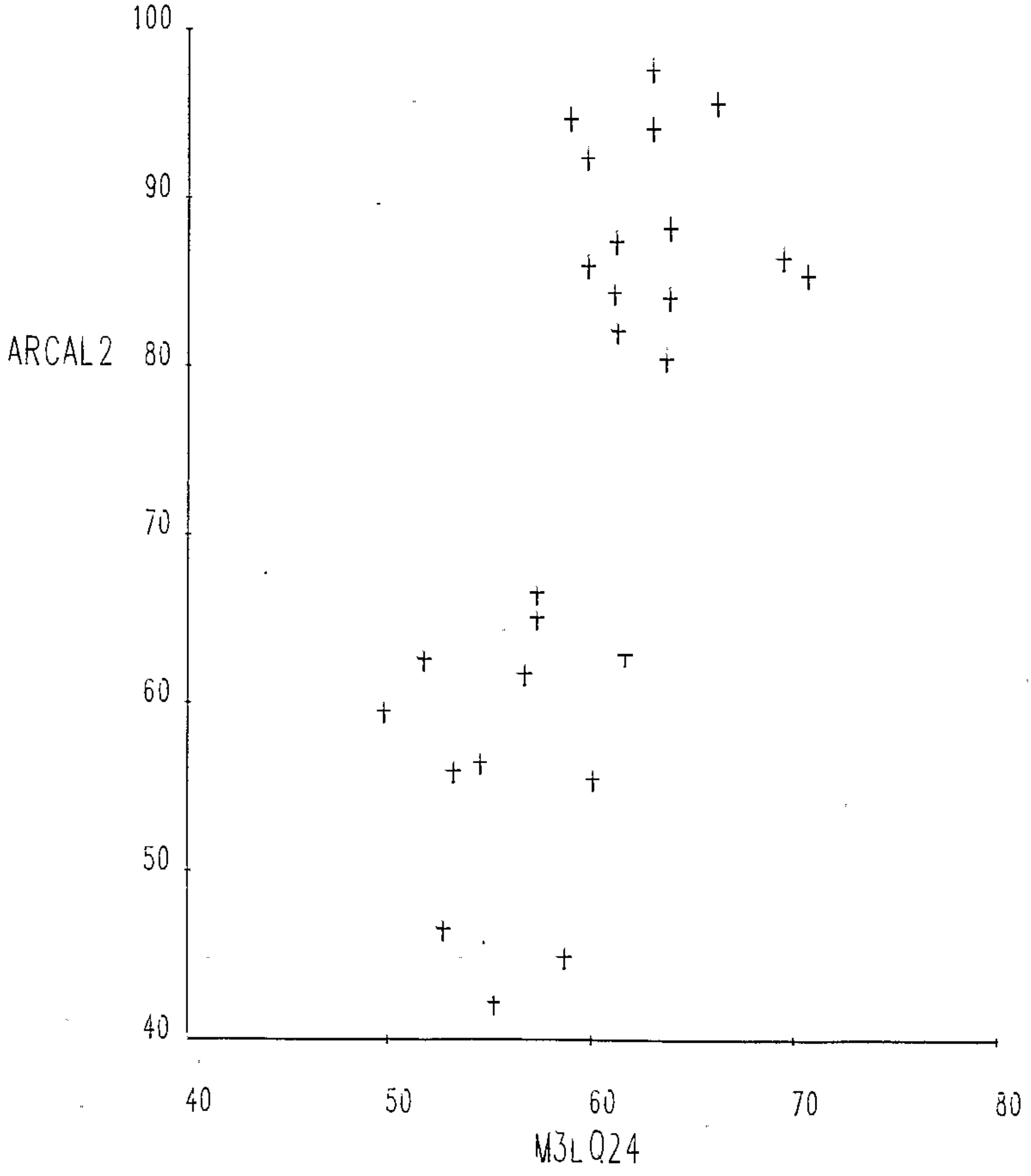


Figure 7.5: Percentage very much annoyed with aircraft noise plotted against 3 month 24 hour Leq (VMANN vs M3LQ24)

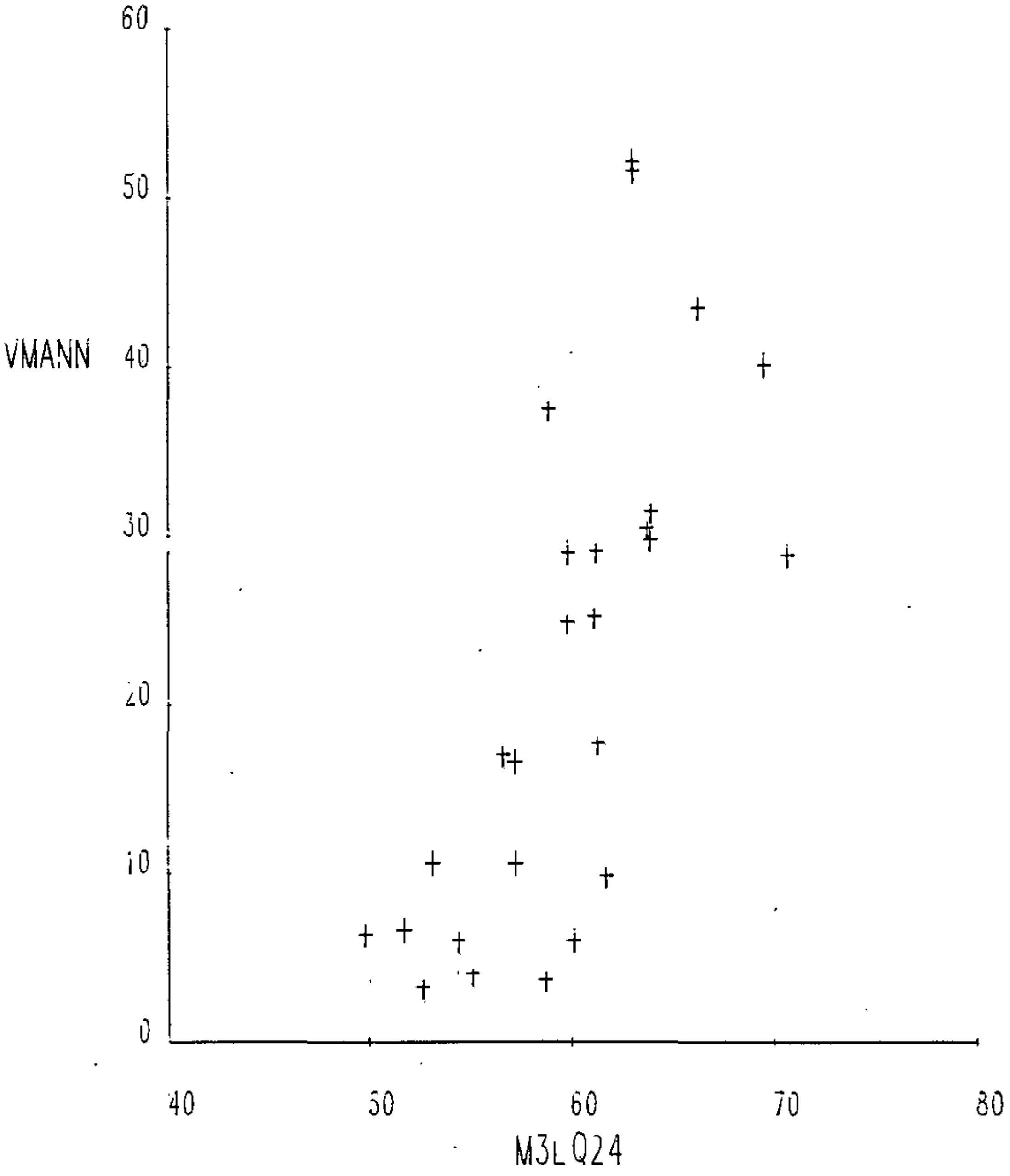


Figure 7.6: Average GAS score on the '67 scale plotted against 3 month 24 hour Leq (AVOGAS vs M3LQ24)

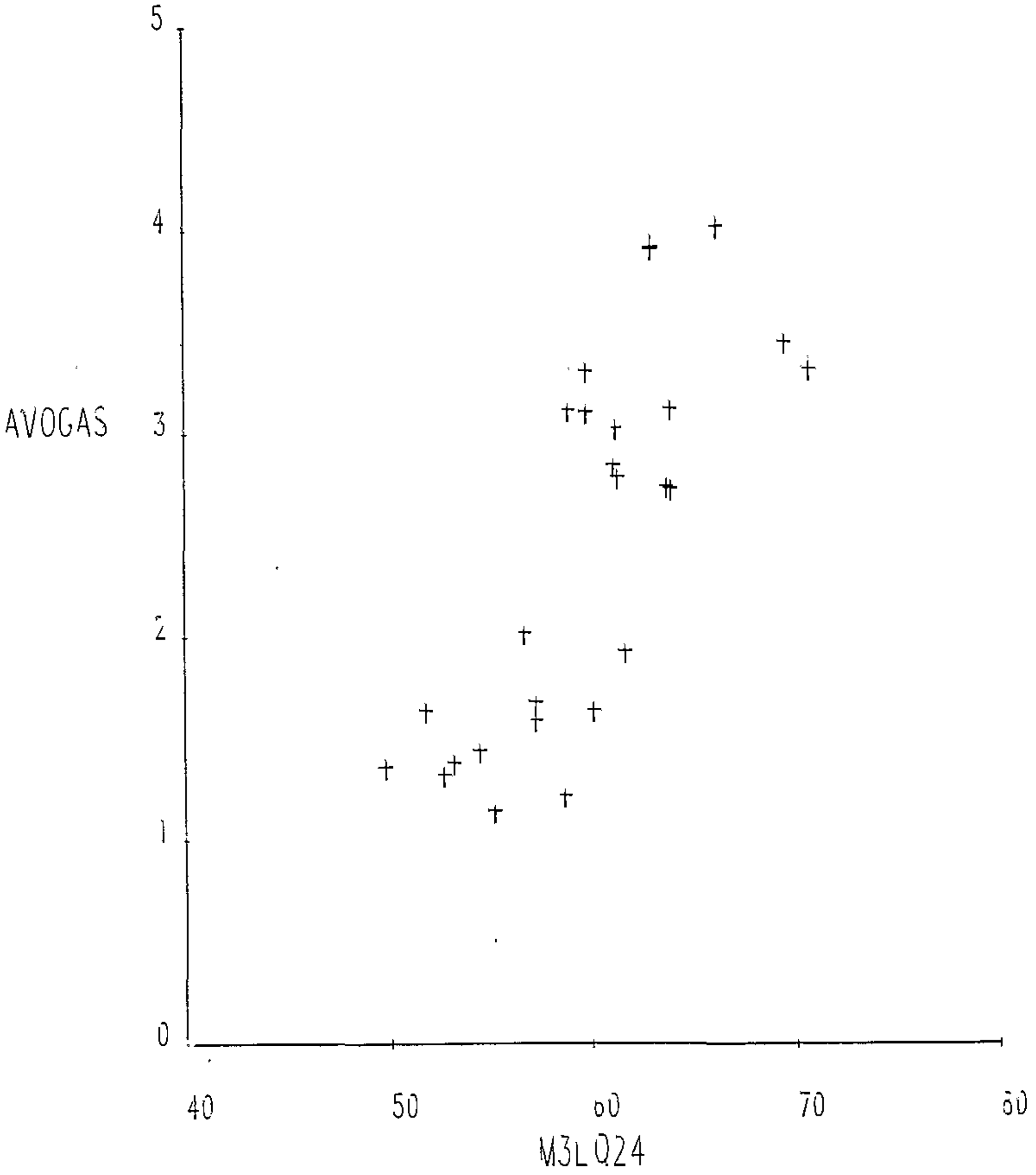


Figure 7.7: Net percentage more bothered by aircraft noise than road traffic noise, plotted against 3 month 24 hour Leq (ARCNET vs M3LQ24)

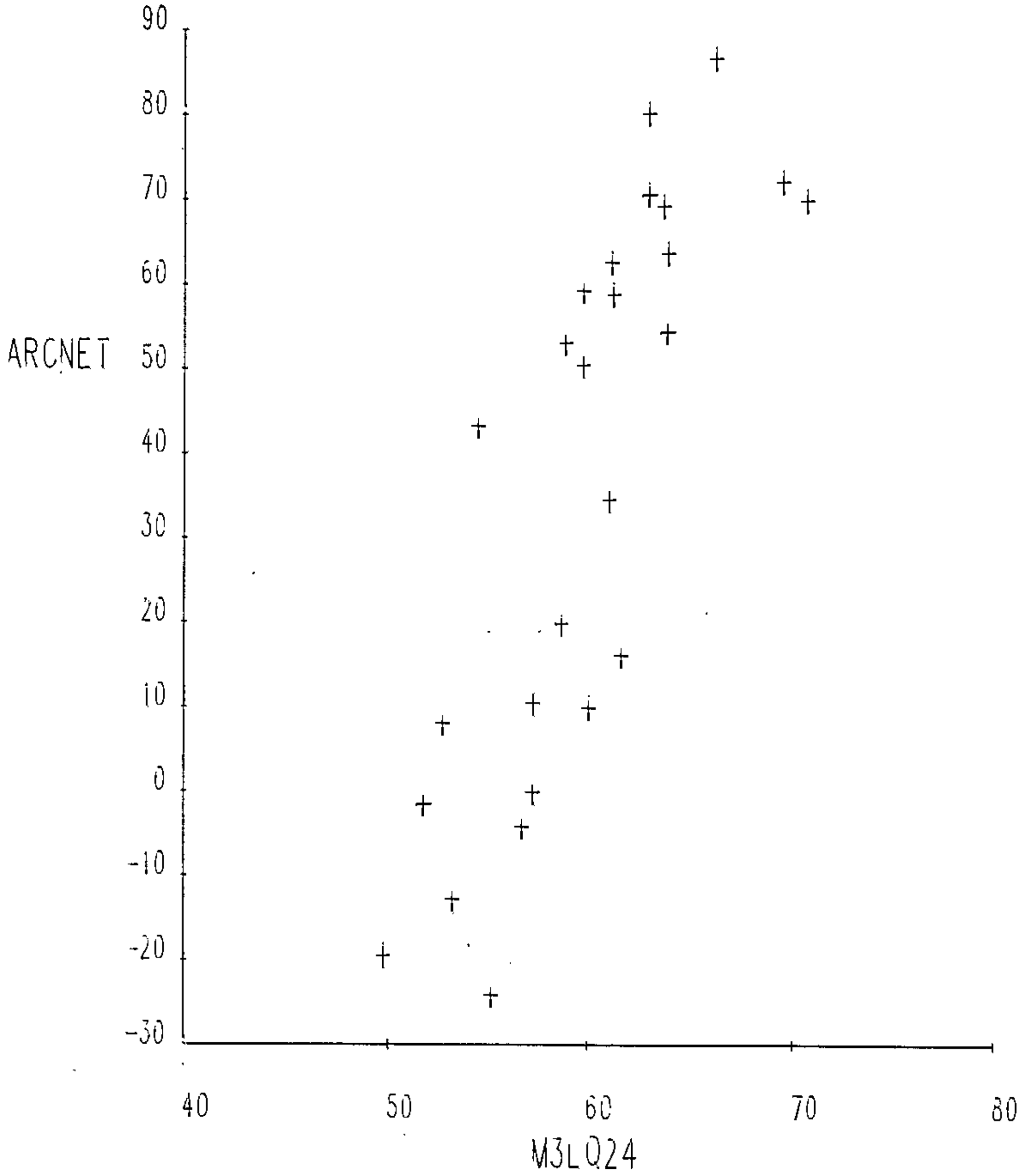


Figure 9.1 : Three month, twenty-four hour Leq plotted against three month NNI (M3LQ24 vs NNI)

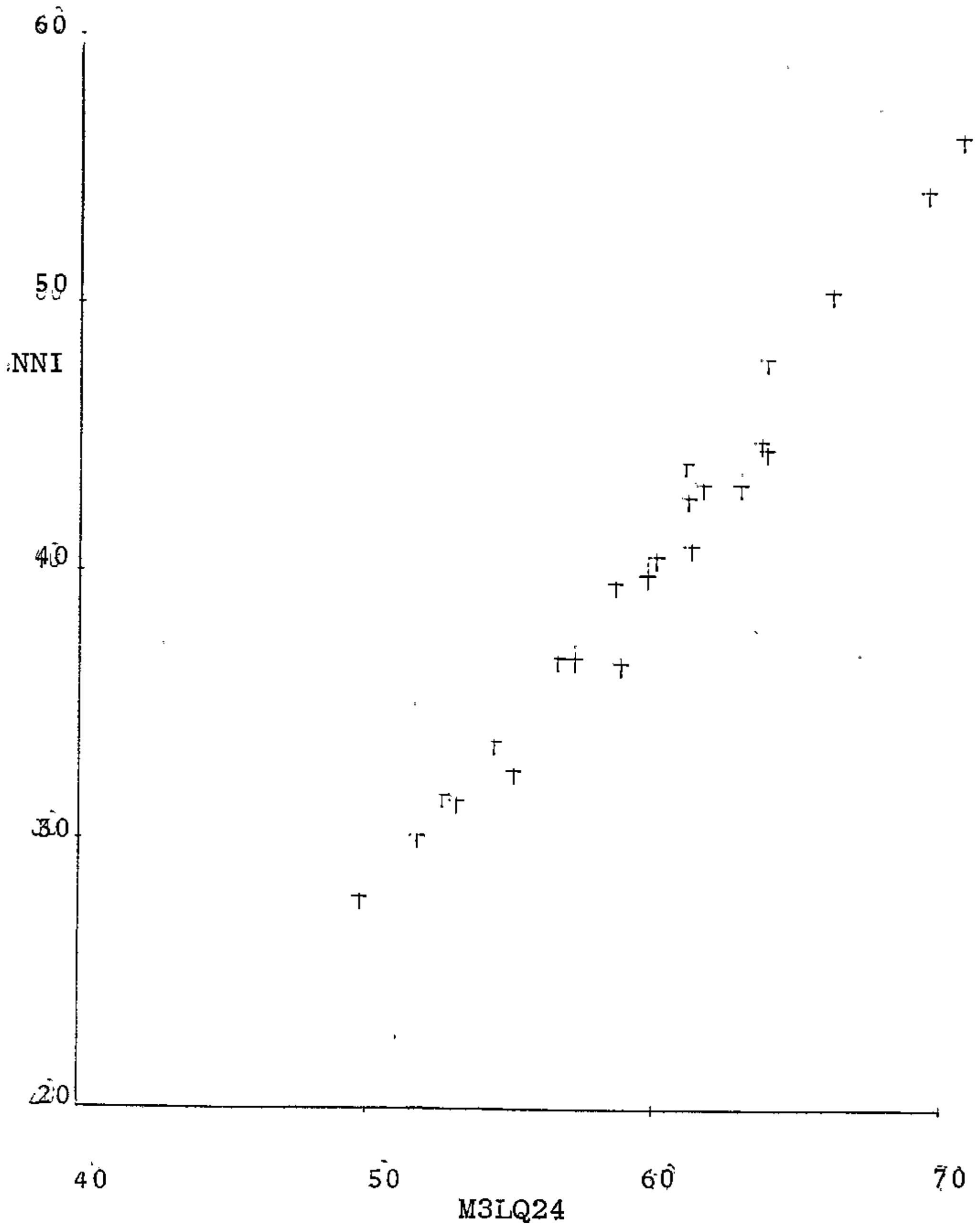
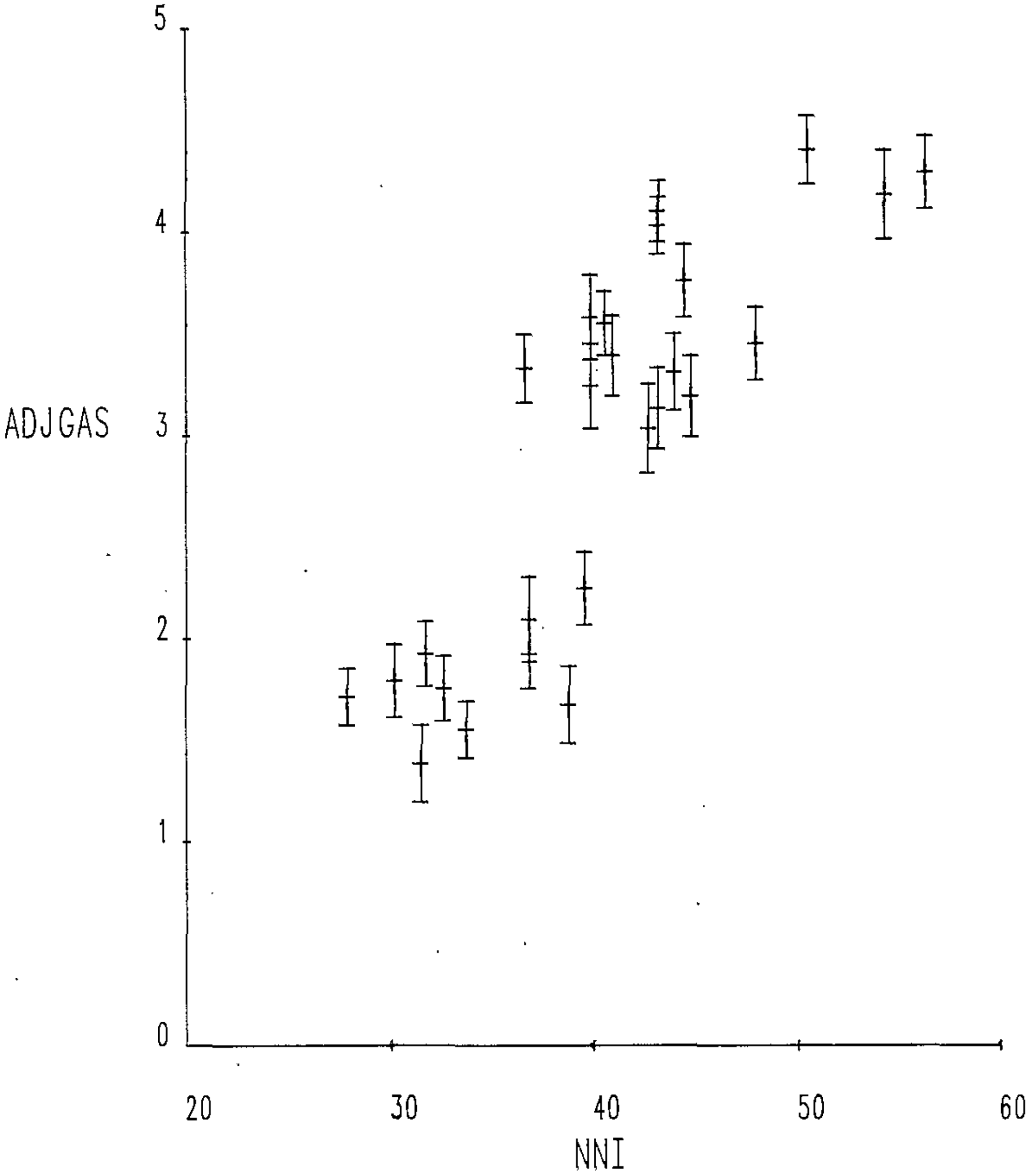


Figure 9.2: Adjusted*values of average community GAS score
plotted against NNI (ADJGAS vs NNI)

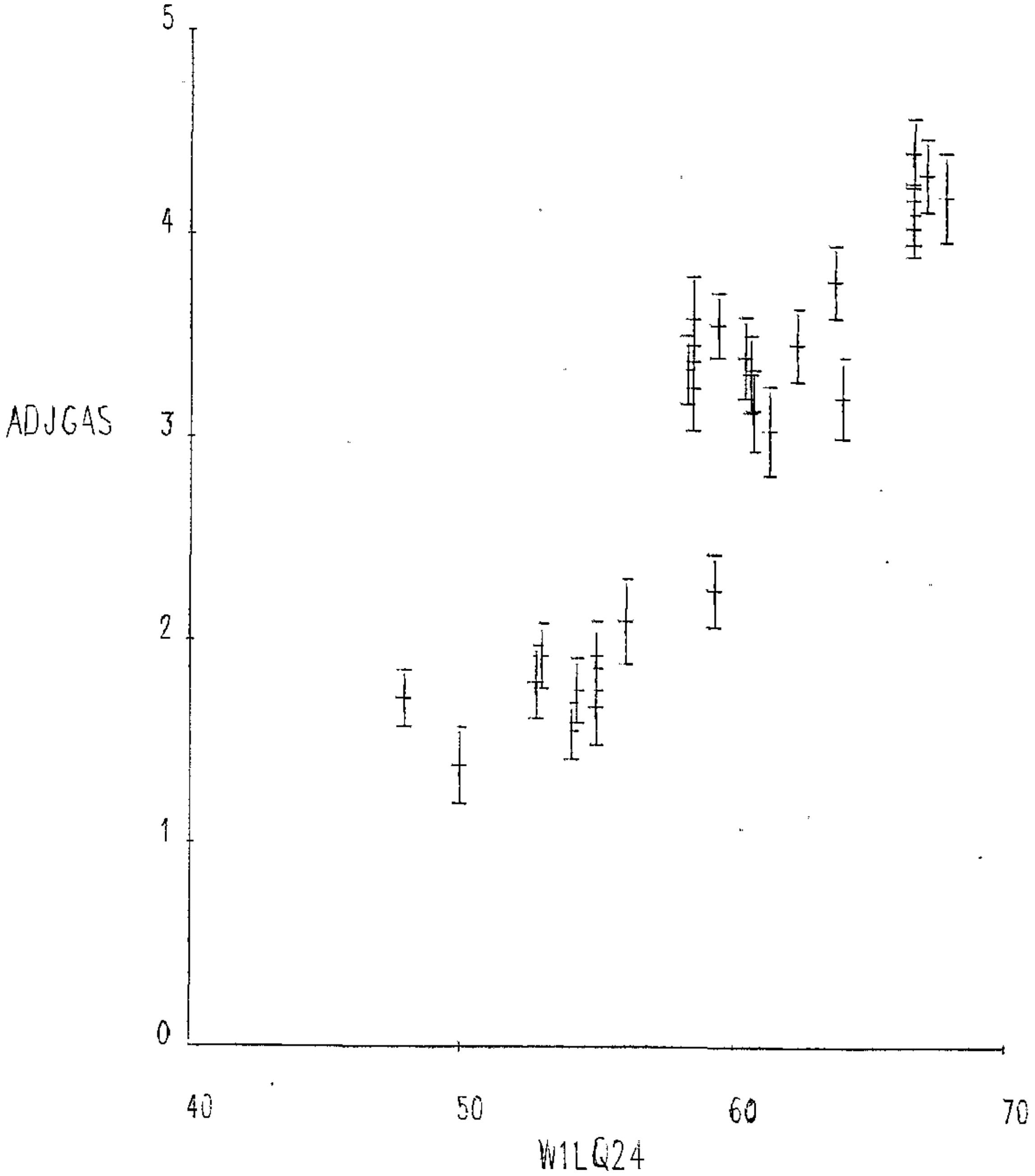


* In this and later graphs, variables are adjusted for the contribution of WORKAP in MRAVII

eg ADJGAS = AVOGAS - coeff MRVII x WORKAP

The confidence bands shown are one standard deviation based on the sample variance of AVOGAS

Figure 9.3: Adjusted* values for average GAS scores, plotted against 1 week 24 hour Leq, showing confidence bands (ADJGAS vs W1LQ24)

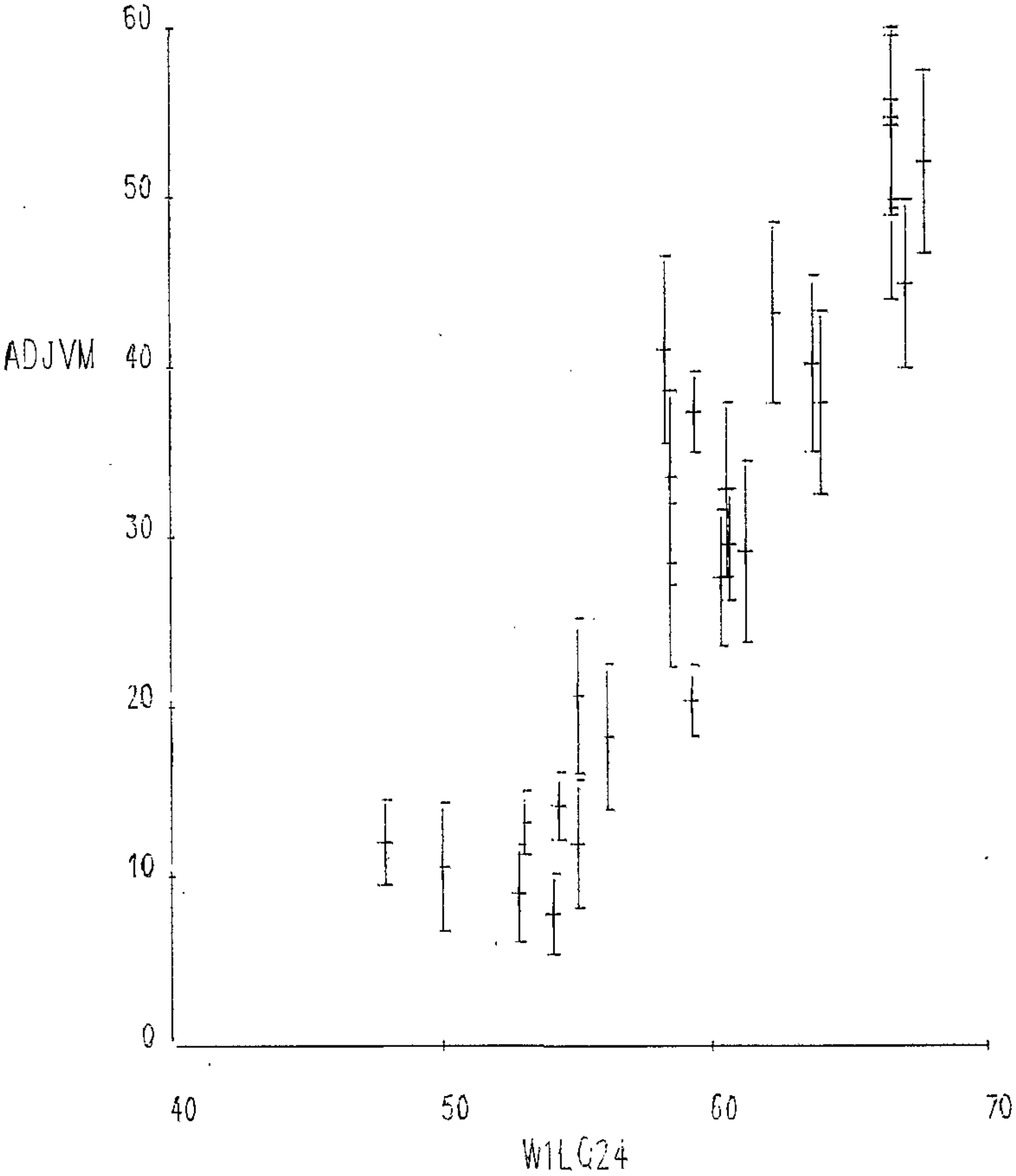


* In this and successive graphs, variables are adjusted for the contribution of WORKAP in MRAVII

eg ADJGAS = AVOGAS - coeff MRAVII x WORKAP

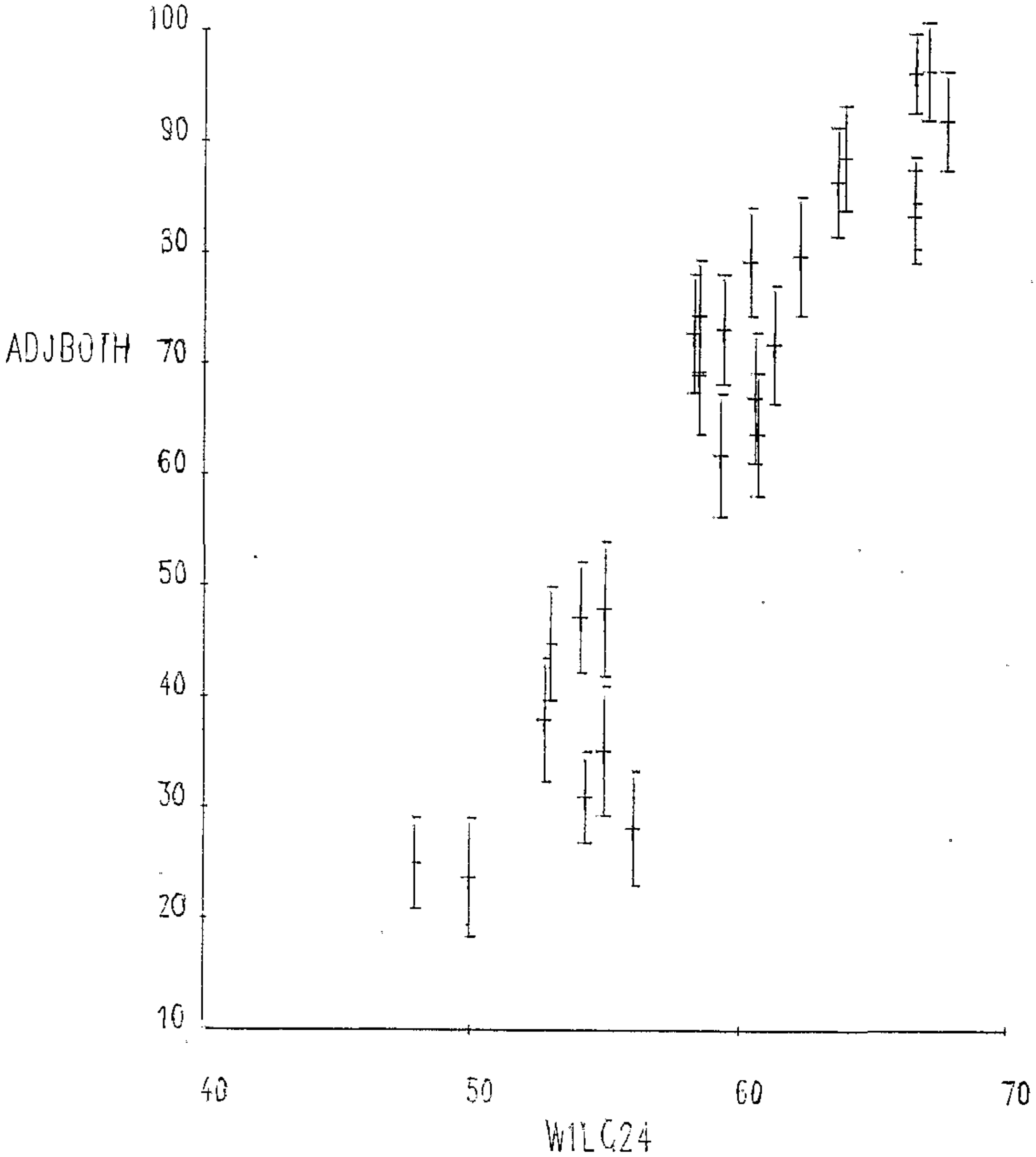
Standard deviation shown are calculated as in previous graphs.

Figure 9.4: Adjusted * percentage 'very much annoyed' plotted against 1 week 24 hour Leq, showing confidence bands (ADJVM vs W1LQ24)



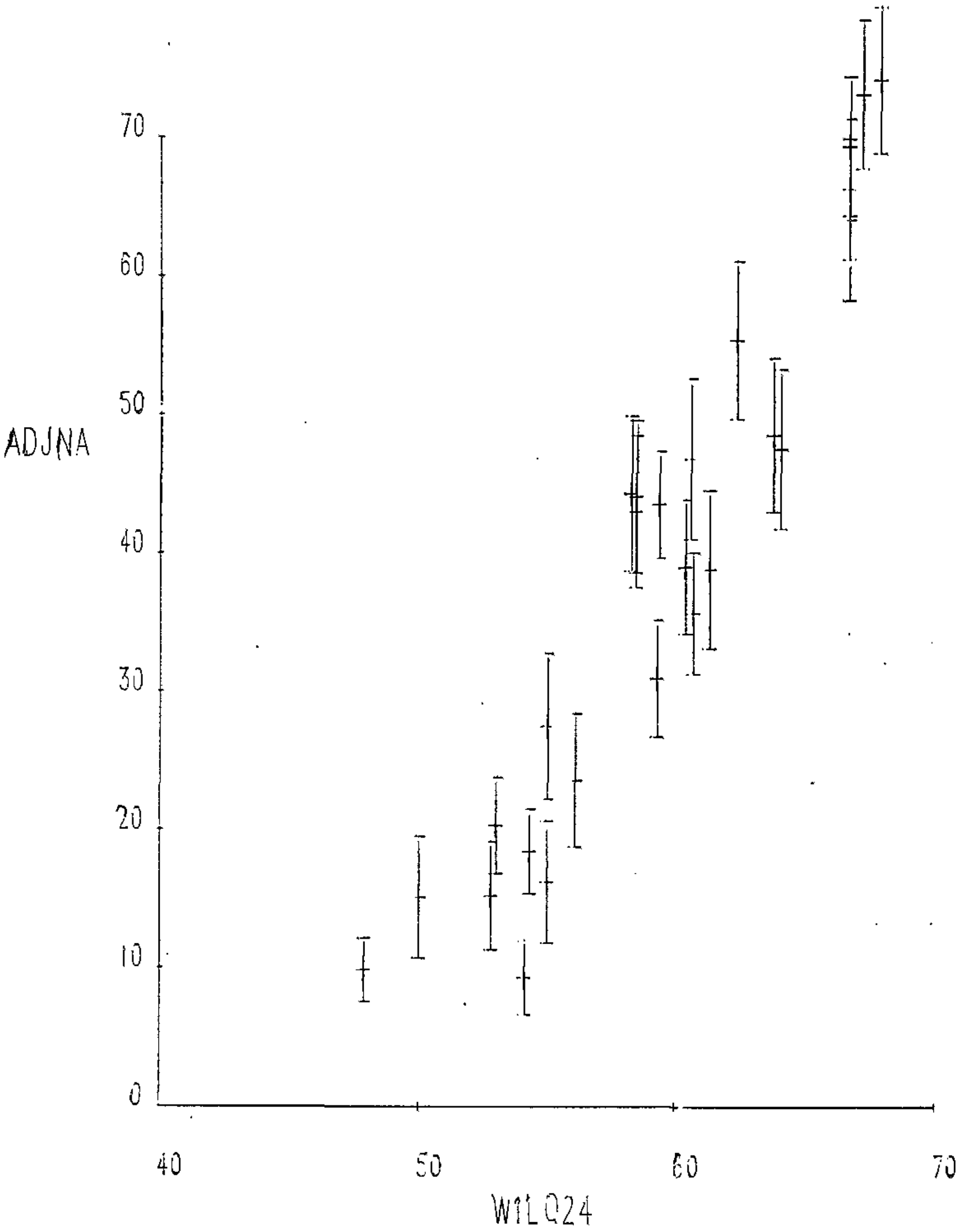
* See footnote, Figure 9.3

Figure 9.5: Adjusted * percentage finding aircraft the most bothersome noise, plotted against 1 week 24 hour Leq showing confidence bands (ADJBOTH vs W1LQ24)



* See footnote, Figure 9.3

Figure 9. 6: Adjusted * percentage finding aircraft noise levels unacceptable plotted against 1 week 24 hour Leq showing confidence bands (ADJNA vs W1LQ24)



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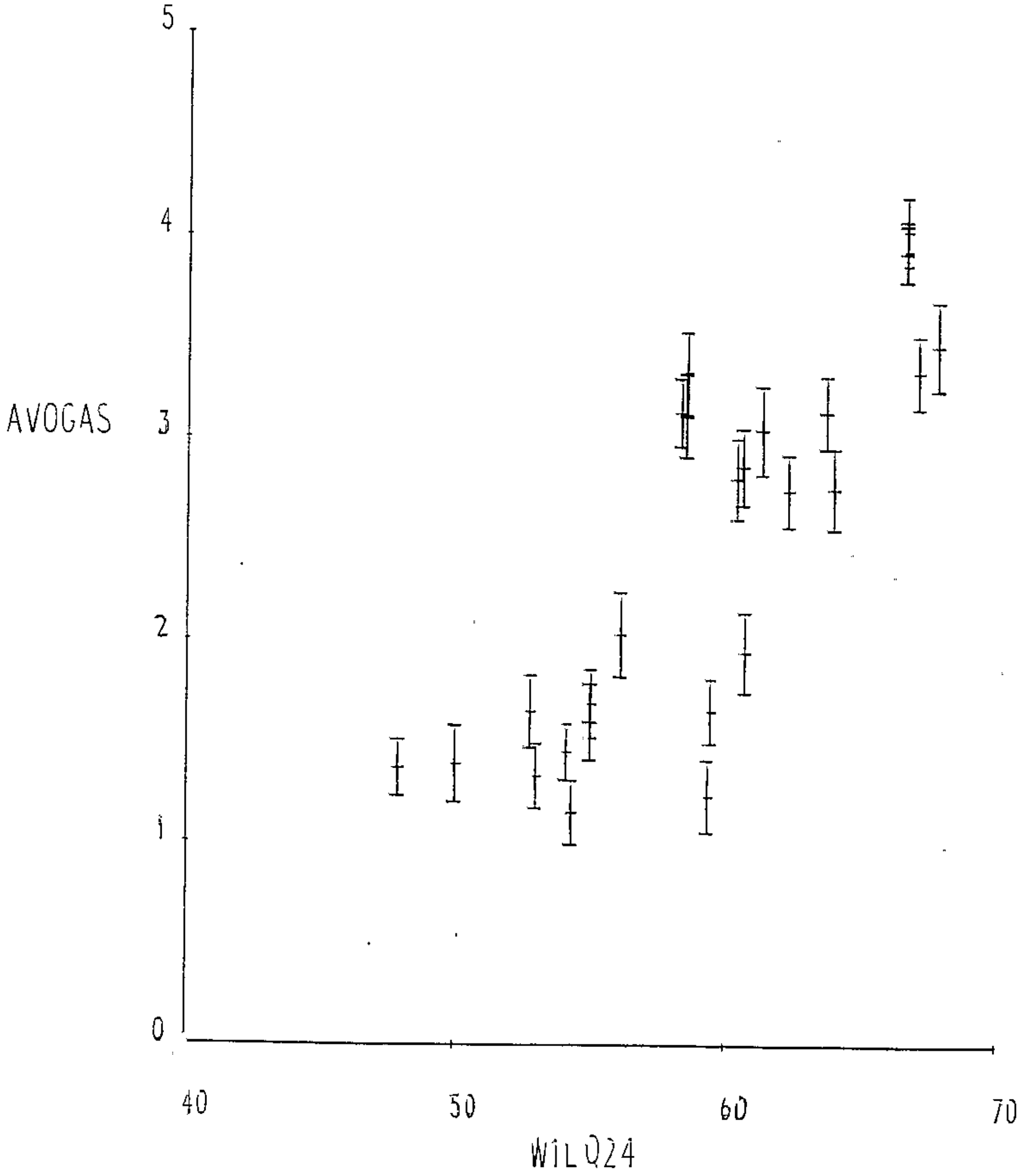
* See footnote Figure 9.3

Figure 9.7: Average GAS score '67 scale, plotted against 1 week 24 hour Leq, showing confidence bands* (AVOGAS vs W1LQ24)



* On this and successive graphs the confidence bands show + one standard deviation, based on the sample variance of the plotted variable.

Figure 9.8: Percentage very much annoyed with aircraft noise levels, plotted against 1 week 24 hour Leq, showing confidence bands (VMANN vs W1LQ24)

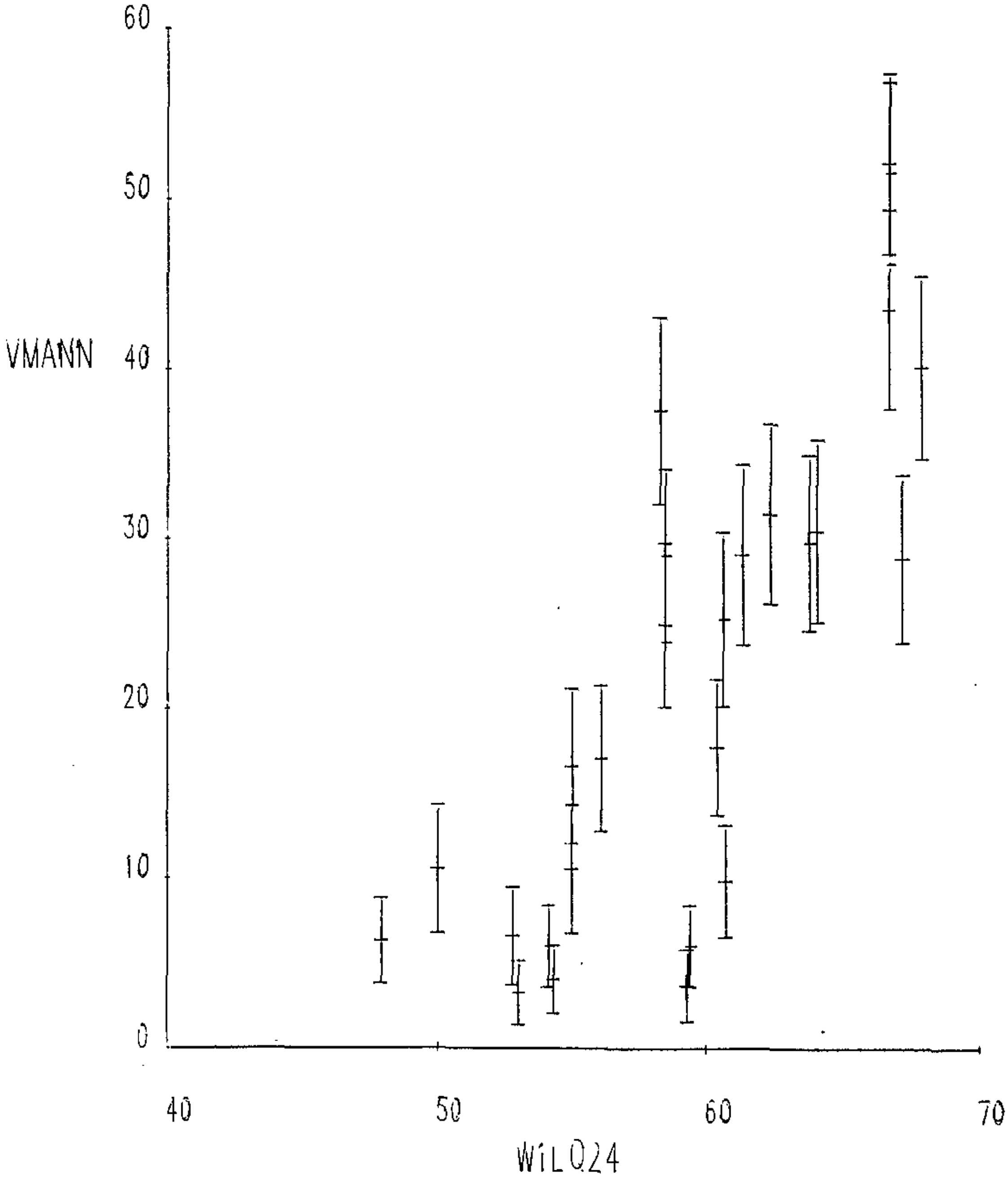


Figure 9.9: Percentage finding aircraft the most bothersome noise, plotted against 1 week 24 hour Leq, showing confidence bands (ARCBOTH vs W1LQ24)

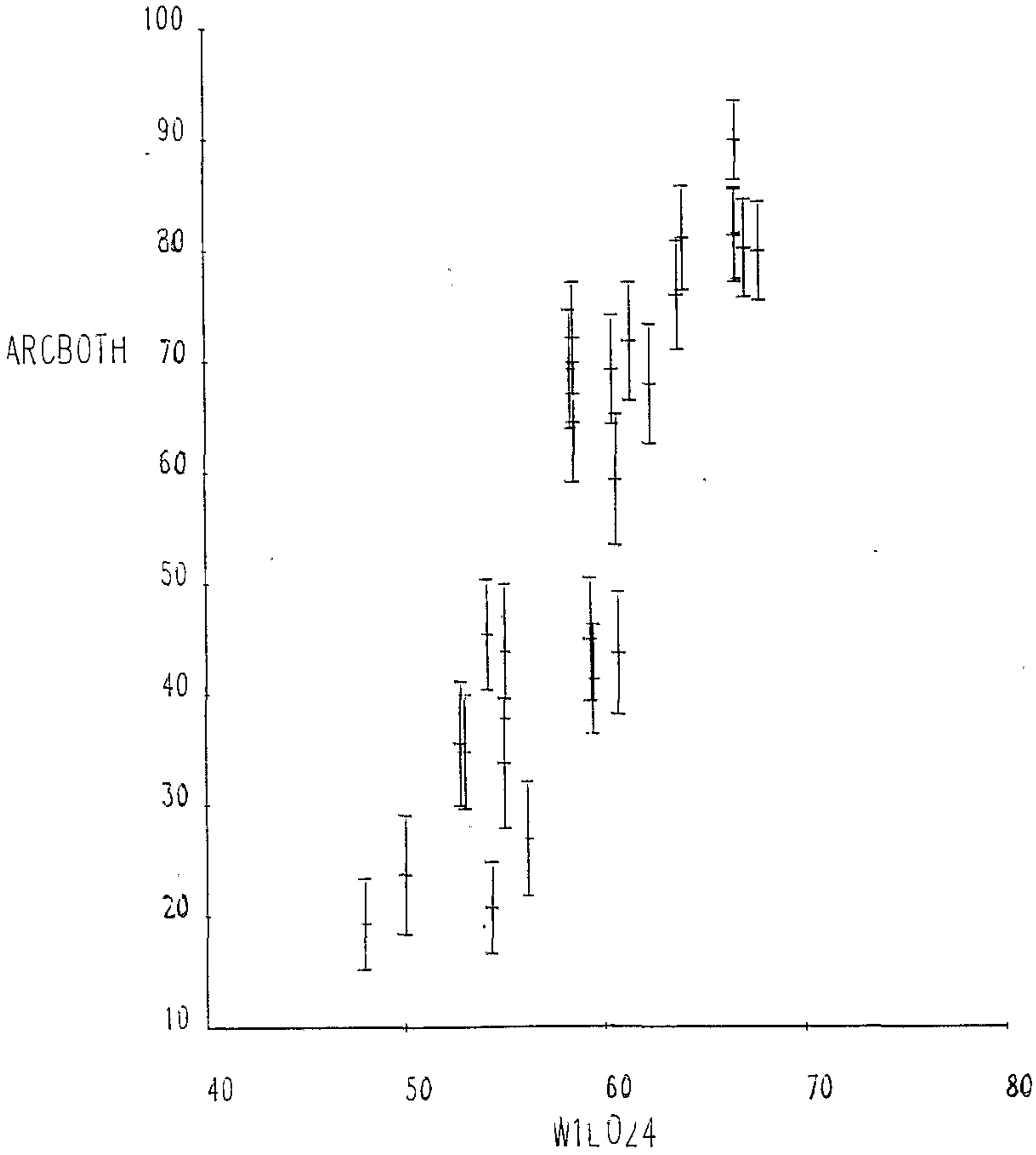
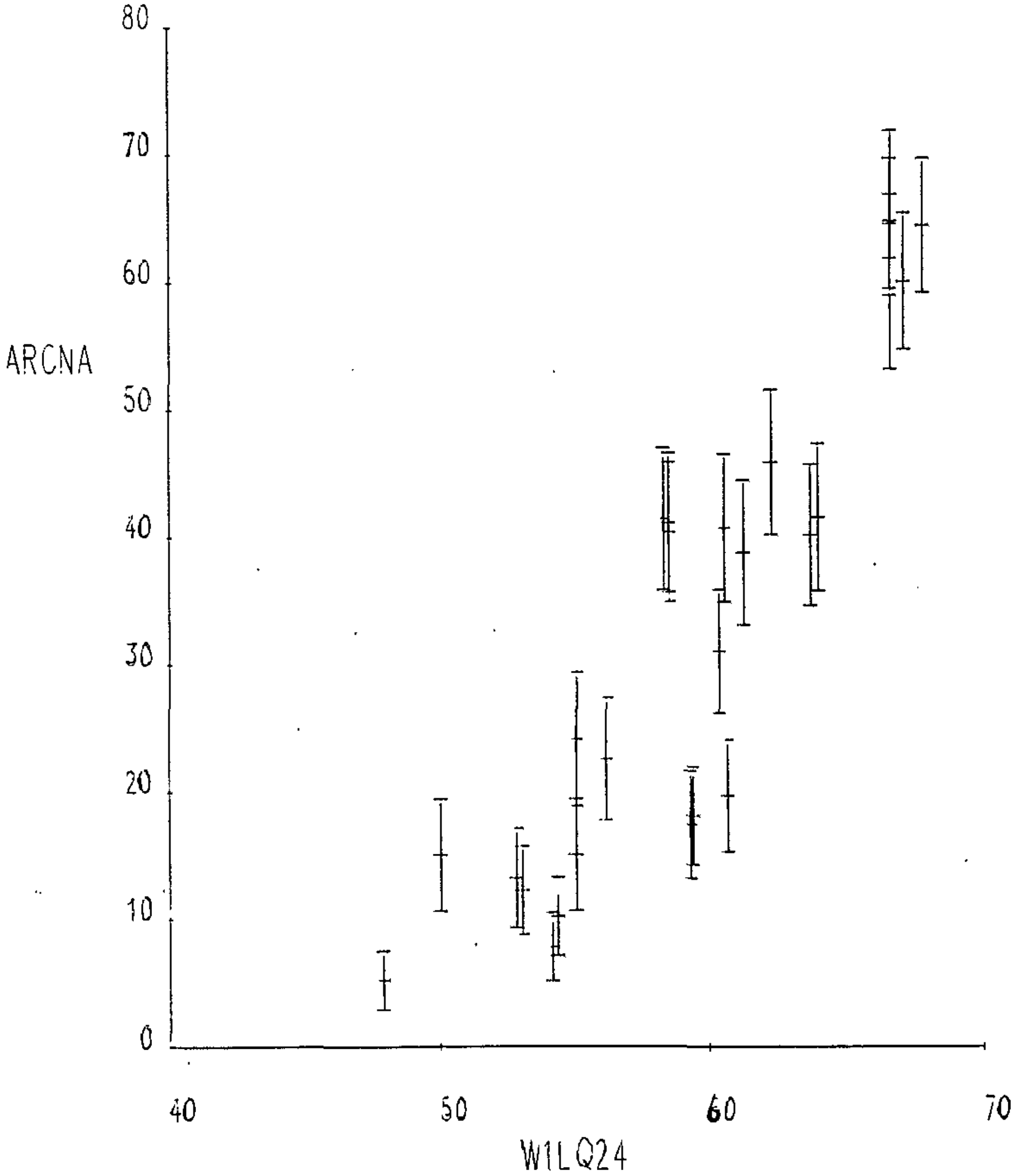


Figure 9.10: Percentage finding levels of aircraft noise unacceptable, plotted against 1 week 24 hour Leq, showing confidence bands (ARCNA vs W1LQ24)



APPENDIX A

FIELDWORK DOCUMENTS

1	Introductory Letter	1980
2	Trials Questionnaire	1980
3	Introductory Letter	1982
4	Main Questionnaire	1982
5	Helicopter Questionnaire	1982
6	Cards used in Questionnaires	

DEPARTMENT OF TRADE
1 Victoria Street London SW1H 0ET
Telex 8811074 DTHQ G
Telegrams Advantage London SW1
Telephone Direct Line 01-215
Switchboard 01-215 7877

Your reference

Our reference P.610/London

Date Summer 1980

Dear Resident,

Attitudes to Neighbourhood

The Department of Trade has asked Social and Community Planning Research, an independent research institute, to carry out an important survey among residents of the London area.

We are enquiring into people's attitudes towards the area in which they live: their likes and dislikes about the area.

It is very important in a survey like this that we get the views of a cross-section of the population. For this reason Social and Community Planning Research have selected names at random from the electoral register. Your name is one of those they have selected. I do hope you will be able to co-operate with the interviewer and provide the information required. Everything you say will be treated in the strictest confidence by the research team. The results of the survey will be presented in statistical form only.

Each interviewer carries an identity card and you may ask to see this before the interview starts. Should you have any problems or want further information, please do not hesitate to contact:

Carolyn Makinson
Social & Community Planning Research
35 Northampton Square
London EC1V 0AX Tel: 01 250 1866

Thank you for your co-operation.

Yours sincerely,

C.Sladen

SOCIAL & COMMUNITY PLANNING RESEARCH
Main Office: 35 Northampton Square London EC1V 0AX Tel: 01-250 1866

P.610

ATTITUDES TO NEIGHBOURHOOD

Summer 1980

Col./Code | Skip to

Address Number (101-103) ☐☐☐

Card (104) 1

Area Code (105-106) ☐☐

Batch code ☐☐ (107-8)

Time interview started (WRITE IN) ____________

I am doing a survey about some of the things which affect people's living conditions.

1. How long have you lived in this area, that is, within about five minutes walk ? Have you lived here all your life or how long ? (IF LESS THAN 3 MONTHS DO NOT INTERVIEW)

	(109)	
3 months but less than 1 year	1	
1 year - under 2 years	2	
2 years - under 4 years	3	
4 years - under 7 years	4	
7 years - under 10 years	5	
10 years - under 20 years	6	
20 years - under 30 years	7	
30 years or more/all my life	8	

2a) On the whole, how do you like living in this area ? Do you rate it as an excellent, good, fair, poor or very poor place to live ?

	(110)	
Excellent	1	
Good	2	
Fair	3	
Poor	4	
Very poor	5	
Don't know	8	

b) What are some of the things you like about living round here ? PROBE: 'Anything else?' - AFTER EACH REPLY.

☐☐ (111-12)
☐☐ (113-14)
☐☐ (115-16)

3. What are some of the things you don't like about living around here ? PROBE : 'Anything else?' - AFTER EACH REPLY.

☐☐ (117-18)
☐☐ (119-20)
☐☐ (121-22)

			Col./Code	Skip to
4.	If you could change just one thing about living round here, which would you choose ?		(123-4)	
5a)	Have you ever felt like moving away from this area ? STRESS <u>AREA</u> NOT HOUSE.		(125)	
		Yes	1	
		No	2	Q6
	<u>IF 'YES' AT a)</u> b) Why did you feel like moving ? <u>PROBE FULLY</u> : Ask 'Any other reasons?'			
			(126-7)	
			(128-9)	
			(130-1)	
	<u>ASK ALL</u>			
6.	On the whole, would you say this was a quiet or noisy neighbourhood ?		(132)	
	IF NOISY : would you say it was very noisy ?	Very noisy	1	
		Noisy	2	
	IF QUIET : would you say it was very quiet ?	Quiet	3	
		Very quiet	4	
		Don't know	8	
7.	All things considered, would you say that the amount of noise here is acceptable or unacceptable ?		(133)	
		Acceptable	1	
		Unacceptable	2	
		Qualified answer (WRITE IN) ____________________ ____________________		
		Don't know	8	
8.	Would you say that you are more sensitive or less sensitive than other people are to noise ?		(134)	
		More sensitive	1	
		Less sensitive	2	
		About the same	3	
		Don't know	8	

			Air-craft (135)	Road traffic (139)	Other(1) SPECIFY .... (143) ☐ (144)	Other(2) SPECIFY .... (148) ☐ (149)	
9a)	What are the different kinds of noises you hear round here?	Mentioned spontaneously	1	1	1	1	
b)	PROMPT AS NECESSARY: Do you ever hear aircraft fly by here?	Mentioned after prompt	2	2	2	2	
	How about road traffic - do you ever hear it go by? Do you hear any other kinds of noises?	Not heard	3	3	3	3	IF NO NOISE HEARD GO TO Q.17
c)	Which is the most bothersome noise you hear round here?	Most bothersome	(136) 1	(140) 2	(145) 3	(150) 4	
10a)	FOR EACH NOISE HEARD		(137)	(141)	(146)	(151)	
	SHOW CARD A: Please look at this scale and tell me how much the noise of aircraft here bothers or annoys you.	Very much	1	1	1	1	
		Moderately	2	2	2	2	
		A little	3	3	3	3	
	REPEAT FOR ROAD TRAFFIC	Not at all	4	4	4	4	
		Don't know	8	8	8	8	
	IN ADDITION ASK ABOUT OTHER NOISE(S) IF MENTIONED AT 9a) OR b)						
	ASK FOR EACH NOISE THAT BOTHERS -CODES 1,2 OR 3 AT a)		(138)	(142)	(147)	(152)	
	b) SHOW CARD B: From this card, how often does the noise of aircraft bother you these days?	Many times a day	1	1	1	1	
		A few times a day	2	2	2	2	
	REPEAT FOR ROAD TRAFFIC	A few times a week	3	3	3	3	
	IN ADDITION ASK ABOUT OTHER NOISE(S) IF MENTIONED AT 9a) OR b)	A few times a month	4	4	4	4	IF AIRCRAFT NOISE NOT HEARD GO TO Q.17
		Less than a few times a month	5	5	5	5	
		Don't know	8	8	8	8	

			Col./ Code	Skip to
	I'd now like to ask you some questions about aircraft noise during daytime, evening and night.			
11a)	During weekdays are you usually at home during the daytime ? (INCLUDE JUST HOME DURING MORNING OR AFTERNOON) (Daytime = 7.00 am - 7.00 pm)		(153)	
		Yes	A	
		No	6	Q.12
	IF 'YES' AT a)			
	b) SHOW CARD A : Please look at this card and tell me how much the noise of aircraft bothers or annoys you during the daytime.	Very much	1	
		Moderately	2	
		A little	3	
		Not at all	4	
		Don't know	8	
12a)	Are you usually at home during the evening ? (ie 3 or more evenings a week) (Evening = 7.00 pm - 11.00 pm)		(154)	
		Yes	A	
		No	6	Q.13
	IF 'YES' AT a)			
	b) SHOW CARD A : How much does the noise of aircraft bother or annoy you during the evening ?	Very much	1	
		Moderately	2	
		A little	3	
		Not at all	4	
		Don't know	8	
13.	SHOW CARD A : And how much does the noise of aircraft bother or annoy you here during the night after you have gone to bed ?		(155)	
		Very much	1	
		Moderately	2	
		A little	3	
		Not at all	4	
		Don't know	8	
		(Usually on night shift)	5	
14.	Would you say on the whole that you were more bothered by aircraft noise here on weekdays or at the weekend ?		(156)	
		More bothered weekdays	1	
		More bothered at weekend	2	
		No difference/don't know	8	
15.	Would you say that you are more bothered by aircraft noise here when you are indoors or when you are outside ?		(157)	
		Indoors	1	
		Outside	2	
		No difference/don't know	8	

Col./Code | Skip to

16a) ASK FOR EACH ITEM BELOW : Do the aircraft ever ...... ?

IF 'YES' SHOW CARD A AND ASK :

b) When they ...., how annoyed does this make you feel ?

		(a)		(b)						
		Yes	No	Very	Mod-erate	Little	Not at all	No TV/ Radio	D.K.	
i)	Startle you ?	A	1	2	3	4	5		8	(158)
ii)	Wake you up ?	A	1	2	3	4	5		8	(159)
iii)	Interfere with listening to radio or TV ?	A	1	2	3	4	5	6	8	(160)
iv)	Make the TV picture flicker ?	A	1	2	3	4	5	6	8	(161)
v)	Make the house vibrate or shake ?	A	1	2	3	4	5		8	(162)
vi)	Interfere with conversation ?	A	1	2	3	4	5		8	(163)
vii)	Interfere with or disturb any other activity ? IF 'YES' SPECIFY ONE O.U.O. ☐☐	A	1	2	3	4	5		8	(164-66)
viii)	Bother, annoy or disturb you in any other way ? IF 'YES' SPECIFY ONE O.U.O. ☐☐	A	1	2	3	4	5		8	(167-9)

17. ASK ALL

All things considered, do you think the amount of aircraft noise here is acceptable or unacceptable ?

	(170)
Acceptable	1
Unacceptable	2
Qualified answer (WRITE IN) ________	
Don't know	8

			Col./ Code	Skip to
18.	Do you happen to work at the airport or for a company doing business at the airport ?		(171)	
		Work at airport	1	
		For company doing business there	2	
		Neither	3	
19.	Have you soundproofed your house or part of it ?		(172)	
		Yes	1	
		No	2	Q22
		(Already soundproofed when moved in)	3	
	IF 'YES' AT Q.19			
20.	Did you soundproof it mainly because of aircraft noise, mainly because of some other noise or mainly for some other reason ?		(173)	
		Aircraft noise	1	
		Other noise	2	Q22
		Other reason (SPECIFY) ______		
	IF 'AIRCRAFT NOISE ' AT Q.20			
21.	Did you obtain a grant from a public body towards the cost ?		(174)	
		Yes	1	
		No	2	
22.	ASK ALL SHOW CARD C: Just to be sure I have it all straight, how do you feel overall about the amount of noise here from aircraft ? Please give how you feel a score out of seven.		(175)	
		Definitely satisfactory	1	
			2	
			3	
			4	
			5	
			6	
		Definitely NOT satisfactory	7	
23.	You have given a score of __(READ OUT CODE AT Q.22). Is that your general feeling about aircraft noise round here or how you feel when it is loudest ?		(176)	
		When noise loudest	1	
		General feeling	2	
		Don't know	8	

	Col./ Code	Skip to
CLASSIFICATION		
24a) SHOW CARD D : Which of the statements on this card applies to you ?	(177)	
Working full-time, 31+ hours per week	1	
Working part-time, 1-30 hours per week	2	
Unemployed and seeking work	3	Q25
Out of work, sick or disabled	4	
Retired	5	
Housewife (not in paid employment)	6	Q26
Full-time student	7	
Other (SPECIFY) ________________	8	Q.25
IF WORKING AT a) - CODES 1 OR 2	(178)	
b) Do you do shift work ? Yes	1	
No	2	
25. DETAILS OF (LAST MAIN PAID) OCCUPATION		
i) What is your job ? NAME/TITLE OF JOB : ________________		
ii) What do you actually do or make in that job ? DESCRIPTION OF ACTIVITY : ________________ ________________		
iii) What qualifications or training do you need for the job ? ________________		
iv) Do you supervise the work of other people ? Yes	A	
No	B	
IF YES : How many people ________________		
v) What is the industry, business or profession of your employer ? ________________		
vi) How many people are employed at the place where you work ? ________________		
vii) Are you an employee or self-employed ? Employee	A	
Self-employed	B	
	(179-80) | 0 U 0	
	(1-3) As Card 1 (4) Card $\boxed{2}$	

			Col./ Code	Skip to
26a)	PROBE TO ESTABLISH STATUS		(205)	
		Respondent is: Head of household	1	Q27
		Housewife	2	
		Other	3	
	IF HOUSEWIFE/OTHER AT a)			
b)	i) What is the HOH's job? NAME/TITLE OF JOB: ______________________			
	ii) What does he/she actually do or make in that job? DESCRIPTION OF ACTIVITY: ______________________			
	iii) What qualifications or training does he/she need for the job? ______________________			
	iv) Does he/she supervise the work of other people?	Yes	A	
		No	B	
	IF YES: How many people ______________			
	v) What is the industry, business or profession of his/her employer? ______________________			
	vi) How many people are employed at the place where he/she works? ______________________			
	vii) Is he/she an employee or self-employed?	Employee	A	
		Self-employed	B	
		O.U.O.	☐☐	(206-7)
27a)	RESPONDENT IS:		(208)	
		Male	1	
		Female	2	
b)	Marital status		(209)	
		Married	1	
		Single	2	
		Widowed/divorced/separated	3	
c)	What was your exact age last birthday?		(210-11)	
		WRITE IN	☐☐	
28	Is there a bus route along the road outside this house?		(212)	
		Yes	1	
		No	2	
i	Time interview finished (WRITE IN ______________)		(213-14) ☐☐	
ii	Date of interview	DAY WRITE IN ☐☐ MONTH ☐☐	(215-18)	
iii	Signature of interviewer ______________	Interviewer No. ☐☐	(219-22) ☐☐	
			(223-80)	SPARE

DEPARTMENT OF TRADE
1 Victoria Street London SW1H 0ET
Telex 8811074/5 DTIHQ G
Telegrams Advantage London SW1
Telephone Direct Line 01-215 3877
Switchboard 01-215 7877

Your reference

Our reference P704A/London

Date Summer 1982

Dear Resident

ATTITUDES TO NEIGHBOURHOOD

The Department of Trade has asked Social and Community Planning Research, an independent research institute, to carry out an important survey among residents of the London area.

We are enquiring into people's attitudes towards the area in which they live: their likes and dislikes about the area.

It is very important in a survey like this that we get the views of a cross-section of the population. For this reason Social and Community Planning Research have selected names at random from the electoral register. Your name is one of those they have selected. I do hope you will be able to co-operate with the interviewer and provide the information required. Everything you say will be treated in the strictest confidence by the research team. The results of the survey will be presented in statistical form only.

Each interviewer carries an identity card and you may ask to see this before the interview starts. Should you have any problems or want further information, please do not hesitate to contact:-

Jean Morton-Williams
Social and Community Planning Research
35 Northampton Square
London EC1V 0AX
(Tel: 01 250-1866)

Thank you for your co-operation.

Yours sincerely

J K Adams

SOCIAL AND COMMUNITY PLANNING RESEARCH
Head Office: 35 Northampton Square London EC1V 0AX. Tel: 01-250 1866
Northern Field Office: Charazel House Gainford Darlington Co. Durham DL2 3EG. Tel: 0325 730 888

P.704 **ATTITUDES TO NEIGHBOURHOOD** (ANIS) Summer 1982

(201-204) ☐☐☐☐ SERIAL NUMBER

(205) 2 CARD

Time Interview started (WRITE IN) ______________

I am doing a survey about some of the things which affect people's living conditions.

1. How long have you lived in this area, that is, within about five minutes walk?

(IF LESS THAN 3 MONTHS DO NOT INTERVIEW)

	Col./ Code	Skip to
	(206)	
3 months but less than 1 year	1	
1 year - under 2 years	2	
2 years - under 4 years	3	
4 years - under 7 years	4	
7 years - under 10 years	5	
10 years - under 20 years	6	
20 years - under 30 years	7	
30 years or more	8	

2a) What are some of the things you like about living round here? PROBE: 'Anything else?' - AFTER EACH REPLY.

b) What are some of the things you don't like about living around here? PROBE: 'Anything else?' - AFTER EACH REPLY.

3. If you could change just one thing about living round here, which would you choose?

			Col./ Code	**Skip to**
4a)	Have you ever felt like moving away from this area? STRESS AREA NOT HOUSE.		(207)	
		Yes	1	
		No	2	Q.5
	IF 'YES' AT a) b) Why did you feel like moving? PROBE FULLY: Ask '*Any other reasons?*'			
5.	On the whole, how do you like living in this area? Do you rate it as an excellent, good, fair, poor or very poor place to live?		(208)	
		Excellent	1	
		Good	2	
		Fair	3	
		Poor	4	
		Very poor	5	
		Don't know	8	
6.	On the whole, would you say this was a quiet or noisy neighbourhood?		(209)	
	IF NOISY: would you say it was very noisy?	Very noisy	1	
	IF QUIET: would you say it was very quiet?	Noisy	2	
		Quiet	3	
		Very quiet	4	
		Don't know	8	
7.	SHOW CARD A: Taking all things into account, how much would you say the noise round here bothers or annoys you?		(210)	
		Very much	1	
		Moderately	2	
		A little	3	
		Not at all	4	
		Don't know	8	
8.	All things considered, would you say that the amount of noise here is acceptable or unacceptable?		(211)	
		Acceptable	1	
		Unacceptable	2	
		Qualified answer (WRITE IN) ____________________ ____________________	3	
		Don't know	8	
9.	Would you say that you are more sensitive or less sensitive than other people are to noise?		(212)	
		More sensitive	1	
		Less sensitive	2	
		About the same	3	
		Don't know	8	

			Air-Craft	Road traffic	Other(1) SPECIFY .... (221) ☐	Other(2) SPECIFY .... (226) ☐
			(213)	(217)	(222)	(227)
10a)	What are the different kinds of noises you hear round here?	Mentioned spontaneously	1	1	1	1
b)	PROMPT AS NECESSARY: Do you ever hear aircraft fly by here?	Mentioned after prompt	2	2	2	2
	How about road traffic - do you ever hear it go by?	Not heard	3	3	3	3
	Do you hear any other kinds of noises?		IF NO NOISE HEARD GO TO Q.19			
			(214)	(218)	(223)	(228)
c)	Which is the most bothersome noise you hear round here?	Most bothersome	1	2	3	4
11a)	FOR EACH NOISE HEARD		(215)	(219)	(224)	(229)
	SHOW CARD A: Please look at this scale and tell me how much the noise of aircraft here bothers or annoys you.	Very much	1	1	1	1
		Moderately	2	2	2	2
		A little	3	3	3	3
	REPEAT FOR ROAD TRAFFIC	Not at all	4	4	4	4
		Don't know	8	8	8	8
	IN ADDITION ASK ABOUT OTHER NOISE(S) IF MENTIONED AT 10a) OR b)					
	ASK FOR EACH NOISE THAT BOTHERS - CODES 1, 2 OR 3 AT a)					
			(216)	(220)	(225)	(230)
	b) SHOW CARD B: From this card, about how often does the noise of aircraft bother you these days?	Many times a day	1	1	1	1
		3 or 4 times a day	2	2	2	2
	REPEAT FOR ROAD TRAFFIC	Once or twice a day	3	3	3	3
	IN ADDITION ASK ABOUT OTHER NOISE(S) IF MENTIONED AT 10a) OR b)	A few times a week	4	4	4	4
		A few times a month	5	5	5	5
		Less than a few times a month	6	6	6	6
		Don't know	8	8	8	8

IF AIRCRAFT NOISE NOT HEARD, GO TO Q.19

			Col./Code	Skip to
	I'd now like to ask you some questions about aircraft noise during daytime, evening and night.			
12a)	During weekdays are you usually at home during the daytime?		(231)	
	(ie 3 or more mornings or afternoons) (Daytime = 7.00am - 7.00pm)	Yes	A	
		No	6	Q.13
	IF 'YES' AT a)			
	b) SHOW CARD A: Please look at this card and tell me how much the noise of aircraft bothers or annoys you during the daytime.	Very much	1	
		Moderately	2	
		A little	3	
		Not at all	4	
		Don't know	8	
13a)	Are you usually at home during the evening?		(232)	
	(ie 3 or more evenings a week) (Evening = 7.00pm - 11.00pm)	Yes	A	
		No	6	Q.14
	IF 'YES' AT a)			
	b) SHOW CARD A: How much does the noise of aircraft bother or annoy you during the evening?	Very much	1	
		Moderately	2	
		A little	3	
		Not at all	4	
		Don't know	8	
14.	SHOW CARD A: And how much does the noise of aircraft bother or annoy you here during the night after you have gone to bed?		(233)	
		Very much	1	
		Moderately	2	
		A little	3	
		Not at all	4	
		Don't know	8	
		(Usually on night shift)	5	
15.	Would you say on the whole that you were more bothered by aircraft noise here on weekdays or at the weekend?		(234)	
		More bothered weekdays	1	
		More bothered at weekend	2	
		(No difference/don't know)	8	
16.	Would you say that you are more bothered by aircraft noise here when you are indoors or when you are outside?		(235)	
		Indoors	1	
		Outside	2	
		(No difference/don't know)	8	

17a) ASK FOR EACH ITEM BELOW: Do the aircraft ever ...?

IF 'YES' SHOW CARD A AND ASK:

b) When they ...., how annoyed does this make you feel?

		(a)		(b)						
		Yes	No	Very	Mod-erate	Little	Not at all	No TV/ Radio	D.K.	
i)	Disturb you when you are reading/writing or generally concentrating?	A	1	2	3	4	5		8	(236)
ii)	Disturb your moments of rest or relaxation at home?	A	1	2	3	4	5		8	(237)
iii)	Make you shut your windows?	A	1	2	3	4	5		8	(238)
iv)	Startle you?	A	1	2	3	4	5		8	(239)
v)	Wake you up?	A	1	2	3	4	5		8	(240)
vi)	Interfere with listening to radio, TV or Hi-Fi?	A	1	2	3	4	5	6	8	(241)
vii)	Make the TV picture flicker?	A	1	2	3	4	5	6	8	(242)
viii)	Make the house vibrate or shake?	A	1	2	3	4	5		8	(243)
ix)	Interfere with conversation?	A	1	2	3	4	5		8	(244)
x)	Interfere with or disturb any other activity? IF 'YES' SPECIFY ONE O.U.O. ☐☐ ______	A	1	2	3	4	5		8	(245) (246-47)
xi)	Bother annoy or disturb you in any other way? IF 'YES' SPECIFY ONE O.U.O. ☐☐ ______	A	1	2	3	4	5		8	(248) (249-50)

18. All things considered, do you think the amount of aircraft noise here is acceptable or unacceptable?

	(251)
Acceptable	1
Unacceptable	2
Qualified answer (WRITE IN) ______ ______ ______	3
Don't know	8

			Col./Code	Skip to
	ASK ALL			
19.	Do you happen to work at an airport or for a company doing substantial business at an airport?		(252)	
		Work at airport	1	
		For company doing business there	2	
		Neither	3	
20.	Have you soundproofed your house or part of it?		(253)	
		Yes	1	
		No	2	Q.23
		(Already soundproofed when moved in)	3	
	IF 'YES' AT Q.20			
21.	Did you soundproof it mainly because of aircraft noise, mainly because of some other noise or mainly for some other reason?		(254)	
		Aircraft noise	1	
		Other noise	2	Q.23
		Other reason (SPECIFY) ________	3	
	IF 'AIRCRAFT NOISE' AT Q.21			
22.	Did you obtain a grant from a public body towards the cost?		(255)	
		Yes	1	
		No	2	
	ASK ALL			
23.	SHOW CARD C: Just to be sure I have it all straight, how do you feel overall about the amount of noise here from aircraft? Please give how you feel a score out of seven.		(256)	
		Definitely satisfactory	1	
			2	
			3	
			4	
			5	
			6	
		Definitely NOT satisfactory	7	
24.	You have given a score of ____ (READ OUT CODE AT Q.23). Is that your general feeling about aircraft noise round here or how you feel when it is loudest?		(257)	
		When noise loudest	1	
		General feeling	2	
		Don't know	8	

			Col./ Code	Skip to
25a)	CLASSIFICATION SHOW CARD D: Which of the statements on this card applies to you?		(258)	
	PROBE AS NECESSARY TO CHECK CHOICE	Working full-time, 31+ hours per week	1	
		Working part-time, 1-30 hours per week	2	
		Unemployed and seeking work	3	Q.26
		Not in employment because sick or disabled	4	
		Retired (and not seeking work)	5	
		Housewife (not in paid employment)	6	Q.27
		Full-time student	7	
		Other (SPECIFY) ______________	8	Q.26
	IF WORKING AT a) - CODES 1 OR 2		(259)	
	b) Do you do shift work?	Yes	1	
		No	2	
26.	DETAILS OF (LAST MAIN PAID) OCCUPATION			
	i) What is your job? NAME/TITLE OF JOB: ______________			
	ii) What do you actually do or make in that job? DESCRIPTION OF ACTIVITY: ______________ ______________			
	iii) What qualifications or training do you need for the job? ______________			
	iv) Do you supervise the work of other people?	Yes	A	
		No	B	
	IF YES: How many people ______________			
	v) What is the industry, business or profession of your employer at your place of work? ______________			
	vi) How many people are employed at the place where you work? ______________			
	vii) Are you an employee or self-employed?	Employee	A	
		Self-employed	B	
			(260-61) OUO	

			Col./Code	Skip to
27.a)	PROBE TO ESTABLISH STATUS			
		Respondent is: Head of household	(262) 1	Q.28
		Housewife	2	
	IF HOUSEWIFE/OTHER AT a)	Other	3	
	b) i) What is the HOH's job? NAME/TITLE OF JOB: ______			
	ii) What does he/she actually do or make in that job? DESCRIPTION OF ACTIVITY: ______			
	iii) What qualifications or training does he/she need for the job? ______			
	iv) Does he/she supervise the work of other people?	Yes	A	
		No	B	
	IF YES: How many people ______			
	v) What is the industry, business or profession of his/her employer at his/her place of work? ______			
	vi) How many people are employed at the place where he/she works? ______			
	vii) Is he/she an employee or self-employed?	Employee	A	
		Self-employed	B	
		O.U.O.	(263-64) ☐☐	
28.a)	RESPONDENT IS:	Male	(265) 1	
		Female	2	
b)	Marital status	Married	(266) 1	
		Single	2	
		Widowed/divorced/separated	3	
c)	Age last birthday	WRITE IN	(267-68) ☐☐	
29.	INTERVIEWER COMPLETE: Any other comments or points about the respondent which may be relevant? eg. hard of hearing, language difficulties: ______			
i)	Time interview finished (WRITE IN ______)		(269-70) ☐☐	
ii)	Date of interview	WRITE IN DAY ☐☐ MONTH ☐☐	(271-74)	
iii)	Signature of interviewer ______	Interviewer No. ☐☐☐☐	(275-78)	
			(279-80)	SPARE

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P.704/H

ATTITUDES TO NEIGHBOURHOOD

Summer 1982

(201-204) ☐☐☐☐   (205) 2

Time interview started (WRITE IN) ____________

I am doing a survey about some of the things which affect people's living conditions.

		Col./Code	Skip to
1.	How long have you lived in this area, that is, within about five minutes walk? (IF LESS THAN 3 MONTHS DO NOT INTERVIEW)	(206)	
	3 months but less than 1 year	1	
	1 year - under 2 years	2	
	2 years - under 4 years	3	
	4 years - under 7 years	4	
	7 years - under 10 years	5	
	10 years - under 20 years	6	
	20 years - under 30 years	7	
	30 years or more	8	
2a)	What are some of the things you like about living round here? PROBE: 'Anything else?' - AFTER EACH REPLY.		
b)	What are some of the things you don't like about living around here? PROBE: 'Anything else?' - AFTER EACH REPLY. (IF AIRCRAFT MENTIONED, PROBE: What sort of aircraft are those?)		
3.	If you could change just one thing about living round here, which would you choose? (IF AIRCRAFT MENTIONED, PROBE: What sort of aircraft?)		

			Col./ Code	Skip to
4a)	Have you ever felt like moving away from this area? STRESS <u>AREA</u> NOT HOUSE.		(207)	
		Yes	1	
		No	2	Q.5
	<u>IF 'YES' AT a)</u> b) Why did you feel like moving? <u>PROBE FULLY:</u> Ask 'Any other reasons?' (IF AIRCRAFT NOISE MENTIONED, PROBE "What sort of aircraft?")			
5.	On the whole, how do you like living in this area? Do you rate it as an excellent, good, fair, poor or very poor place to live?		(208)	
		Excellent	1	
		Good	2	
		Fair	3	
		Poor	4	
		Very poor	5	
		Don't know	8	
	<u>ASK ALL</u>			
6.	On the whole, would you say this was a quiet or noisy neighbourhood?		(209)	
		Very noisy	1	
	IF NOISY: would you say it was very noisy?	Noisy	2	
		Quiet	3	
	IF QUIET: would you say it was very quiet?	Very quiet	4	
		Don't know	8	
7.	<u>SHOW CARD A:</u>			
	Taking all things into account, how much would you say the noise round here bothers or annoys you?		(210)	
		Very much	1	
		Moderately	2	
		A little	3	
		Not at all	4	
		Don't know	8	
8.	All things considered, would you say that the amount of noise here is acceptable or unacceptable?		(211)	
		Acceptable	1	
		Unacceptable	2	
		Qualified answer (WRITE IN)	3	
		Don't know	8	
9.	Would you say that you are more sensitive or less sensitive than other people are to noise?		(212)	
		More sensitive	1	
		Less sensitive	2	
		About the same	3	
		Don't know	8	

			Ordinary Air craft	Helicopters	Road traffic	Other(1) SPECIFY .... (223) ☐	Other(2) SPECIFY .... (228) ☐
10a)	What are the different kinds of noises you hear round here? IF AIRCRAFT MENTIONED: Is that ordinary aircraft or helicopters, or both? IF 'BOTH', RING BOTH CODE 1's)	Mentioned spontaneously	(213) 1	(217) 1	(219) 1	(224) 1	(229) 1
b)	PROMPT AS NECESSARY: - do you ever hear aircraft fly by here? IF YES: Is that ordinary aircraft or helicopters, or both? IF NO: Do you ever hear helicopters fly by here?	Mentioned after prompt	2	2	2	2	2
	- how about road traffic, do you ever hear it go by? - do you hear any other kinds of noises?	Not heard	3	3	3	3	3
			IF NO NOISE HEARD, GO TO Q.27				
c)	Which is the most bothersome noise you hear round here? (IF NO BOTHER, WRITE IN)	Most bothersome	(214) 1	(218) 2	(220) 3	(225) 4	(230) 5
11a)	FOR EACH NOISE HEARD SHOW CARD A: Thinking now of all kinds of aircraft you hear round here, please look at this scale and tell me how much the noise of aircraft here bothers or annoys you.	Very much	ALL AIRCRAFT (215) 1		(221) 1	(226) 1	(231) 1
		Moderately	2		2	2	2
		A little	3		3	3	3
		Not at all	4		4	4	4
		Don't know	8		8	8	8
	REPEAT FOR: ROAD TRAFFIC IN ADDITION ASK ABOUT OTHER NOISE(S) IF MENTIONED AT 10a) OR b) ASK FOR EACH NOISE THAT BOTHERS - CODES 1, 2 OR 3 AT a)	Many times a day	(216) 1		(222) 1	(227) 1	(232)
		3 or 4 times a day	2		2	2	2
		Once or twice a day	3		3	3	3
	b) SHOW CARD B: From this card, about how often does the noise of .... bother you these days?	A few times a week	4		4	4	4
		A few times a month	5		5	5	5
		Less than a few times a month	6		6	6	6
		Don't know	8		8	8	8
			IF NO AIRCRAFT OR HELICOPTER NOISE HEARD, GO TO Q.[illegible]				

			Col./Code	Skip to
12	You said that you were ... (REF. TO Q11a) bothered by aircraft noise; is this your general feeling about aircraft noise, or your feeling about <u>particular</u> aircraft?		(233)	
		Aircraft noise generally	1	
		Particular aircraft	2	
	(SPECIFY) ____________________			
		Don't know	8	
	I'd now like to ask you some questions about aircraft noise during daytime, evening and night.			
13a)	During weekdays are you usually at home during the daytime?		(234)	
	(i.e. 3 or more mornings or afternoons) (Daytime = 7.00 a.m. - 7.00 p.m.)	Yes	A	
		No	6	Q.14
	<u>IF 'YES' AT a)</u>			
	b) SHOW CARD A: still thinking about all kinds of aircraft, please tell me from the card how much the noise of aircraft bothers or annoys you during the <u>daytime</u>.	Very much	1	
		Moderately	2	
		A little	3	
		Not at all	4	
		Don't know	8	
14 a)	Are you usually at home during the evening?		(235)	
	(i.e. 3 or more evenings a week) (Evenings = 7.00 p.m. - 11.00 p.m.)	Yes	A	
		No	6	Q.15
	<u>IF 'YES' AT a)</u>			
	b) SHOW CARD A: How much does the noise of aircraft of all kinds bother or annoy you during the <u>evening</u>?	Very much	1	
		Moderately	2	
		A little	3	
		Not at all	4	
		Don't know	8	
15	SHOW CARD A: And how much does the noise of aircraft bother or annoy you here during the night after you have gone to bed?		(236)	
		Very much	1	
		Moderately	2	
		A little	3	
		Not at all	4	
		Don't know	8	
		(Usually on night shift)	5	
16	Would you say on the whole that you were more bothered by aircraft noise here on <u>weekdays</u> or at the <u>weekend</u>?		(237)	
		More bothered weekdays	1	
		More bothered at weekend	2	
		(No difference/don't know)	8	

		Col./ Code
17	Would you say that you are more bothered by the noise of aircraft here when you are <u>indoors</u> or when you are <u>outside</u>?	(238)
	Indoors	1
	Outside	2
	(No difference/don't know)	8

18a) ASK FOR EACH ITEM BELOW: Thinking of all the kinds of aircraft you hear round here, do aircraft ever ....?

IF 'YES' SHOW CARD A AND ASK:

b) When they .... how annoyed does this make you feel?

		(a)		(b)						
		Yes	No	Very	Mod-erate	Little	Not at all	No TV/ Radio	D.K.	
i)	Disturb you when you are reading/writing or generally concentrating?	A	1	2	3	4	5		8	(239)
ii)	Disturb your moments of rest or relaxation at home?	A	1	2	3	4	5		8	(240)
iii)	Make you shut your windows?	A	1	2	3	4	5		8	(241)
iv)	Startle you?	A	1	2	3	4	5		8	(242)
v)	Wake you up?	A	1	2	3	4	5		8	(243)
vi)	Interfere with listening to radio, TV or Hi-Fi?	A	1	2	3	4	5	6	8	(244)
vii)	Make the TV picture flicker?	A	1	2	3	4	5	6	8	(245)
viii)	Make the house vibrate or shake?	A	1	2	3	4	5		8	(246)
ix)	Interfere with conversation?	A	1	2	3	4	5		8	(247)
x)	Interfere with or disturb any other activity? IF 'YES' SPECIFY ONE O.U.O ☐☐☐	A	1	2	3	4	5		8	(248-50)
xi)	Bother annoy or disturb you in any other way? IF 'YES' SPECIFY ONE O.U.O ☐☐☐	A	1	2	3	4	5		8	(251-53)

19	All things considered, do you personally think the amount of aircraft noise here is acceptable or unacceptable?	(254)
	Acceptable	1
	Unacceptable	2
	Qualified answer (WRITE IN) ____________________	3
	Don't know	8

20a) Has anyone in your household ever taken any of these actions about aircraft noise? READ OUT

	Col./Code			Skip to
	YES	NO		
Signed a petition ?	1	2	(255)	
Contacted the airport ?	1	2	(256)	
Contacted the police ?	1	2	(257)	
Contacted a politician ?	1	2	(258)	
Contacted a councillor ?	1	2	(259)	
Joined a protest group ?	1	2	(260)	
Written to a newspaper ?	1	2	(261)	
Contacted your local residents association ?	1	2	(262)	
Contacted any other official body ?	1	2	(263)	
Has anyone in your household ever taken any other action about aircraft noise ?	1	2	(264)	
IF YES, SPECIFY ______________________				
IF NONE, GO TO	Q.21			

IF ANYTHING DONE (ANY CODE 1 AT (a)):

b) What was it about? (PROBE FULLY)

21a) When you hear aircraft fly overhead, do you ever feel there is any danger they might crash nearby?

	(265)	
Yes	1	
No	2	Q.22
Don't know	8	

IF YES:

b) Would you say that you feel this: READ OUT

	(266)	
Very often	1	
Fairly often	2	
OR Only occasionally?	3	
(Don't know)	8	

c) Are there particular types of aircraft you feel this about?

	(267)	
No	1	
Yes (SPECIFY)	2	

____

____

CHECK Q.10, SECOND COLUMN
IF HELICOPTERS NOT HEARD (CODE 3), GO TO Q.27

IF HELICOPTERS HEARD:

22a) You said that you hear helicopters fly by here; (SHOW CARD A) please tell me from this card how much the noise of helicopters bothers or annoys you.

	Col./Code	Skip to
	(268)	
Very much	1	
Moderately	2	
A little	3	
Not at all	4	Q.24
Don't know	8	

IF BOTHERS AT ALL (CODES 1, 2 OR 3 AT a)

b) SHOW CARD B: From this card, about how often does the noise of helicopters bother you these days?

	Col./Code	Skip to
	(269)	
Many times a day	1	
3 or 4 times a day	2	
Once or twice a day	3	
A few times a week	4	
A few times a month	5	
Less than a few times a month	6	
Don't know	8	

23 You said you were .... (REF Q22a) bothered by helicopter noise; were you thinking about helicopter noise generally or about particular kinds of helicopter noise?

	Col./Code	Skip to
	(270)	
Helicopter noise generally	1	
Particular kinds of helicopter noise	2	
(SPECIFY) ______________________		
Don't know	8	

24a) Do you find the noise of helicopters more or less disturbing than that of other aircraft?

IF MORE, PROBE: Would you say "Much more?"
IF LESS, PROBE: Would you say "Much less?"

	Col./Code	Skip to
	(271)	
Much more	1	
More	2	
Less	3	
Much Less	4	
(No difference)	5	Q.25

IF MORE/LESS (CODES 1-4 AT a)

b) In what way is the noise of helicopters more/less disturbing than that of other aircraft? PROBE FULLY

			Col./Code	Skip to
25	All things considered, do you personally think the amount of helicopter noise here is acceptable or unacceptable?		(272)	
		Acceptable	1	
		Unacceptable	2	
		Qualified answer (WRITE IN) ______________	3	
		Don't know	8	
26	Apart from noise, do you find anything else annoying or disturbing about helicopters? PROBE FULLY		(273)	
		No	1	
	ASK ALL			
27	Do you happen to work at an airport or heliport or for a company doing substantial business at an airport or heliport?		(274)	
		Work at airport/heliport	1	
		For company doing business there	2	
		Neither	3	
	CLASSIFICATION			
28a)	SHOW CARD C: Which of the statements on this card applies to you?		(275)	
	PROBE AS NECESSARY TO CHECK CHOICE	Working full-time, 31+ hours per week	1	
		Working part-time, 1-30 hours per week	2	
		Unemployed and seeking work	3	Q.29
		Not in employment because sick or disabled	4	
		Retired (and not seeking work)	5	
		Housewife (not in paid employment)	6	Q.30
		Full-time student	7	
		Other (SPECIFY) ______________	8	Q.29
	IF WORKING AT a) CODES 1 OR 2		(276)	
	b) Do you do shift work?	Yes	1	
		No	2	
			(277-80)	SPARE

			Col./ Code	Skip to
29	DETAILS OF (LAST MAIN PAID) OCCUPATION			
	i) What is your job? NAME/TITLE OF JOB: ______		(301-4)	As Card2
	ii) What do you actually do or make in that job? DESCRIPTION OF ACTIVITY: ______ ______		(305)	Card 3
	iii) What qualifications or training do you need for the job? ______			
	iv) Do you supervise the work of other people?	Yes	A	
	IF YES: How many people? ______	No	B	
	v) What is the industry, business or profession of your employer at your place of work? ______ ______			
	vi) How many people are employed at the place where you work? ______			
	vii) Are you an employee or self-employed?	Employee	A	
		Self-employed	B	
			(306-7) ☐☐ O.U.O.	
30a)	RESPONDENT IS:		(308)	
		Male	1	
		Female	2	
			(309)	
b)	Marital status	Married	1	
		Single	2	
		Widowed/divorced/separated	3	
			(310-11	
c)	Age last birthday	WRITE IN	☐☐	

	Col./Code	Skip to
31a) PROBE TO ESTABLISH STATUS	(312)	
Respondent is: Head of household	1	Q.32
Housewife	2	
Other	3	

IF HOUSEWIFE/OTHER AT a)

b) i) What is (Head of Household's) job?

NAME/TITLE OF JOB: ______________________

ii) What does he/she actually do or make in that job?

DESCRIPTION OF ACTIVITY: ______________________

____

iii) What qualifications or training does he/she need for the job?

____

	Col./Code
iv) Does he/she supervise the work of other people? Yes	A
IF YES: How many people? __________ No	B

v) What is the industry, business or profession of his/her employer at his/her place of work?

____

vi) How many people are employed at the place where he/she works?

____

vii) Is he/she an employee or self-employed?

	Col./Code
Employee	A
Self-employed	B
	(313-4) ☐☐
	O.U.O.

32. INTERVIEWER COMPLETE

Any other comments or points about the respondent which may be relevant? eg. hard of hearing, language difficulties.

____

____

____

	Col./Code	Skip to
Time interview finished (WRITE IN __________)	(315-6) ☐☐	
Date of interview WRITE IN DAY ☐☐ MONTH ☐☐	(317-20)	
Signature of interviewer ______________________		
Interviewer Number ☐☐☐☐	(321-24)	
	(325-80)	SPARE

CARD A

Very much
Moderately
A little
Not at all

CARD B

Many times a day
A few times a day
A few times a week
A few times a month
Less than a few times a month

CARD C

Definitely satisfactory	1	2	3	4	5	6	7	Definitely NOT satisfactory

CARD D

Working full-time, 31+ hours per week
Working part-time, 1-30 hours per week
Unemployed and seeking work
Out of work, sick or disabled
Retired
Housewife (not in paid employment)
Full-time student
Something else (PLEASE DESCRIBE)

APPENDIX B

NOISE MEASUREMENT : METHODOLOGY AND EQUIPMENT.

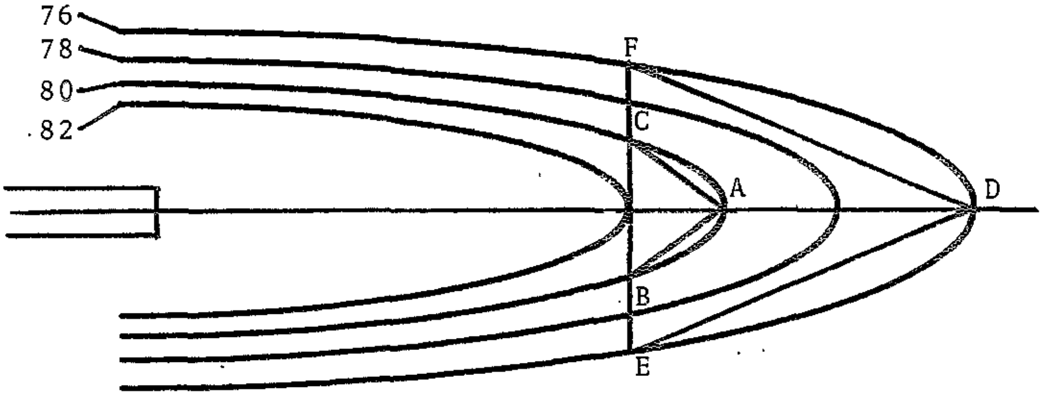
Selection of Measurement Locations

B.1 Noise measurements were made at a single measurement site situated centrally within each of a number of small communities. In each of these the exposure to external noise levels from aircraft overflights is approximately the same - they are known in this study as common noise areas. The method of delineating these areas is described in paragraphs B.2 to B.9.

B.2 Laboratory research has demonstrated that the average person cannot easily discriminate between aircraft noise events which differ in intensity by about 3dB or less. This finding suggested an appropriate target criterion for approximating a community with a common noise climate or - stated more simply - a common noise area. This common noise area was therefore initially defined as an area within which the maximum noise level from any single aircraft overflight received at any point on the ground was estimated as not more than 3dB different from that received at any other point on the ground, assuming the maximum noise level to be unmodified by the presence of buildings and ground effects, etc. In later paragraphs other considerations are discussed which required that this original criterion of 3dB be relaxed: in addition other caveats about the common noise area are necessary. However, the basic justification of an experimental design based on common noise areas is not that all respondents within the area receive exactly the same perceived exposure, but that these respondents all lie within a relatively small interval in the large range of aircraft noise exposure which obtains around UK airports.

B.3 Common noise areas can be delineated from knowledge of the aircraft flight paths which dominate the noise exposure in the area and of the characteristics of noise attenuation. Although common noise areas can take irregular shapes, it is convenient for the purposes of illustration to consider a common noise area under the final approach to landing. Using an assumption of 8dB attenuation per doubling of distance and constant source noise, common noise areas are readily delineated as triangles or parts of triangles under landing flight paths (for which the flight path is fixed for all aircraft by the Instrument Landing System). As the common noise triangle is based on the difference in maximum noise level received over its area from any overflight, the delineation of such a triangle is independent of the actual level of source noise - providing it is constant - of the aircraft. Thus it is solely the geometry of the flight paths which determines the triangle.

B.4 The diagram shows the noise level contours of a landing aircraft at



intervals of 2PNdB. The area between any two adjacent contours is therefore a '2dB common noise area'. However it is convenient and theoretically conservative to use a triangular area, eg triangle ABC which lies completely between the 80PNdB and 82PNdB contours and is therefore again a 2dB common noise area. For the landing footprint of any other aircraft there are always contours at 2dB intervals which coincide with these contours (because the flight path is fixed) but they will have different values dependent on the source noise level of the aircraft. However, as noted in the previous paragraph, only differences in noise level over the area are relevant here.

B.5 Where it is necessary to fit common noise areas to specific irregular areas of population other shapes based on triangles can be used. For example, the triangle DEF is a 6dB triangle, but if the 2dB triangle ABC is removed the shape EBACFD which remains is a 4dB(=6dB-2dB) common noise area. Thus if it were necessary - to include enough population for adequate sampling - to use a 4dB common noise area, then the shape EBACFD contains a greater population. Even where a triangle is suitable, if it contains a more than adequate population then the actual area can be any shape within the triangle.

B.6 Where areas are required under take-off flight paths the situation is rather more complex because aircraft climb paths differ. However, by basing the common noise area on the fastest rate of climb of the various aircraft types commonly using the airport and the height achieved over the triangle by the slowest climbing type. the common noise area will be conservative for other types. Where common noise areas laterally displaced from flight paths are required, these too can be constructed by slight modification of the basic principles outlined above.

B.7 It was noted in paragraph B.2 that certain caveats are necessary in respect of common noise areas. The first of these concerns the target criterion of no more than 3dB variation, within the common noise area, in peak noise level from any flight. Near to the airport, where aircraft heights are lower, common noise areas can be quite small and hence contain only a small population. Since about 400-500 dwellings are desirable within a common noise area in order to draw the intended sample of respondents, it is sometimes necessary to relax the 3dB target criterion.

B.8 It is also apparent that common noise areas, although constructed on the basis of the principal or dominant mode of exposure to which they are subject, are also affected by other, more distant, flight paths. The noise levels from the modes of lesser exposure may give rise to greater variation than the stated value for the common noise area. However they will generally be noise levels of much lesser intensity and any excess variation will have little or no effect on the validity of the common noise areas for the higher noise levels.

B.9 Any relaxation of the variation in noise level across the common noise area and the caveats mentioned in the preceding paragraph do not invalidate the experimental design. The rationale of the common noise areas is to group respondents with closely similar noise exposure so that measurement at one central site within the area would describe the band of noise exposure within which they all fall and that the width of this band should be as narrow as possible, consistent with the feasibility of a statistically valid social survey.

Method of Measurement

B.10 Most of the noise measurements were made using unattended equipment but some attended measurements were made at sites having minor modes of operation at low average noise energy. Attended measurements only were made at sites in the Stanwell areas.

B.11 The noise measurement programme was designed to obtain an extensive sample of the values of LAmax and the associated values of LAX of the aircraft noise events occurring at each selected site, such that an estimate would be made of the noise exposure over various time periods.

Unattended measurements

B.12 The values of LAmax and LAX were obtained from the Digitronix Nomal. This instrument, sampled the noise climate throughout the measurement period at intervals of one second. The value of LAmax which it gave for an aircraft noise event was therefore the greatest value of LA occurring during the event at the instants of sampling. The equipment is generally installed in the gardens of co-operative householders, the various noise events recorded being identified with the help of the ATC runway logs.

B.13 The value of LAX for each event was not obtained by direct integration of LA with respect to time. The available program for analysis of Digitronix Nomal tapes does not permit such integration so values of LAX were obtained by the approximation recommended by the Noise Advisory Council and by the International Organization for Standarization (Refs B1 and B2) for aircraft noise events, viz

$$\mathrm{LAX} = \mathrm{LAmax} + 10 \log \tau/2$$

Where τ is the time in seconds between the '10dB down' points. In this expression events for which the peak value does not rise as much as 10dBA above the background are ignored. In practice the contribution to average Leq values of such events is usually less than 0.5dBA.

Apparatus for unattended noise measurement

B.14 The Digitronix Nomal Mk 2B is a precision instrument which measures and records noise levels. It incorporates a General Radio ½ inch Electret Microphone type 1962-9601 (or 9610) with a CEL 152 pre-amplifier and sound level meter. The noise level is sampled at given intervals, converted into digital form and stored along with the time of the noise level on the magnetic tape of a cassette. The sampling rate can be pre-set within the range of one measurement every 0.125 seconds to one every 4.0 secs. The selection of sampling rate in practice is a compromise between the necessity of obtaining a reasonably 'fine-grain' time history of the noise climate and allowance of a reasonable period of unattended monitoring between replacement of the cassette and the batteries which drive the instrument: for the study reported here a sampling rate of one per second was selected - allowing periods of up to 44 hours between services. Measurements are normally made utilizing the 'A' weighting network of the instrument which meets the response and tolerance characteristics of BS 4197/IEC 179. The instrument conforms to the 'slow' response mentioned in these standards. Cassettes are replayed through a specially designed micro-processor unit which is programmed to detect noise events above pre-determined noise level and duration thresholds. For each noise event detected, the time of occurrence, the maximum noise level and duration in seconds within the '10dB down' points are printed out. The processor also computes the LAX value of an event using the approximation for LAX referred to in para B.13 above.

B.15 At each site where unattended measurements were made, a Digitronix Nomal was set up in the following manner:-

> The Nomal is mounted on its tripod with the microphone at a height of about 6 feet. The battery is connected, the apparatus switched on and allowed a ten-minute stabilization period. The cassette is inserted and the appropriate measuring range and weighting network selected. Cassette information such as site number, session number and date are recorded on the tape. The Nomal is then calibrated by inserting the microphone slowly into a Bruel and Kjaer Sound Level Calibrator and adjusting the meter to read 94dB: this signal is then recorded at a scan rate of 0.125 seconds with zero attenuation. An attenuation of 40dB or 20dB (according to the range selected) is then switched in and the calibration signal recorded thus calibrating the upper and lower part of the range. The Nomal is then returned to zero attenuation with a scan rate of 1 second and the foam wind shield fitted to the microphone. The Nomal is switched to record, the time noted and all other relevant details noted on a cassette record card.

Attended measurements

B.16 The values of LAmax and LAX were obtained by feeding the output of a sound level meter directly into a portable level recorder. This allows a continuous trace of LA throughout the event to be obtained. LAmax is taken to be the maximum value of the time history of the instantaneous values of LA during the event.

B.17 The values of LAX were obtained by measurement of the time between the '10dB down' points from the paper trace and using the approximation quoted previously.

Apparatus for attended measurement

B.18 The 'A' weighted output of a Bruel and Kjaer sound level meter (type 2209) fitted with a Bruel and Kjaer half inch condenser microphone type 4163 - is fed directly into a Rion Level Recorder type LR04. The writing speed of the level recorder is set to 'slow' response and the paper speed to 3mm per second.

B.19 At each site where attended measurements were made the equipment was set up in the following manner:-

> The sound level meter is mounted on a tripod such that the microphone is at a height of about 6 feet above the ground. The A.C. output of the sound level meter is connected to the input of the RION level recorder. Information such as site number, and date are recorded on a log sheet and annotated on the paper roll of the level recorder. The equipment is calibrated by applying a Bruel and Kjaer Sound Level calibrator to the microphone and adjusting the meter to read 94dBA. This signal is then recorded on the level recorder paper - usually on a 4dB line somewhere near the centre of the paper. The calibrator is then removed and the attenuator on the sound level meter adjusted to the required measurement range. The level recorder allows for a 50dB range. The sound level meter is generally left switched on whilst the level recorder is only switched on when an aircraft noise measurement is being made. Care is taken to allow the noise event to rise and fall by 10dB relative to its peak value. Details such as time of event, aircraft type, movement type and runway and attenuator setting are recorded on the log sheet.

B.20 This method of making attended measurements was developed from standard procedure used for many years by DR, as follows (note that the type numbers quoted here are for the current updated types of the various items of apparatus):

> Recordings of noise events were made with a Bruel and Kjaer Sound Level Meter Type 2209 (set to 'fast' response) fitted with a Bruel and Kjaer ½ inch condenser microphone Type 4163 and feeding a Nagra E (or Nagra IV D) Tape Recorder. The tape from the Nagra was input to a Bruel and Kjaer Audio Frequency Spectrometer Type 2112 and thence to Bruel and Kjaer Level Recorder Type 2305, the stylus of which traced out the time history of the noise level of the event of a paper roll. The stylus was set to a writing speed of 63mm/sec with a paper speed

of 3mm/sec. The short term excursions of noise level ie the 'saw-teeth' of the trace, were smoothed out by drawing a curve through them such that the area under this curve was approximately equal to the area under the original trace. The maximum value of this curve was regarded as the value of LAmax appropriate to subjective responses: this method of obtaining LAmax is widely adopted.

B.21 Subsequently it became apparent that, allowing for the difference between operators in drawing the smoothing curve, there was essentially no difference between the LAmax thus derived from that obtained if the stylus were set to write at 16mm/sec and the unsmoothed peak of this trace taken. A Rion Level Recorder Type LR-04 was subsequently acquired by DR. This instrument had only two settings for writing speed - 'fast' and 'slow' - and it was found that the trace provided by the 'slow' writing speed was not significantly different from that produced by the Bruel and Kjaer Level Recorder writing at 16mm/sec. The smoothing of traces written at fast speeds was therefore ended and the standard method of determining LAmax was to read the peak of an unsmoothed trace produced by the 'slow' writing speed of the Rion Recorder or the 16mm/sec writing speed of the Bruel and Kjaer recorder.

Comparison of Attended and Unattended Measurements

B.22 A trial was performed to compare the noise levels measured by the six Digitronix Nomal machines used by DR in the Night Disturbance Study measurement programme (Ref B3) with values obtained by the standard method. Sixty one noise events were measured simultaneously by:

(i) the standard method using the Rion Level Recorder
(ii) each of the six Nomal machines

B.23 Averaged over the sixty one noise events (ranging from an LAmax of 62 dBA to 97 dBA) the variance of the six Nomals about their mean in measuring LAmax for each event was almost exactly 1dB (to the nearest 0.1 dB). Typically the mean difference between the value of the LAmax produced by the standard method and that measured by a Nomal for any event was 1 dB, a value of which can be regarded as an average systematic bias of +1dB for the Nomal with respect to the standard method.

B.24 The values of LAX measured by the Nomals were then considered. The Nomals measure LAX (to 10dB down) by using the approximate form:

$$LA = LAmax + 10 \log \tau/2$$

and some of the error on the part of the Nomals in measuring LAX arises from the use of this approximation.

B.25 The variance of the Nomals about their mean value in measuring LAX was 0.5dB. The mean difference between the values of LAX determined by a Nomal for any event and the value of LAX obtained by integration (to 10dB down) of the time history of the event from the Rion trace was 2.5dB (Nomal <u>high</u>). From a separate exercise in which the value of the LAX approximation was applied to the Rion trace it was found for a paired sample of 51 events that the approximation gave a value, on average, 1.2dB higher (s.d = 1dB). Thus the mean systematic bias of the Nomals in measuring LAX is, relative to integration of the standard trace, 2.5dB as mentioned above, but 1.2dB of this is accounted for by the approximate form of LAX used. The remaining systematic bias of +1.3dB is in reasonable accord with the systematic bias of +1dB in measuring LAmax. The values of LAmax, and LAX, obtained from unattended measurement have been adjusted to conform with those values obtained from the attended equipment.

B.26 Attended measurements were made for the minor modes of operation at three sites, and attended measurements only were taken at the four Stanwell sites. All the measurements were made on the dBA scale and PNdB values were derived from the ICAO approximation (Ref B4).

PNdB = dBA + 13

REFERENCES

B1 The Noise Advisory Council
A Guide to Measurement and Prediction of the Equivalent Continuous Sound Level Leq.
HMSO 1978

B2 International Organization for Standardization
Acoustics - Procedure for Describing Aircraft Noise on the Ground.
ISO 3891 (First Edition)
January 1978

B3 Directorate of Operational Research and Analysis
Aircraft Noise and Sleep Disturbance

DORA Communication	7817	April 1978
	8003	August 1980
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DORA Report	8008	August 1980

B4 International Standards and Recommended Practices
Environmental Protection
Annex 16 Vol 1 : Aircraft Noise
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APPENDIX C

CALCULATION OF THE DATABASE

C.1 The original social survey database was formed of the raw data provided by SCPR. It consisted of 2173 cases, each a complete record of an individual's responses to the questionnaire. These were subsequently sorted so that all cases from a single sampled or a split double-sampled site were stored together. This sorted data base was then used as a source file for the SPSS* procedure AGGREGATE to produce a set of aggregated statistics on the study data. These statistics, stored in a binary date file, were used to produce a new database in which the 'cases' were now the 26 individual areas including the trial areas (but excluding Cranford) and the corresponding aggregated statistics, now including noise metric data.

C.2 The following gives details of the calculation of the statistics. The questionnaire in Appendix A gives the exact wording of, and the allowed responses to, the social survey questions. Because some areas were surveyed using slightly different questionnaires from the main ANIS work, not all questions were asked in certain areas. Those statistics using such questions could not, of course, be calculated in those areas; the resultant missing variables are flagged by '101.00' in the data printout. Where a question should have been answered, but nothing has been recorded for a particular respondent, a 'missing value' is flagged in the original database. Except where a smaller sample population has been explicitly defined in the text, the base population for percentile type statistics is the number of respondents in a given area recording non-missing answers. Where the statistics have been formed from a composite of responses to several questions (e.g. the GAS scores, NET % MORE BOTHERED EVENINGS etc) the statistic has been calculated including only those respondents for whom none of the component elements are missing.

1) % THINK GNL NOISE UNACC [NSENA]
This is based on Q8 and is calculated as:
100% - % (think noise is acceptable).
Thus those responding 'don't know' or giving a qualified answer are counted in the database among those finding noise unacceptable.

2) % THINK A-C NOISE UNACC [ARCNA]
This is based on Q18 and is calculated as above, except that there is now have the additional category: those who from Q10b said they did not hear aircraft and were therefore not asked this question. Clearly they should not be counted as finding the noise level unacceptable, so the expression becomes:
100% - [% (think noise is acceptable) + % (did not hear aircraft)]

3) % AT LEAST LITTLE ANNOYED: GNL [NSEAL2]
This is based on Q7. Respondents pick from a card one of the possible responses: 'very much annoyed', 'moderately annoyed', 'a little annoyed' or 'not at all annoyed'. The statistic is:
% (very much annoyed) + % (moderately annoyed) + % (a little annoyed)

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* See Appendix F.

4) % AT LEAST LITTLE ANNOYED : A-C [ARCAL2]
Analogous to the above, except that those who heard no aircraft were not asked this question. This is based on Q11.

5) % VERY MUCH ANNOYED : A-C [VMANN]
Again based on Q11, this is simply :
% (very much annoyed).

8) AV ANAS SCORES [AVANAS]
The Aircraft Noise Annoyance Scale is based on Q11.
A respondent scores 3 for responding 'very much annoyed', 2 for 'moderately annoyed' 1 for 'a little annoyed' and 0 for 'not at all annoyed', 'aircraft not heard' or 'don't know'. The statistic is the sample mean ANAS score for the area.

6,7, 9-12) GAS SCALES

For calculation of GAS Scales see Appendix D.

The aggregate statistics calculated from the GAS scores are:

(6) AV GAS SCORES ON 1967 SCALE) sample mean for [AVOGAS]
(7) AV GAS SCORES ON NEW SCALE) each community [AVNGAS]

(9) % WITH NEWGAS SCORE 3-6: % Scoring 3,4,5 or 6 [NGASHI]
(10) % WITH NEWGAS SCORE >0: % Scoring 1,2,3,4,5 or 6 [NGASPOS]

(11) % WITH 1967GAS SCORE 3-6: % Scoring 3,4,5 or 6 [OGASHI]
(12) % WITH 1967GAS SCORE >0: % Scoring 1,2,3,4,5 or 6 [OGASPOS]

13) AV SATISFACTION ON 7PT SCALE [SCALE7]

Based on Q23, where the respondent is asked to rate his satisfaction with the aircraft noise exposure on a 7 point scale (where 1 = highly satisfied, 7 = highly dissatisfied), this statistic is the sample mean score for the area. One respondent in Willesden Green responded 'don't know'; he was counted as 'missing' and so the base population for Willesden in this case is reduced by one.

14) % SCALING IN WORST MODE [WORSTM]
Based on Q24, where the respondent is asked whether the above score represents 'overall feelings', or when the noise is at its worst. The statistic is:
% (based response on times when noise was worst).

15) % AIRCRAFT ITEM LEAST LIKED [ARCLIV3]
This is based on Q3. Respondents named any single item they would most wish to change about their area. The statistic is:
% (naming aircraft).

16) % AIRCRAFT MOST BOTHERSOME NOISE [ARCBOTH]
Similarly, in Q10, the respondents were asked to name the single most bothersome noise they heard. Statistic is:
% (naming aircraft).

17) NET % MORE BOTHERED EVENINGS [NEWEVE]
18) NET % MORE BOTHERED NIGHTS [NEWNGT]

These two statistics are based on Q12 with Q13, and Q12 with Q14 respectively. For each question, respondents may record an answer of 'very much', 'moderately', 'a little' or 'not at all annoyed', or 'don't know'. In addition, the question may have been skipped because the respondent has already stated that he does not hear aircraft. A recorded answer of 'don't know' or 'aircraft not heard' is considered equivalent to 'not at all annoyed'. From those people who recorded non-missing answers to both Q12 and Q13, and who are usually in both during the day and during the evening, the net percentage (more bothered in the evening) is calculated as the percentage recording greater (not equal) annoyance in the day than in the evening, less the percentage recording greater annoyance in the evening than in the day. Similarly, for those who recorded non-missing answers to both Q12 and Q14, and who are usually in both during the day and at night, the net percentage (more bothered at night) is the percentage recording greater annoyance at night less the percentage recording greater annoyance in the day.

19) NET % MORE BOTHERED WEEKENDS [WKEBOTH]
Based on Q15, this is:
% (more bothered weekends) - % (more bothered during week).

Those responding 'same; don't know' and those who said they did not hear aircraft are all treated as 'neutral'.

20) % RATED AREA AT LEAST NOISY [ANOISY]
Based on Q6, this is:
% (area noisy) + % (area very noisy).

21) % RATED AREA LESS THAN GOOD [AXGOOD]
This is from Q5 and is:
100% - [% (area good) + % (area excellent)]
Thus the statistic includes all those rating area 'fair', 'poor' or 'very poor', and those answering 'don't know'.

22) % WITH DOUBLE-GLAZED HOMES [DGL]
Based on Q20, this is:
% (put in double-glazing) + % (already had double-glazing).

23) % NON-MANUAL [NONMAN]
The answers to Q27b, on the work of the head of household, were used by SCPR to devise a 16point classification of socio-economic groups. In preliminary recording, this was reduced to 7 major divisions.

1 = Professional, Managerial
2 = Other White Collar
3 = Skilled Manual
4 = Semi-Skilled Manual
5 = Unskilled Manual
6 = Unclassifiable
7 = Housewife/Student

This present statistic comprises:
% (Prof, Managerial) + % (other white collar).

24) % IN WORK & ON SHIFT [SHIFTI]
This is based on Q25b. Because of the exceptionally high number of missing values recorded for this question, it was necessary to create a surrogate statistic. Those who (in Q.25a) stated that they were not currently in work were not asked this question. However, of those in work who should have answered Q25b comparatively few actually did so. On the assumption that the distribution of missing values is independent of whether the respondent was on shift work, the percentage of those answering the question (and thus in work) who said they were on shift is used as a sample statistic for the employed population percentage on shift work, i.e. the statistic is:

$$100 \times \frac{(\text{no. on shift})}{(\text{no. on shift}) + (\text{no. in work but not on shift})}$$

25) % WORK CONNECTED WITH AIRPORT [WORKAP]
Based on Q19, this is:
% (work at airport) + % (work for business connected with airport).

26) AV AGE OF RESPONDENT [AVAGE]
Although the actual age of the respondent was asked in Q30, this was recoded at an early stage into eight age bands. The average age is taken to be the arithmetic mean resulting from respondents in a given age-range being 'assigned' the age at the midpoint of the range.

That is, if the sample population in each range is Pi, and the range is $X_i \leqslant \text{age} \leqslant X_{i+1}$ our statistic is

$$\frac{\Sigma_i \; P_i \times (X_i + X_{i+1})/2}{\Sigma_i \; P_i}$$

27) AV LENGTH OF RESIDENCE [LRES]
As above, length of residence, asked in Q1, has been classified into eight categories. The mean is calculated as if each respondent had lived in the area for the period of time at the midpoint of the range.

28) % FEMALES [FEMALE]
Based on Q28, this is simply:
% (respondents female)

Noise Metrics* [M3LEQ]

THREE MONTH DAY LEQ

C.3 The average mode Leq value over the period 0700-1900 LT based on the modal split of operations during the three months mid-June to mid-September and attributed to aircraft alone.

$$Leq = 10 \log \frac{1}{T} \sum_{i=1}^{N} 10^{LAX_i/10} dB$$

where there are N aircraft events in the time period T (seconds) and LAXi is the LAX value of the ith aircraft. This metric is repeated for the evening (1900-2300LT) [EM3LEQ], night (2300-0700LT) [NM3LEQ] and total 24 hour periods [M3LQ24] and for the modal splits pertaining to 30 days and 7 days prior to the survey [M1LEQ, W1LEQ, etc].

WORST-MODE DAY LEQ [WMLEQ]

C.4 The highest value of Leq over the period 0700-1900LT attributable to a particular runway operating mode of the airport.

This metric is repeated for the evening (1900-2300LT) [EWMLEQ], night (2300-0700LT) [NWMLEQ] and total 24 hour periods [WMLQ24].

THREE MONTH AVERAGE MODE NNI [M3NNI]

C.5 The average mode Noise and Number Index value based on the modal split of operations during the three months mid-June to mid-September.

$$NNI = L + 15 \log N - 80$$

where L is the logarithmic average peak noise level in PNdB and N the number of aircraft in the period 0700-1900LT of aircraft making 80 PNdB or more.

WORST MODE NNI [WMNNI]

C.6 The value of NNI, attributable to the runway operating mode of the airport, corresponding to the highest Leq value.

THREE MONTH L80 [M3L80]

C.7 The logarithmic average of the peak noise levels ≯ 80PNdB during the period 0700-1900LT and based on the modal split of operations during the three months mid-June to mid-September.

$$L\ (PNdB) = 10 \log \frac{1}{N} \sum_{i=1}^{N} 10^{L_i/10}$$

This metric is repeated for the modal splits pertaining to 30 days and 7 days prior [M1L80, W1L80] to the survey and for cut-off values of 75PNdB and 70PNdB [M3L75, M3L70, etc].

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* Not all of the noise metric data are used in the compact database. Only evening and night Leqs are included <u>not</u> the corresponding noise levels and number of movements. These are given in Tables 6.1 - 6.4.

WORST MODE L80 [WML80]

C.8 Worst mode values of L and N are governed by the mode of operation of the airport producing the highest value of Leq and are not necessarily the maximum values of L or N recorded. The highest value of logarithmic average of the peak noise levels for the period 0700-1900LT of 80PNdB or more attributable to one particular runway mode of operation of the airport. This metric is repeated for cut-off values of 75PNdB and 70PNdB [WML75, WML70]

THREE MONTH N80 [M3N80]

C.9 The number of aircraft noise peaks ≥80PNdB during the period 0700-1900LT based on the modal split of operations during the three months mid-June to mid-September.

This metric is repeated for the modal splits pertaining to 30 days and 7 days prior to the survey [M1N80, W1N50] and for cut-off values of 75PNdB and 70PNdB [M3N75, M3N70, etc].

WORST MODE N80 [WMN80]

C.10 The maximum number of aircraft noise peaks ≥80PNdB during the period 0700-1900LT attributable to one particular mode of operation of the airport.

This metric is repeated for cut-off values of 75PNdB and 70PNdB [WMN75, WMN70].

VARIABLE NAMES IN DATABASE

log 10 prefix	time of day prefix	period or mode prefix	CORE	cut-off suffix
		M3	LQ24	
	E N	M1	LEQ	
L		W1	N	70 75
		WM	L	80
with N only, optional	with LEQ only, compulsory, may be default blank	ALL		compulsory with N, L

C.11 The computer names for the variables are made up of a core name, referring to the type of noise measure represented by the variable, together with various suffixes and prefixes which identify the particular measure in question. See above Figure.

The core names are

LQ24 - referring to Leq measured over a 24 hr period.
LEQ - referring to Leq measured over only part of the day.
N - referring to numbers of aircraft.
L - referring to average peak noise level.

These core names are <u>always</u> prefixed by a pair of characters which identify over what period of time, or in what mode, they were calculated (see Noise Metrics).

M3 - three months
M1 - one month
W1 - one week
WM - worst mode
e.g. M3LQ24 = three months 24 hr Leq.

In addition, the core name LEQ must be prefixed by a letter which tells what portion of the (24 hour) day is identified with the variable.

E - evening (1900-2300LT)
N - night (2300-0700LT)

By default, no prefix here means - day (0700-1900LT)
e.g. EW1LEQ = one week evening Leq
WMLEQ = worst mode day Leq

The number, N, and noise level, L, variables must be suffixed by a number which identifies what PNdB cut off was used.

70 - aircraft above 70PNdB only
75 - aircraft above 75PNdB only
80 - aircraft above 80PNdB only
e.g. WMN80 - worst mode number above 80PNdB.

Finally the logarithm of the numbers of aircraft is also considered, for all possible number variables. This is indicated by prefixing with an L the entire N variable name.
e.g. LW1N75 = log (W1N75)
= log (one week number above 75PNdB)

TABLE C1 Glossary of Social Survey Variable Names

Name	No	LABEL
ARCAL2	4	% AT LEAST A LITTLE ANNOYED: A-C
ARCBOTH	16	% A-C MOST BOTHERSOME NOISE
ARCLIV3	15	% A-C ITEM LEAST LIKED
ARCNA	2	% THINK A-C NOISE UNACC
ANOISY	20	% RATED AREA AT LEAST NOISY
AVAGE	26	AV AREA OF RESPONDENTS
AVANAS	8	AV ANAS SCORES
AVNGAS	7	AV GAS SCORES ON NEW SCALE
AVOGAS	6	AV GAS SCORES ON 1967 SCALE
AXGOOD	21	% RATED AREA LESS THAN GOOD
DGL	22	% WITH DOUBLE GLAZED HOMES
FEMALE	28	% OF FEMALES
LRES	27	AV LENGTH OF RESIDENCE
NEWEVE	17	NET % MORE BOTH'D EV'NGS
NEWNGT	18	NET % MORE BOTH'D NIGHTS
NGASHI	10	% NEW GAS SCORES 3-6
NGASPOS	9	% NEW GAS SCORES > 0
NONMAN	23	% NON-MANUAL
NSEAL2	3	% AT LEAST A LITTLE ANNOYED: GNL
NSENA	1	% THINK GNL NOISE UNACC
OGASHI	12	% 1967 GAS SCORES 3-6
OGASPOS	11	% 1967 GAS SCORES > 0
SCALE7	13	AV SATISFAC'N ON 7PT SCALE
SHIFT1	24	% IN WORK AND ON SHIFT
VMANN	5	% VERY MUCH ANNOYED: A-C
WKEBOTH	19	NET % MORE BOTH'D W'ENDS
WORKAP	25	% WORK CONNECTED WITH A-PORT
WORSTM	14	% SCALING IN WORST MODE

Variables not in Database

ARCNET	NET % MORE BOTH'D BY AIRCRAFT
W1DE	Decrease in one week Leq from day to evening
W1DN	Decrease in one week Leq from day to night

Abbreviations:

A-C	Aircraft
ANNOYD	Annoyed
A-PORT	Airport
BOTH'D	Bothered
EV'NGS	Evenings
GNL	General
SATISFAC'N	Satisfaction
UNACC	Unacceptable
W'ENDS	Weekends
'67	1967 Social Survey

Table C2

A FORMATTED REPORT OF NOISE AND ANNOYANCE DATA

AREAS WITH DOUBLE SAMPLES SPLIT	%THINK GNL NOISE UNACC.	%THINK A-C NOISE UNACC.	% AT LEAST LITTLE ANNOYD :GNL	% AT LEAST LITTLE ANNOYD :A-C	%VERY MUCH ANNOYED :A-C	AV GAS SCORES ON '67 SCALE	AV ANAS SCORES	%WITH NEWGAS SCORE 3-6	%WITH NEWGAS SCORE >0	%WITH '67GAS SCORE 3-6	%WITH '67GAS SCORE >0	AV SATIS-FACT'N ON 7PT SCALE	%SCAL-ING IN WORST MODE
HARLESDEN A	28.79	15.15	65.15	65.15	10.61	1.60	1.06	10.77	67.69	26.15	72.31	2.89	36.36
HARLESDEN B	15.15	24.24	65.15	66.67	16.67	1.69	1.26	20.00	67.69	28.12	70.31	3.35	35.38
WILLESDEN	16.67	15.15	57.58	56.06	10.61	1.39	.95	13.64	57.58	22.73	60.61	2.55	31.25
WOODHAM	8.51	5.32	62.77	59.57	6.38	1.37	.89	4.26	59.57	18.48	68.48	2.27	24.47
CHISWICK	20.00	13.33	65.33	62.67	6.67	1.65	1.00	6.67	64.00	28.00	68.00	2.92	37.33
FELTHAM A	38.64	64.77	92.05	97.73	52.27	3.92	2.35	67.05	97.73	86.36	97.73	4.89	30.68
FELTHAM B	39.77	67.05	80.68	94.25	51.72	3.93	2.28	56.98	94.19	88.24	96.47	5.15	47.73
HOUNSLOW	53.66	64.63	81.71	86.59	40.24	3.45	2.00	52.50	87.50	70.15	91.04	4.82	19.51
ISLEWORTH	38.03	59.15	87.32	95.77	43.66	4.03	2.17	52.11	97.18	84.51	97.18	5.06	33.80
COLNBROOK	48.19	60.24	84.34	85.54	28.92	3.33	1.83	42.17	90.36	71.08	93.98	4.65	35.37
HOUNSLOW W	38.16	46.05	78.95	84.21	31.58	2.74	1.79	36.00	85.33	59.46	90.54	4.17	32.89
HOUNSLOW C	29.58	40.85	86.96	84.51	25.35	2.85	1.69	26.87	89.55	59.09	93.94	4.16	34.29
STANWELL I	25.32	17.50	56.25	45.00	3.75	1.23	.67	7.59	48.10	18.18	55.84	2.67	20.25
STANWELL II	13.40	10.31	65.98	42.27	4.12	1.15	.64	9.28	46.39	20.21	45.74	2.28	20.62
STANWELL III	25.93	19.75	66.67	62.96	9.88	1.94	1.06	23.46	64.20	34.57	70.37	3.16	13.58
STANWELL IV	15.15	18.18	61.62	55.56	6.06	1.65	.89	12.12	57.58	24.24	69.70	2.72	22.22
IFIELD	12.36	12.36	58.43	46.67	3.33	1.33	.78	6.74	47.19	20.22	57.30	2.48	25.56
HORLEY	27.78	31.11	73.33	82.22	17.78	2.80	1.53	31.11	83.33	51.69	85.39	3.72	36.67
MANCHESTER	23.68	22.67	65.79	61.84	17.11	2.03	1.20	14.86	66.22	34.78	75.36	3.11	14.47
ABERDEEN	3.96	7.92	32.67	56.57	6.06	1.45	.82	5.05	58.59	21.21	66.67	101.00	101.00
LUTON A	28.75	41.25	77.50	92.50	25.00	3.12	1.82	32.47	93.51	55.07	92.75	4.08	32.91
LUTON B	32.91	40.51	82.28	86.08	29.11	3.32	1.73	32.91	87.34	70.83	91.67	3.96	20.51
EALING	23.38	41.56	101.00	94.81	37.66	3.13	2.01	101.00	101.00	63.64	98.70	4.43	24.68
EGHAM	20.78	40.26	101.00	88.31	29.87	3.13	1.78	101.00	101.00	68.42	92.11	4.44	44.16
SLOUGH	14.08	41.67	101.00	80.56	30.56	2.75	1.75	101.00	101.00	56.94	81.94	4.08	30.56
SHEEN	26.39	38.89	101.00	87.50	29.17	3.04	1.86	101.00	101.00	51.39	91.67	4.06	27.78

FOOTNOTE: A VALUE OF 101.00 INDICATES THE QUESTION WAS NOT ASKED IN THAT AREA

Table C2

A FORMATTED REPORT OF NOISE AND ANNOYANCE DATA

AREAS WITH DOUBLE SAMPLES SPLIT	%AIR-CRAFT ITEM LEAST LIKED	%A-C MOST BOTHER SOME NOISE	NET% MORE BOTH'D EV'NGS	NET% MORE BOTH'D NIGHTS	NET % MORE BOTH'D W'ENDS	%RATED AREA AT LEAST NOISY	%RATED AREA LESS THAN GOOD	%WITH DOUBLE GLAZED HOMES	%NON-MANUAL	% IN WORK & ON SHIFT	%WORK CONNEC TED WITH A-PORT	AV AGE OF RESPON DENTS	AV LENGTH OF RES IDENCE	%FE-MALES
HARLESDEN A	.00	33.85	-23.33	-54.84	12.31	43.94	68.18	25.76	31.82	17.39	1.52	43.38	15.70	56.06
HARLESDEN B	.00	43.94	-27.78	-47.22	16.67	25.76	59.09	19.70	45.45	22.22	4.55	42.22	16.57	51.52
WILLESDEN	.00	23.81	-9.09	-36.17	6.06	21.21	49.23	7.58	33.85	12.50	.00	48.88	17.04	62.12
WOODHAM	1.06	19.35	-16.28	-43.18	17.02	20.21	15.96	21.28	58.51	4.84	6.38	48.93	23.24	48.94
CHISWICK	.00	35.62	-4.65	-29.55	21.33	25.33	14.67	10.67	60.00	12.50	2.67	51.65	20.31	58.67
FELTHAM A	50.00	81.40	-4.44	-78.72	47.73	45.98	26.14	40.91	54.55	11.36	2.27	50.72	18.12	51.14
FELTHAM B	47.73	81.61	-8.16	-78.00	39.77	29.55	22.73	34.09	35.63	11.90	3.41	46.51	17.57	55.68
HOUNSLOW	15.85	80.00	11.54	-52.94	20.73	51.85	53.66	57.32	35.37	26.32	13.41	47.00	15.62	54.88
ISLEWORTH	45.07	90.00	14.63	-48.78	31.88	37.14	35.21	28.17	67.61	10.00	7.04	46.39	17.47	48.57
COLNBROOK	31.33	80.25	-32.56	-72.73	49.40	46.99	46.99	92.77	39.76	30.43	18.07	44.41	15.40	48.19
HOUNSLOW W	14.67	68.00	-21.95	-60.98	38.16	57.89	44.74	53.95	55.26	20.00	13.16	43.96	15.47	48.68
HOUNSLOW C	8.57	59.42	-11.76	-55.56	11.27	44.29	49.30	38.03	36.62	21.62	8.45	43.24	15.50	49.30
STANWELL I	6.33	45.00	-4.00	-22.00	10.00	47.50	58.75	61.25	28.75	21.95	18.75	45.24	23.00	52.50
STANWELL II	8.25	20.83	.00	-14.29	9.28	34.02	30.93	42.27	51.55	6.67	11.34	45.04	18.07	54.64
STANWELL III	8.75	43.75	12.12	-31.43	1.23	44.44	49.38	83.95	34.57	10.34	22.22	41.54	19.14	46.91
STANWELL IV	5.05	41.41	-1.85	-23.64	12.12	22.22	54.55	76.77	35.35	34.04	35.35	44.48	19.24	51.52
IFIELD	2.22	34.88	7.27	-1.75	22.47	20.00	19.10	24.44	30.00	9.09	11.11	48.81	18.16	50.00
HORLEY	24.44	69.32	32.65	10.00	31.11	33.33	30.00	68.89	53.33	18.75	11.11	46.17	17.14	55.56
MANCHESTER	.00	27.03	12.20	-14.29	28.00	42.11	61.84	6.58	24.66	18.75	1.32	43.66	20.43	51.32
ABERDEEN	1.00	45.45	-8.77	-38.98	-8.91	2.97	8.91	.00	27.72	20.00	1.98	39.30	3.11	52.48
LUTON A	12.66	72.15	18.18	13.64	38.75	20.00	36.25	23.75	32.50	9.76	2.50	45.79	18.44	48.75
LUTON B	13.92	64.56	25.58	-9.52	26.58	32.05	45.57	25.32	21.52	11.63	5.06	47.18	19.38	56.96
EALING	10.39	69.33	.00	-75.86	24.68	25.97	48.05	16.88	36.84	21.95	3.90	43.94	17.69	54.55
EGHAM	12.00	76.00	13.16	-56.10	24.68	25.97	22.08	10.39	25.97	10.64	11.69	49.39	29.19	50.65
SLOUGH	25.00	81.16	-14.29	-62.86	34.72	11.11	22.22	29.17	54.93	4.76	8.33	47.16	19.97	44.44
SHEEN	23.61	71.83	.00	-45.95	22.22	18.84	11.11	12.68	41.67	2.13	.00	48.28	22.92	54.17

FOOTNOTE: A VALUE OF 101.00 INDICATES THE QUESTION WAS NOT ASKED IN THAT AREA

Table C2

A FORMATTED REPORT OF NOISE AND ANNOYANCE DATA

AREAS WITH DOUBLE SAMPLES SPLIT	THREE MONTH L80	ONE MONTH L80	ONE WEEK L80	WORST MODE L80	THREE MONTH L75	ONE MONTH L75	ONE WEEK L75	WORST MODE L75	THREE MONTH L70	ONE MONTH L70	ONE WEEK L70	WORST MODE L70
HARLESDEN A	92.70	92.40	91.60	93.80	91.70	91.40	90.50	93.10	90.80	90.30	89.10	93.00
HARLESDEN B	92.70	92.40	91.60	93.80	91.70	91.40	90.50	93.10	90.80	90.30	89.10	93.00
WILLESDEN	90.70	90.80	90.50	90.90	88.90	89.20	87.60	90.10	87.70	88.30	85.70	90.00
WOODHAM	88.30	88.10	88.00	88.50	86.60	86.20	85.80	87.10	85.60	84.70	83.90	86.70
CHISWICK	83.90	83.90	84.00	84.00	81.90	81.80	82.10	82.30	81.30	81.20	81.60	81.90
FELTHAM A	96.50	96.50	97.00	97.20	95.20	95.20	96.00	96.30	94.60	94.70	95.70	96.10
FELTHAM B	96.50	96.50	97.00	97.20	95.20	95.20	96.00	96.30	94.60	94.70	95.70	96.10
HOUNSLOW	101.40	99.80	99.60	103.40	101.20	99.60	99.40	103.40	101.20	99.60	99.40	103.40
ISLEWORTH	97.00	97.20	97.40	98.20	96.30	96.60	96.80	98.20	96.10	96.50	96.60	98.20
COLNBROOK	99.80	98.60	95.80	104.20	99.70	98.60	95.80	104.20	99.70	98.60	95.80	104.20
HOUNSLOW W	92.70	92.20	91.10	96.30	91.90	91.30	90.20	96.10	91.80	91.20	90.10	96.10
HOUNSLOW C	89.30	89.20	88.90	89.50	88.40	88.20	87.80	88.90	88.20	88.00	87.60	88.80
STANWELL I	87.40	87.40	87.40	87.70	86.00	86.20	86.20	86.90	85.10	85.40	85.40	86.40
STANWELL II	86.80	86.70	86.30	85.40	83.80	83.60	83.40	82.90	82.10	82.00	81.70	81.90
STANWELL III	90.20	89.90	89.40	91.30	88.80	88.50	87.90	90.60	88.20	87.80	87.10	90.30
STANWELL IV	88.60	88.20	87.90	89.30	87.30	87.00	86.60	88.60	86.30	86.10	85.60	88.10
IFIELD	83.40	83.50	83.50	83.60	82.00	82.00	81.60	81.30	81.70	81.60	81.10	80.70
HORLEY	90.30	89.80	89.10	91.20	89.00	88.70	88.40	89.40	88.10	88.00	87.90	88.30
MANCHESTER	91.80	90.90	90.80	94.60	91.30	90.30	90.20	94.20	91.00	90.00	89.90	94.10
ABERDEEN	95.00	95.20	94.90	95.70	94.40	94.70	94.20	95.60	93.70	94.10	93.60	95.20
LUTON A	97.20	97.10	95.50	98.70	96.60	96.40	94.80	98.30	96.30	96.10	94.50	98.10
LUTON B	97.20	97.10	95.50	98.70	96.60	96.40	94.80	98.30	96.30	96.10	94.50	98.10
EALING	98.80	98.80	98.80	98.80	98.80	98.80	98.80	98.80	98.60	98.60	98.60	98.60
EGHAM	97.60	97.50	97.50	99.20	97.40	97.30	97.30	99.00	97.00	97.00	96.90	98.50
SLOUGH	93.70	93.70	93.70	94.30	93.50	93.40	93.50	94.10	92.80	92.80	92.90	93.50
SHEEN	88.00	88.00	88.00	88.50	87.50	87.40	87.40	88.10	87.30	87.20	87.20	87.90

Table C2

A FORMATTED REPORT OF NOISE AND ANNOYANCE DATA

AREAS WITH DOUBLE SAMPLES SPLIT	THREE MONTH N80	ONE MONTH N80	ONE WEEK N80	WORST MODE N80	THREE MONTH N75	ONE MONTH N75	ONE WEEK N75	WORST MODE N75	THREE MONTH N70	ONE MONTH N70	ONE WEEK N70	WORST MODE N70
HARLESDEN A	40.20	35.40	27.70	109.00	50.00	44.50	35.90	127.30	64.20	59.30	51.40	134.80
HARLESDEN B	40.20	35.40	27.70	109.00	50.00	44.50	35.90	127.30	64.20	59.30	51.40	134.80
WILLESDEN	24.40	30.80	12.10	82.40	40.70	47.50	27.50	102.90	55.70	61.70	44.20	110.20
WOODHAM	20.20	15.90	13.30	29.50	32.10	27.50	24.40	43.00	42.80	41.40	40.20	48.90
CHISWICK	56.80	58.10	72.40	123.20	119.50	123.50	152.40	224.20	149.60	155.40	185.00	265.40
FELTHAM A	61.00	64.90	135.10	193.40	84.90	89.50	173.70	239.70	100.50	105.50	194.90	262.20
FELTHAM B	61.00	64.90	135.10	193.40	84.90	89.50	173.70	239.70	100.50	105.50	194.90	262.20
HOUNSLOW	156.90	162.70	185.50	313.00	161.60	168.20	191.00	313.40	162.60	169.20	192.10	313.40
ISLEWORTH	170.30	180.70	175.80	300.90	194.40	211.10	206.60	304.10	217.60	224.30	219.90	304.80
COLNBROOK	271.80	267.30	260.00	312.60	276.30	272.00	263.80	313.60	277.10	273.00	264.50	313.80
HOUNSLOW W	226.60	221.30	216.40	231.90	271.40	269.60	267.10	295.40	289.20	288.80	287.20	300.00
HOUNSLOW C	210.50	207.60	196.40	231.30	268.30	265.70	263.80	267.30	289.60	287.30	288.00	283.50
STANWELL I	140.20	148.80	152.50	196.10	201.10	206.80	207.80	242.30	248.30	251.40	251.60	271.70
STANWELL II	52.60	51.90	39.40	81.10	120.70	123.10	112.70	166.70	185.20	186.80	177.00	222.80
STANWELL III	160.80	154.30	142.50	229.30	227.70	220.80	212.00	274.20	261.10	254.80	248.90	288.20
STANWELL IV	136.90	142.40	135.00	201.10	187.00	194.20	189.60	237.10	239.80	243.90	241.30	267.60
IFIELD	76.50	75.60	56.80	45.20	126.20	125.60	112.00	133.80	145.20	144.80	138.00	133.90
HORLEY	111.00	120.10	132.40	94.20	152.20	154.90	158.60	147.20	190.10	185.90	180.10	198.10
MANCHESTER	46.60	49.40	49.70	37.30	54.00	57.90	58.20	40.80	57.40	61.70	62.10	42.30
ABERDEEN	17.60	19.00	16.80	24.40	21.20	22.10	20.60	25.80	25.20	25.80	24.70	28.80
LUTON A	32.40	33.50	34.90	31.20	38.00	39.10	41.90	34.60	41.40	42.70	45.70	36.70
LUTON B	32.40	33.50	34.90	31.20	38.00	39.10	41.90	34.60	41.40	42.70	45.70	36.70
EALING	15.40	22.30	12.70	128.10	15.60	22.60	12.90	129.80	16.10	23.30	13.30	134.00
EGHAM	62.80	60.20	63.80	70.70	68.00	65.30	69.00	76.00	75.80	72.70	76.80	88.10
SLOUGH	120.90	113.50	123.90	139.40	129.60	121.60	132.70	148.10	147.00	137.90	150.60	168.30
SHEEN	208.90	187.30	202.20	256.40	255.00	230.00	248.40	299.50	275.00	249.00	268.20	319.40

Table C2

A FORMATTED REPORT OF NOISE AND ANNOYANCE DATA

AREAS WITH DOUBLE SAMPLES SPLIT	THREE MONTH DAY LEQ	ONE MONTH DAY LEQ	ONE WEEK DAY LEQ	WORST MODE DAY LEQ	THREE MONTH EVN'G LEQ	ONE MONTH EVN'G LEQ	ONE WEEK EVN'G LEQ	WORST MODE EVN'G LEQ	THREE MONTH NIGHT LEQ	ONE MONTH NIGHT LEQ	ONE WEEK NIGHT LEQ	WORST MODE NIGHT LEQ	THREE MONTH 24HR LEQ	ONE MONTH 24HR LEQ	ONE WEEK 24HR LEQ	WORST MODE 24HR LEQ	THREE MONTH NNI	SAMPLE SIZE
HARLESDEN A	59.8	59.1	57.3	65.2	55.7	54.7	54.4	62.0	37.8	37.4	37.2	40.3	57.3	56.6	55.0	62.8	36.8	66
HARLESDEN B	59.8	59.1	57.3	65.2	55.7	54.7	54.4	62.0	37.8	37.4	37.2	40.3	57.3	56.6	55.0	62.8	36.8	66
WILLESDEN	55.6	56.5	52.7	60.6	51.7	52.7	44.4	57.5	36.3	36.3	36.3	36.5	53.2	54.1	50.0	58.3	31.5	66
WOODHAM	52.2	51.2	50.3	53.8	48.5	47.1	46.0	50.3	36.9	36.5	35.8	37.9	49.8	48.8	47.9	51.5	27.9	94
CHISWICK	53.6	53.8	55.0	57.0	52.4	51.9	52.1	55.8	43.6	45.5	42.6	48.4	51.8	52.0	52.8	55.3	30.2	75
FELTHAM A	65.3	65.5	69.1	70.8	61.8	61.6	64.5	68.1	50.0	50.1	52.8	55.1	63.0	63.1	66.6	68.6	43.3	38
FELTHAM B	65.3	65.5	69.1	70.8	61.8	61.6	64.5	68.1	50.0	50.1	52.8	55.1	63.0	63.1	66.6	68.6	43.3	88
HOUNSLOW	70.9	69.6	70.1	75.7	71.1	69.6	63.1	75.3	63.0	60.7	62.8	66.7	69.5	68.1	67.8	74.1	54.3	82
ISLEWORTH	68.0	68.5	68.4	71.4	67.0	66.9	67.3	73.7	56.5	58.5	57.3	60.9	66.2	66.6	66.6	69.7	50.5	71
COLNBROOK	73.1	71.9	68.9	78.1	69.6	69.0	68.4	73.5	54.0	52.6	50.4	55.2	70.7	69.6	67.1	75.6	56.3	83
HOUNSLOW W	66.3	65.6	64.5	70.8	62.6	62.0	61.8	67.6	50.4	49.7	49.9	52.1	63.9	63.2	62.3	68.5	48.0	76
HOUNSLOW C	62.9	62.9	62.1	64.5	61.6	61.7	61.9	63.1	52.4	51.3	53.2	54.5	61.1	61.0	60.6	62.7	44.1	71
STANWELL I	61.1	61.5	61.8	62.6	57.4	57.5	57.1	59.7	44.3	44.8	44.8	46.3	58.7	59.1	59.3	60.3	39.6	80
STANWELL II	57.5	57.4	56.6	57.9	54.6	54.6	53.6	56.0	41.8	41.6	39.9	43.9	55.2	55.2	54.3	55.8	32.6	97
STANWELL III	64.0	63.5	62.8	66.5	60.9	60.4	60.7	63.6	47.8	48.0	48.2	50.5	61.7	61.2	60.7	64.2	43.3	81
STANWELL IV	62.4	62.1	61.6	64.8	59.1	58.7	59.2	61.8	46.1	46.1	46.5	48.7	60.1	59.8	59.4	62.5	40.6	99
IFIELD	54.0	54.0	54.1	54.1	52.7	52.6	53.3	54.1	49.3	49.4	50.2	52.8	52.7	52.7	53.0	53.7	31.7	90
HORLEY	63.3	62.9	62.4	63.9	60.9	60.6	59.6	61.4	54.3	54.2	53.7	54.7	61.3	61.0	60.4	61.9	41.0	90
MANCHESTER	58.5	57.7	57.6	60.4	55.6	56.5	56.4	56.6	52.1	51.4	51.4	53.7	56.7	56.2	56.1	58.5	36.8	76
ABERDEEN	57.3	57.8	57.0	59.3	49.2	49.4	47.4	51.0	-1.3	-1.3	-1.3	-1.3	54.5	55.0	54.1	56.5	33.7	101
LUTON A	61.3	61.3	60.0	62.6	57.3	57.2	56.6	58.2	57.4	57.6	56.1	58.7	59.8	59.8	58.5	61.0	39.9	80
LUTON B	61.3	61.3	60.0	62.6	57.3	57.2	56.6	58.2	57.4	57.6	56.1	58.7	59.8	59.8	58.5	61.0	39.9	79
EALING	61.2	62.8	60.4	70.4	58.2	61.1	59.0	67.6	39.9	41.7	39.9	50.3	58.9	60.7	58.3	68.1	36.6	77
EGHAM	66.1	65.8	66.1	68.0	63.3	63.1	61.6	65.6	51.2	50.5	50.8	52.2	63.9	63.6	63.7	65.8	44.6	77
SLOUGH	65.9	65.5	66.0	67.1	63.7	62.6	65.1	66.6	43.4	42.9	42.9	44.6	63.7	63.2	64.0	65.2	44.9	72
SHEEN	62.6	62.1	62.4	63.7	62.2	61.9	63.0	64.1	56.2	55.9	56.3	57.1	61.2	60.8	61.3	62.5	42.8	72

APPENDIX D

SEARCH FOR A NEW GUTTMAN SCALE FROM THE ANIS RESULTS

Introduction

D.1 The Guttman Annoyance Scale (GAS), developed from the results of the 1967 Heathrow Survey (Ref D1), has been established as one of the principal indices for assessing annoyance by aircraft noise. Using a combination of the responses to a series of questions relating to the annoyance experienced when specific activities and states are disturbed by aircraft noise, the scale gives a single measure of annoyance (expressed as a score of 0 to 6) which has been found to exhibit a strong relationship to the Noise and Number Index NNI (Ref D2). In subsequent smaller studies of aircraft noise, for example the General Aviation Study and Helicopter Disturbance Study (Refs D3 and D4 respectively), the questions which make up the scale have been asked with respect to different aircraft types, together with three additional questions which ascertain a respondent's reactions when concentration and moments of relaxation are disturbed, and when aircraft noise necessitates the shutting of windows. Although alternative scales have been developed from the responses to the expanded set of questions using the Guttman techniques, the 1967 scale was maintained as the measure of annoyance for general aviation traffic, and for helicopters in conjunction with fixed-wing aircraft. The new scales were not adopted because of the relatively small sample sized involved, compared with the 4678 sample in the 1967 survey, and because of the ease of comparison with previous results which the old scale affords. ANIS is the first major study which provides a sufficient sample size, first to test the scale fully and second to devise a new scale without the danger of sampling fluctuations discounting the improved performance of any new scale over the old.

The Guttman Technique

D.2 Scalogram analysis, or Guttman Scaling, is a method of analysing the responses to three or more questions (items) in order to determine whether or not their inter-relationships satisfy the two special properties which define a Guttman scale.

These properties are:-

a) Unidimensionality : the component items in a scale must all measure movement towards, or away from, the same single underlying altitude or continuum; and,

b) Cumulativeness : it must be possible to order the component items by degrees of 'strength of attitude' so that respondents who reply positively to a particular item will reply positively to less strong ones. Hence it is possible to reproduce the pattern of any respondent's answers from a knowledge of his final score on the scale. The pattern of responses for each scale type on a perfect six questions scale is shown in Figure D1. Items A - F are ordered in decreasing order of strength so a respondent with scale score 1, must 'pass' item F and 'fail' items A - E. In practice, these conditions are unlikely to be met fully: it is the extent to which they are satisfied which determines whether or not the items concerned can be said to form a Guttman scale. A judgement is made by examining the values of a number of standardized coefficients described in para D.5

D.3 Possible items for a new Guttman scale are formed from two questions, Q11a and Q17 (i) - (xi) (see ANIS questionnaire, Appendix A). At Q17, a respondent is asked whether or not aircraft noise causes disturbance to, or interference with, various activities and states. If the answer is yes, he is asked to select one of the categories 'Very much', 'Moderately', 'A little' or 'Not at all' which best describes the annoyance felt. He is also asked for his general opinion of aircraft noise on the same rating at Q11a. Each of these items is ordinal in the sense that it can be divided at some point-called the cutting point - into two portions. Respondents who have values equal to or greater than the cutting point (i.e. those who express that degree of annoyance or greater) are considered to have 'passed' an item and score a point. Likewise, those with values less than the cutting point are considered to have 'failed' and score zero. Potentially there are three alternative cutting points for each item viz 'Very much' 'Moderately' and 'A little' annoyed, giving a total of 3 x 12 scale items from which to select six for a new Guttman scale.

D.4 The consistent items in a scale are usually ordered by sorting into descending order according to the proportion of respondents who score zero. Errors on the scale occur when the actual response pattern differs from that expected for a particular score. For example, consider the six items scale in Figure D2. Each of the scale points is scored by three respondents but there are 3 errors in deviations from the pattern of Figure D1: a responent with scale score 4 has passed item B instead of item C; one with score 2 has passed item A instead of item E and a second has passed item C instead of item F. The test of scalability of the items is the degree to which the data fits the model of Figure D1.

D.5 Guttman devised an index called the 'Coefficient of Reproducibility' which give a measure of how good or how bad a scale is by measuring the number of errors. This, and three other statistics useful in assessing the performance of a scale are examined below:

a) Coefficient of Reproducibility : This evaluates the scalability of the items and is given by :

$$CR = 1 \quad \frac{\Sigma \text{ errors}}{\Sigma \text{ items x respondents}}$$

This statistic ranges from 0 to 1, with a value of 1 indicating a perfect scale. The minimum value for a valid scale is considered to be 0.9 (Ref D5).

b) Minimum Marginal Reproducibility : This represents the minimum coefficient of reproducibility that could have occurred by chance, given the items used and the proportion of respondents passing and failing each of them. It is given by,

$$\frac{\sum_{\text{Items}} \text{Max (sums)}}{\sum \text{Items} \times \sum \text{Respondents}}$$

c) Percent Improvement : This indicates the extent to which the coefficient of reproducibility is due to the response patterns rather than to the inherent cumulative interrelation of the items used. It is given by

$$\text{CR} - \text{Minimum Marginal Reproducibility}$$

d) Coefficient of Scalability : This is given by

$$\frac{\text{Percent Improvement}}{1 - \text{Minimum Marginal Reproducibility}}$$

It represents the ratio of the actual percent improvement to the largest possible percent improvement. If a scale is truly unidimensional and cumulative, this statistic should take a value well above 0.6.

A New Guttman Scale

D.6 A major difficulty faced in constructing a new scale is that there appear to be no formal statistically-based rules for including or excluding items when selecting the contents of a scale. In previous studies, a method of search was used based in general terms on the heuristics suggested by Guttman et al (Ref D6), which imposed strict limits on the number of scales considered (see Appendix C of Ref D3). The first step in this method was the exclusion of any cutting points on questions giving less than 15% of the sample above the cutting point. This is used to reduce the effect of sampling fluctuations in low response questions resulting from the small sample size. Next, all possible scales involving all of the remaining components were evaluated and the 'best' scale (i.e. one with the highest CR) was examined to reveal the item contributing the largest minimum error * to that CR. This question was then eliminated, and again, all possible remaining scales were evaluated. In this way, questions were discarded until a six-question scale was reached which could be compared with the 1967 scale.

D.7 The large sample size in ANIS allows the '15% above the cutting point' criterion to be relaxed leaving 36 scale items to be considered. This number may be reduced to 30 by combining** the responses to Q17(iv)

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* Minimum error = min (no. of errors on passes, no. of errors on failures).

** The 'very much', 'moderately' and 'a little' categories of the composite item represent the greatest degree of annoyance expressed over the three questions.

(x) and (xi) as in the 1967 scale. The percentage of the sample above the three cutting points on each question is given in Table D1. Under the old procedure, the number of different scales to be examined at the first stage is immense, viz $3^{10} = 59049$. Moreover the amount of analysis time and computing expenditure required would exceed the resources available. A second method for searching was therefore devised which used the 1967 scale as a starting point, and followed on algorithm for replacing one item in the scale at a time, if the coefficient of reproducibility could be improved. The method is detailed in flow chart of Figure D3 and the results of the search are presented in Table D2. Since any new scale must be compared with the 1967 version, it is reasonable to use the latter as the basis of a search procedure. However, the scale attained under this algorithm is not necessarily the best possible scale ie the global optimum, but must represent a local optimum scale. Nevertheless, it is difficult to see how it can be improved upon without recourse to an exhaustive search or by some justification for some statistically-based search algorithm.

D.8 Figures D4 and D5 show how scores are calculated on the old and new scales respectively. The new scale uses two questions not included as items in the 1967 survey : annoyance when moments of relaxation are disturbed and when windows need to be shut because of aircraft noise. The most noticable feature of the new scale is that four of the items have their cutting point as 'very much' annoyed whereas the 1967 scale used cutting points of 'moderately' and 'a little' annoyed. Hence a smaller proportion of respondents pass the stronger items in the scale and the overall scores are consequently lower than those on the old GAS scale. The performance of each scale with the data is given in Figures D6 and D7. The Coefficient of Reproducibility achieved on the old scale is below 0.9 while the coefficient of scalability is just 0.626. On the new scale, these values have risen to 0.94 and 0.72 respectively.

D.9 Table D3 shows a comparison between the two scales. Each cell gives the number of respondents who have a specific pair of scores under the old and new scales. As expected, the correlation between the scales in extremely high (0.846) but the average score on the new scale is markedly lower than on the 1967 scale; 1.68 compared with 2.36. 49% of respondents have the same score under both scales and 47% record a lower score on the new scale.

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Batsford Ltd 1973

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Princeton University Press 1950

TABLE D1: Possible Items for a New GAS Scale

Question	Percentage of sample above the cutting point		
	Very much	Moderately	A little
11a	20.0	46.0	70.8
17i	11.6	22.3	31.1
17ii	12.3	23.6	34.6
17iii	15.1	26.6	35.1
17v	9.4	13.6	20.1
17vi	24.0	41.1	56.6
17vii	9.3	17.6	28.9
17viii	12.3	23.6	36.8
17ix	19.7	34.2	47.8
17iv,x,xi	12.8	17.8	24.1

TABLE D2 Search for a new Guttman scale: cutting points

	17(i)			17(ii)			17(iii)			17(v)			17(vi)			17(vii)			17(viii)			17(ix)			17(v) (x) (xi)			Coeff. of Reproducibility
	VM	M	L	VM	M	L	VM	M	L	VM	M	L	VM	M	L	VM	M	L	VM	M	L	VM	M	L	VM	M	L	
1967															✓						✓		✓				✓	0.887
1	✓														✓						✓		✓				✓	0.891
2	✓						✓								✓						✓		✓					0.907
3	✓					✓	✓								✓								✓					0.910
4						✓	✓								✓								✓					0.912
5						✓	✓								✓													0.920
6	✓					✓									✓													0.922
7	✓					✓									✓	✓												0.923
8	✓				✓										✓	✓												0.927
9	✓				✓		✓								✓	✓												0.931
10	✓				✓		✓							✓		✓												0.937
11	✓						✓							✓		✓												0.940
12	✓						✓			✓				✓														0.940*
13				✓			✓			✓				✓														0.941

* Higher Coefficient of Scaleability

TABLE D3: A Comparison of the 1967-Type Guttman scale with the new scale

		OLD SCALE							
		6	5	4	3	2	1	0	Totals
	6	37	14	2					53
NEW SCALE	5	28	37	17	7				89
	4	10	49	46	21	1			127
	3	18	47	61	54	8			188
	2	9	30	81	117	95	5		337
	1		4	39	79	184	205	1	513
	0			1	2	22	64	404	493
Totals		102	181	247	280	310	274	405	1799

FIGURE D1: Pattern of responses expected on a perfect six-item Guttman scale

		ITEMS					
		A	B	C	D	E	F
Scale Type	6	1	1	1	1	1	1
	5	0	1	1	1	1	1
	4	0	0	1	1	1	1
	3	0	0	0	1	1	1
	2	0	0	0	0	1	1
	1	0	0	0	0	0	1
	0	0	0	0	0	0	0

FIGURE D2: An example of a six-item scale

ITEMS

Scale Score	A		B		C		D		E		F			TOTAL
	0	1	0	1	0	1	0	1	0	1	0	1	pass	
	ERR--		ERR--		ERR--		ERR--		ERR--		ERR--		fail	
6	0	3	0	3	0	3	0	3	0	3	0	3		3
	--ERR													
5	3	0	0	3	0	3	0	3	0	3	0	3		3
			--ERR											
4	3	0	2	1	1	2	0	3	0	3	0	3	*	3
					--ERR									
3	3	0	3	0	3	0	0	3	0	3	0	3		3
							--ERR							
2	2	1	3	0	2	1	3	0	2	1	0	3	**	3
									--ERR					
1	3	0	3	0	3	0	3	0	3	0	0	3		3
											--ERR†			
0	3	0	3	0	3	0	3	0	3	0	3	0		3
Sums	17	4	14	7	12	9	9	12	8	13	3	18		21
Errors	0	1	0	1	1	1	0	0	2	0	0	0		3

Coefficient Reproducibility = 0.976
Minimum Marginal Reproducibility = 0.683
Percent Improvement = 0.293
Coefficient of Scalability = 0.924

*No. of respondents with score 4 who passed item E

**No. of respondents with score 2 who failed item F

†A response is in error if it is a <u>pass</u> below 'ERR--', or a <u>fail</u> above.

FIGURE D3 Search Procedure for a new Guttman Scale

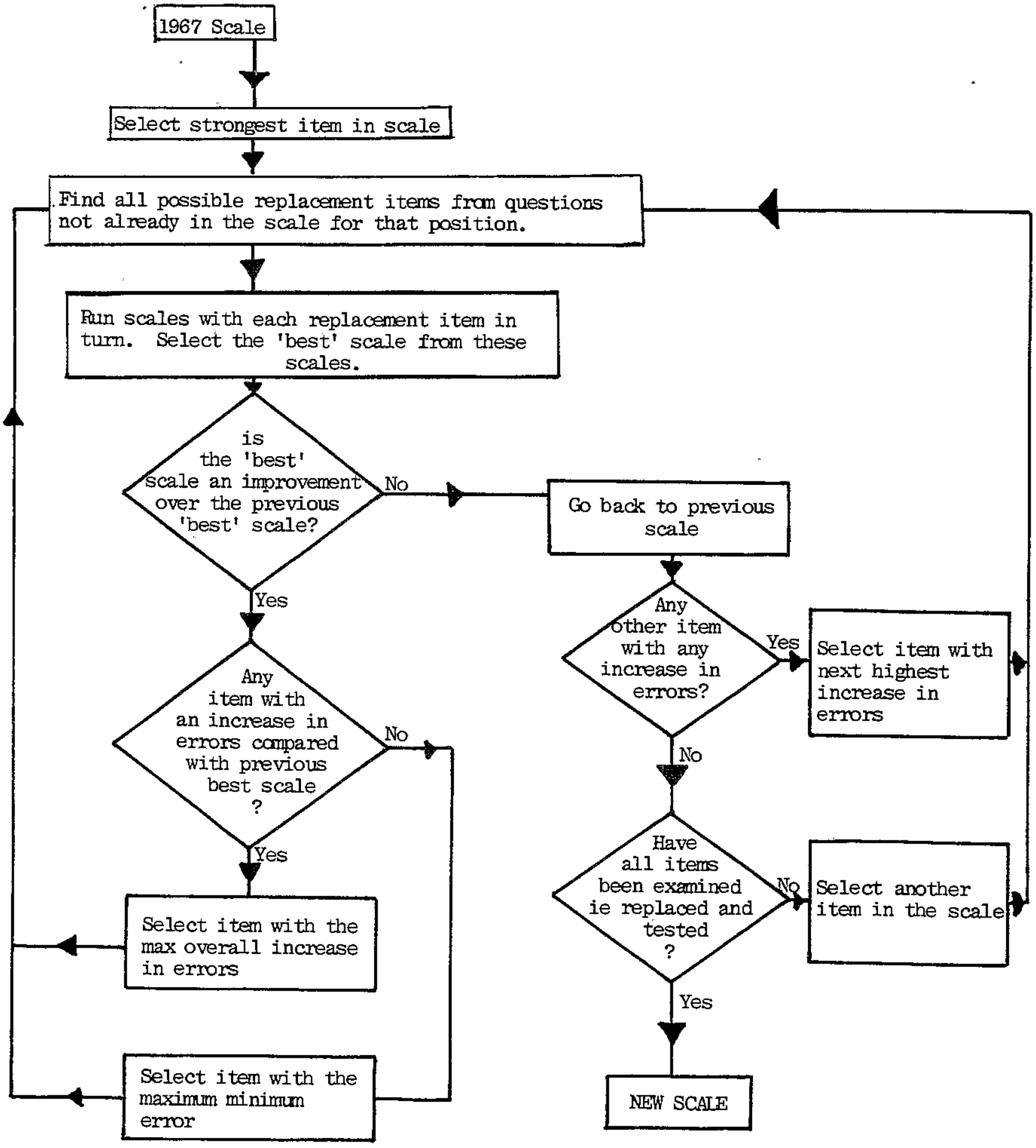

FIGURE D4: The 1967-type Guttman scale

Q11a	How much does the noise of aircraft here bother or annoy you? (Score one point for 'very much', 'moderately' or 'a little')
Q17(v)	Does aircraft noise ever wake you up? IF 'YES', ASK: When they wake you up, how annoyed does this make you? (Score one point for 'very much' or 'moderately')
Q17(vi)	Does aircraft noise ever interfere with listening to radio, TV or Hi-fi*? IF 'YES', ASK: When they interfere with listening to radio, TV or Hi-fi, how annoyed does this make you? (Score one point for 'very much', 'moderately' or 'a little')
Q17(viii)	Does aircraft noise ever make the house vibrate or shake? IF 'YES', ASK: When they make the house vibrate or shake, how annoyed does this make you? (Score one point for 'very much', 'moderately' or 'a little')
Q17(ix)	Does aircraft noise ever interfere with conversation? IF 'YES', ASK: When they interfere with conversation, how annoyed does this make you? (Score one point for 'very much' or 'moderately')
Q17(iv), (x), (xi)	Does aircraft noise ever startle you, interfere with or disturb any other activity, or annoy or disturb in any other way? IF 'YES', ASK: When they startle you, interfere with or disturb any other activity, or annoy or disturb in any other way, how annoyed does this make you? (Score one point for 'very much', 'moderately' or 'a little').

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* 'Hi-fi' was not included in the question asked in the 1967 Heathrow survey.

FIGURE D5: The new Guttman scale

Q11a	How much does the noise of aircraft here bother or annoy you? (Score one point for 'very much', 'moderately' or 'a little')
Q17(ii)	Does aircraft noise ever disturb you moments of rest or relaxation at home? IF 'YES' ASK: when they disturb your relaxation, how annoyed does this make you? (Score one point for 'very much')
Q17(iii)	Does aircraft noise ever make you shut your windows? IF 'YES' ASK: when they make you shut your windows, how annoyed does this make you? (Score one point for 'very much')
Q17(v)	Does aircraft noise ever wake you up? IF 'YES' ASK: when they wake you up, how annoyed does this make you? (Score one point for 'very much')
Q17(vi)	Does aircraft noise ever interfere with listening to radio, TV or Hi-fi? IF 'YES', ASK: when they interfere with listening to radio, TV or Hi-fi, how annoyed does this make you? (Score one point for 'very much' or 'moderately')
Q17(ix)	Does aircraft noise ever interfere with conversation? IF 'YES' ASK: when they interfere with conversation, how annoyed does this make you? (Score one point for 'very much').

FIGURE D6: The 1967 type Guttman scale used in ANIS

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        ITEMS

        Q17v  Q17iv,x,xi  Q17ix  Q17viii   Q17vi     Q11a
        ---------------------------------------------------------
RESP         0   1    0   1    0   1    0   1   0    1    0    1       TOTAL
             ERR---   ERR---   ERR---   ERR---  ERR---    ERR---
        ---------------------------------------------------------
OGAS  6      0 102    0 102    0 102    0 102   0  102    0  102        102
          -----ERR
      5    104  77   45 136   11 170   15 166   6  175    0  181        181
                   -----ERR
      4    211  36  156  91   57 190   50 197  17  230    3  244        247
                            -----ERR
      3    258  22  224  56  150 130  158 122  42  238    8  272        280
                                     -----ERR
      2    304   6  270  40  288  22  256  54  89  221   33  277        310
                                              ----ERR
      1    274   0  264  10  274   0  255  19 226   48   77  197        274
                                                       -----ERR
      0    405   0  405   0  405   0  405   0 405    0  405    0        405
        ---------------------------------------------------------
SUMS      1556 243 1364 435 1185 614 1139 660 785 1014  526 1273       1799
PCTS        86  14   76  24   66  34   63  37  44   56   29   71
ERRORS       0 141   45 197   68 152  223  73 154   48  121    0       1222

1799 CASES HERE PROCESSED
   0 (OR 0.0 PCT) MISSING

STATISTICS:

COEFFICIENT OF REPRODUCIBILITY = 0.8868
MINIMUM MARGINAL REPRODUCIBILITY = 0.6977
PERCENT IMPROVEMENT = 0.1891
COEFFICIENT OF SCALABILITY = 0.6255
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FIGURE D7: The new Guttman scale developed for ANIS

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                Q17v       Q17ii     Q17iii      Q17ix      Q17vi      Q11a

          ----------------------------------------------------------------

RESP             0    1     0    1     0    1     0    1     0  1       0    1       TOTAL
               ERR---+    ERR---+    ERR---+    ERR---+    ERR-- -+   ERR----+
          ----------------------------------------------------------------------
NGAS  6          0   53|    0   53|    0   53|    0   53|    0   53|     0   53|       53
              +-----ERR|          |          |          |          |          |
      5       | 46   43    15   74|   15   74|   10   79|    3   86|     0   89|       89
              |         +-----ERR |          |          |          |          |
      4       | 97   30|   67   60    46   81|   35   92|    8  119|     1  126|      127
              |        |            +-----ERR|          |          |          |
      3       |158   30|  161   27|  141   47    82  106|   20  168|     2  186|      188
              |        |          |          +-----ERR  |          |          |
      2       |325   12|  331    6|  322   15|  315   22    50  287|     5  332|      337
              |        |          |          |          +-----ERR  |          |
      1       |512    0|  511    1|  511    1|  512    0|  489   23    25  487|      512
              |        |          |          |          |          +-----ERR  |
      0       |493    0|  493    0|  493    0|  493    0|  493    0|   493    0        493
          ----------------------------------------------------------------------

SUMS          |1631 168|1578  221|1528  271|1447  352|1063  736|   526 1273        1799
PCTS          |  91   9|  88   12|  85   15|  80   20|  59   41|    29   71
ERRORS        |   0 115|  15   94|  61   63| 127   22|  81   23|    33    0         634

1799 CASES HERE PROCESSED
   0 (OR 0.0 PCT) MISSING

STATISTICS:

COEFFICIENT OF REPRODUCIBILITY = 0.9413
MINIMUM MARGINAL REPRODUCIBILITY = 0.7893
PERCENT IMPROVEMENT = 0.1619
COEFFICIENT OF SCALABILITY = 0.7212
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APPENDIX E

STATISTICAL ASPECTS OF STUDY DESIGN AND RESULTS

E.1 This Appendix deals with some of the major aspects of the study design and results which are concerned with the statistical properties of variables. It is in two main parts; the use of multiple regression theory in estimating the noise level and number 'trade-off' precision of noise variable measurements. These paragraphs only sketch out the statistical mathematics involved.

Multiple Regression Theory

E.2 The general form of the regression model used is:

$$Y_i = b_1 X_{1i} + b_2 X_{2i} + b_3 X_{3i} + \ldots + \varepsilon_i$$

where -

Subscript i : denotes the ith set of data points, i ranging from 1 to n (n=26 for the sample areas).

Y_i : independent variable

X_{1i}, X_{2i}, X_{3i} : dependent variables

ε_i : error, viz lack of fit, term

b_1, b_2, b_3 : regression coefficients

All these variables are taken - without loss of generality - to be measured about their sample means. In statistical testing the error term ε_i is taken to have a Gaussian distribution with zero mean and variance σ^2.

E.3 The object of the analysis here is to determine the precision of the 'trade-off' factor defined by,

$$k = b_1/b_2$$

where b_2 corresponds to a noise level variable and b_1 to a number variable. The intention is to make an estimate of $\hat{k}$ from the regression analysis and determine the sampling error on $\hat{k}$. In the following, only the final algebraic expressions are quoted: the matrix version of least squares analysis can be found in Ref E1.

E.4 Initially consider the case when there are no additional 'confounding' variables, i.e. MRA I of Appendix F with only variables X_{1i} and X_{2i} Define sample variances etc:

$$\sigma_j = \sum_{i=1}^{n} X_{ji}^2 / n \qquad ,j = 1,2$$

$$\sigma_{12} = \sum_{i=1}^{n} X_{1i} X_{2i} / n$$

$$\sigma_{yj} = \sum_{i=1}^{n} Y_i X_{ji} / n \qquad , j = 1,2$$

Then it can be shown (e.g. Ref E1) that the variances etc for b_1, b_2 are given by -

$$\text{var}\ (b_1) = n\sigma^2\sigma_2^2/\Delta$$

$$\text{var}\ (b_2) = n\sigma^2\sigma_1^2/\Delta$$

$$\text{Cov}\ (b_1 b_2) = -\ n\sigma^2\sigma_{12}^2/\ \Delta$$

where $\Delta = n^2\sigma_1^2\sigma_2^2\ (1 - \rho_{12}^2)$,

ρ_{12} being the correlation between X_1 and X_2.

E.5 From a Taylor expansion approach (e.g. Ref E2, para 10.17) it can be shown that - <u>to first order</u>:-

$$\text{var}(\hat{k}) = \frac{1}{b_2^2}\ .\ (\text{var}\ (b_1) + k^2 \text{var}\ (b_2) - 2k\ \text{cov}\ (b_1 b_2)\ )$$

which on substitution gives

$$\text{var}\ (\hat{k}) = \frac{1}{b_2^2}\ .\ \frac{\sigma^2}{n\sigma_1^2\sigma_2^2}\ .\ \frac{1}{1-\rho_{12}^2}\ .\ (\sigma_2^2 + k^2\sigma_1^2 + 2k\ \rho_{12}\sigma_1\sigma_2)$$

For MRA I in Appendix F:-

$b = 0.148$

$\sigma^2 = 0.324$

$\sigma_1^2 = 0.136$

$\sigma_2^2 = 23.8$

$\rho_{12} = -0.0993$

$n = 26$

$\hat{k} = 0.9521 \div 0.1481 = 6.43$

which gives

$$\text{var}\ (\hat{k}) = 45.7\text{x}0.00385\text{x}1.01\text{x}(23.8 + k^2 (0.136) - k(0.357)\ )$$

$$= 4.23 + 0.0242k^2 - 0.0634k$$

For k = 15 - the NNI trade-off - this becomes

$$\text{Var }(\hat{k}) = 8.73, \text{ i.e. standard error} = 2.96$$

The difference between the estimate $\hat{k}$ and the value of 15 used in NNI is thus about some 2.9 standard errors, so it is therefore unlikely that the observed value is merely a product of sampling fluctuations from a hypothesized value of 15.

E.6 The above analysis ignores the possible effects of a confounding variable (or set of variables), e.g. MRA II in Appendix F. If this is examined, the values of b_2, Var (b_1) etc need to change to accommodate X_{3i} (SHIFT1). It can be shown that the new expressions are

$$\text{Var }(b_1) = \frac{n\sigma^2}{\Phi} (\sigma_2^2\sigma_3^2 - \sigma_{23}^2)$$

$$\text{Var }(b_2) = \frac{n\sigma^2}{\Phi} (\sigma_1^2\sigma_3^2 - \sigma_{13}^2)$$

$$\text{Cov }(b_1 b_2) = \frac{n\sigma^2}{\Phi} (\sigma_{12}\sigma_3^2 - \sigma_{13}\sigma_{23})$$

where

$$\Phi = n^2 (\sigma_1^2 \sigma_2^2\sigma_3^2 + 2\sigma_{12}\sigma_{13}\sigma_{23} - \sigma_{12}^2 - \sigma_{23}^2 - \sigma_{13}^2)$$

and the variances σ_3^2 etc are analogous to those previously defined. Using the var$(\hat{k})$ expression of E.5 and correlations ρ_{13}, ρ_{23} gives the revised equation:

$$\text{Var }(\hat{k}) = \frac{1}{b_2^2} \cdot \frac{\sigma^2}{n\sigma_1^2\sigma_2^2} \cdot \frac{1}{\Theta} \cdot [(1-\rho_{23}^2)\sigma_2^2 + (1-\rho_{13}^2) k^2\sigma_1^2 + 2 (\rho_{12} - \rho_{13}\rho_{23}) k \cdot \sigma_1\sigma_2]$$

with $\Theta = 1 + 2 \rho_{12}\rho_{23}\rho_{13} - \rho_{12}^2 - \rho_{13}^2 - \rho_{23}^2$

This equation has the (necessary) quality that it reduces to the two variable case if ρ_{13}, ρ_{23} tend to 0.

From MRA II in Appendix F:-

$b_2 = 0.165$

$\sigma^2 = 0.244$

$\sigma_1^2 = 0.136$

$\sigma_2^2 = 2.38$

$\rho_{12} = -0.0993$

$\rho_{23} = 0.249$

$\rho_{13} = 0.187$

$n = 26$

$\hat{k} = 1.128 \div 0.1649 = 6.84$

which gives:

$$\text{Var}\ (\hat{k}) = 36.7 \times 0.00290 \times 1.13\ (22.3+k^2(0.131)-k(0.525)\ )$$

$$= 2.68 + 0.0158k^2 - 0.0631k$$

for the k = 15 NNI trade-off, this gives

$\text{Var}\ (\hat{k}) = 5.29$, i.e. standard error = 2.3

Again the standard error value implies that a $\hat{k}$ value of 10 or less is unlikely to be just a sampling fluctuation.

E.7 The simple analysis of the two variable case of paragraph E.5 was used in the original statistical design for ANIS. A particular aim was to minimise the sampling error on $\hat{k}$. This was achieved by:

(i) as large a range - and hence variance for both noise level and number - as possible.

(ii) the choice of areas which produced a small correlation between noise level and number - through the omission of 'inefficient' combinations and double samples at 'efficient' combinations.

In the planning work a target standard error for k was set at about 2 units. This value has been achieved for the 'Leq trade-off' of k=10.

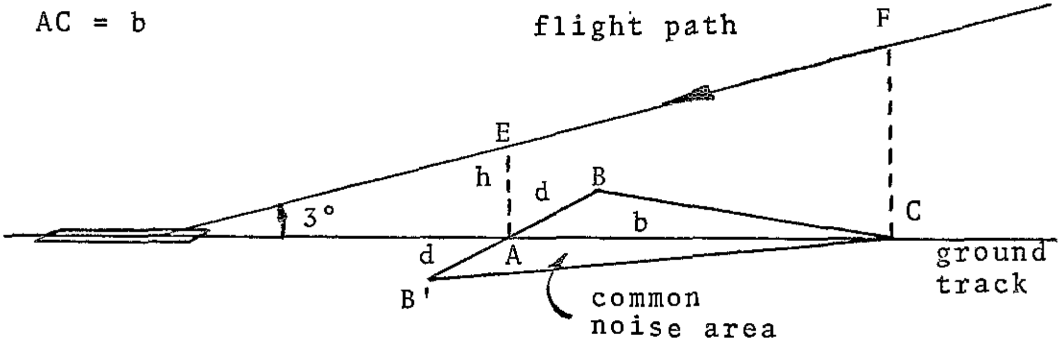
Precision of Noise Variable Measurements

E.8 In the regression analysis approach, used here to identify good relationships between noise stimuli and disturbance responses, the aggregated data for the 26 single survey areas has been used. This means that the noise metrics obtained for the measurement site in each area have been used to characterise the noise exposure for <u>all</u> the respondents surveyed in that area. The following paragraphs examine the questions of bias and accuracy arising from this approach, and the precision of noise metric estimation.

E.9 Common noise areas are discussed in Appendix B. To reiterate, they are delineated such that if the highest peak noise level recorded in the area for an event is L PNdB then nowhere in the area should a peak noise level of less than (L-p) PNdB be heard form that event - for a 'p'dB common noise area. Given this range of pdB, what is the distribution of the level of noise events within the area?

E.10 It can be shown that for sites under landing routes the common noise area is approximately triangular. This is also the case for departure routes, sites away from routes requiring special examination. First, consider the landing case:

AE = h
AB = AB' = d
BC = B'C
AC = b



The sketch above illustrates the common noise area (isosceles triangle BB'C) in relation to the landing flight path FE and corresponding ground track CA. The maximum noise level in the area is heard at point A (base mid-point): points C, B and B' receive pdB less than point A because the aircraft is further away from them. On the assumptions of 8dB attenuation for doubling of distance, constant source noise and propagation vertically downwards, then it can be shown that

$$p = 26.6 \log ((d^2+h^2)^{\frac{1}{2}}/h) \qquad \text{- from B,B'}$$

$$= 26.6 \log ((h + b\tan 3^\circ)/h) \qquad \text{- from C.}$$

Solving for b and d, then keeping only first order terms for p in expanding out exponential terms, leads to a triangle area:

$$A_p = \tfrac{1}{2} b.2d = 0.69\ p^{3/2} h^2 = \lambda p^{3/2} \quad *$$

It can be shown that this is an approximation of the exact area to within 20% or so, for p around 3dBA - adequate for present purposes.

E.11 By differentiating, the difference in area dAp between pdB and (p+dp) dB triangles is $1/2\lambda p^{\frac{1}{2}}$ dp. Now assume that the population density is uniform throughout the triangle: this gives the mean μ_p and variance σ_p for the noise levels heard in the triangle for an aircraft event (referenced down from the mid-base level) as

$$\mu_p = \int_o^p 1/2\ \lambda p^{3/2}\ dp \ / \int_o^p \lambda p^{\frac{1}{2}}\ dp$$

$$= 3/5p$$

and $$\sigma_p^2 = (3/7 - (3/5)^2)p^2 = 0.0686\ p^2$$

i.e. $$\sigma_p = 0.26p$$

---

* λ is a constant

Hence, for example, for 2,3 and 4dB triangles the average noise levels over the whole area are 1.2dB, 1.8dB and 2.4dB respectively less than the mid-base level, with corresponding standard deviations 0.52dB, 0.78dB and 1.04dB.

E.12 The common noise areas for departing aircraft can be constructed in an analogous fashion, except that account has to be taken of the lateral dispersion about take-off routes. The essential difference is that the area A_p of a 'p'dB triangle is, to leading order, of the form

$$A_p = \xi p^2$$

where ξ is a constant. Following the mode of analysis of the previous section gives:

$$\mu_p = 2/3p$$

$$\sigma_p^2 = (1/2-(2/3)^2)p^2 = 0.055p^2$$

i.e. $$\sigma_p = 0.24p$$

Thus again for 2, 3 and 4dB triangles, the values of μ_p are 1.3dB, 2dB and 2.7dB, and the corresponding standard deviations 0.48dB, 0.72dB and 0.96dB. Note, however, that the measurement site is generally at or near the centroid of the triangle, i.e. 1/3 of the AC distance. To first order this is p/3dB down from the mid-base noise level, i.e. for landing sites the 'bias' of the true mean versus the measured value is (3/5-1/3)p = 0.27p, and for departure sites (2/3-1/3)p = 0.33p. As a rough rule for the common noise areas used in ANIS the bias is therefore around 1dB down -the actual average is 1dB lower than the measured value i.e. the 'stimulus' is being over estimated. As uniform population densities have been assumed here, this is probably an appropriate figure to use generally. However, it must be noted that the few irregular or 'non-route' sites used will not necessarily have this bias.

E.13 In the above the bias and variation in noise level measurements within a common noise area have been examined. The noise metrics quoted in the data base for each measurement site are subject to further causes of inaccuracy:-

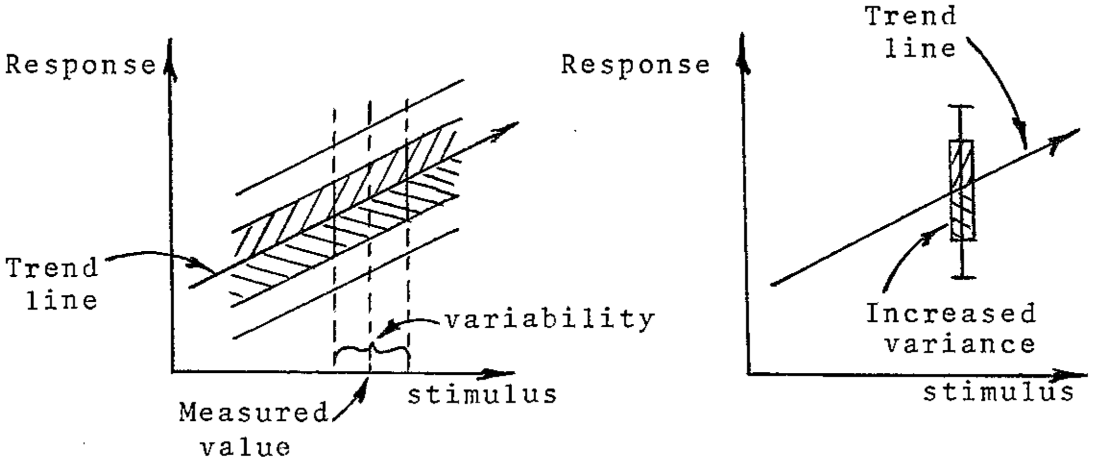
(a) Measurements for the different modes are taken on a number of days and then used to synthesize noise metrics for longer periods.

(b) The 80, 75 and 70 PNdB cut-off points for the number of aircraft heard will each produce different number of aircraft values throughout the common noise area, i.e. there will be a bias and variation in the estimate for the area's respondents.

E.14 In the case of (a) above, the traffic at major airports does not vary dramatically throughout the summer, and for dominant modes of operation of the airport the number and noise level of overflights will not vary markedly. Less important modes tend to correspond to activity a greater distance away, with an associated noise level reduction through greater atmospheric attenuation. For the dominant modes - in noise energy terms - a sample examination of the noise data underpinning the noise metric data base indicates that a standard error of estimate for Leq is of the order of one unit or less. For minor modes standard errors of 2 or 3 units are possible, but the Leq estimates quoted for the 1 week etc periods are probably determined, as regards standard error, by the dominant modes.

E.15 Reference to the data base will show that the difference in the number of aircraft noise effects heard above 70 PNdB and 80 PNdB can be very marked - sometimes more than 100%. This sort of difference is likely to be reflected throughout the common noise area - so from a 100% change in a 10dB range it might be expected that there is a 30% change over a 3dB triangle. As the number of aircraft enters through a logarithmic term, the range of difference would be log 1.3 = 0.11. The standard deviation of a distribution must be less than the range, so this gives a log number variance less than 0.013, which is an order down on the variance of log number over the range of area values - e.g. 0.136 for MRA I of Appendix F. Better estimates of the effect are difficult to make because the distribution of the number of aircraft above the cut-off within the common noise area vary so much from area to area. However, on similar grounds to the noise level estimation above, it can be assumed that any bias due to the location of the measurement site will tend to be be an overestimate of the 'stimulus' variable.

E.16 The variability in noise level and number throughout each area does not markedly affect the validity of the multiple regression analysis examined in the earlier paragraphs. Essentially the variability in the noise stimulus variable turns up as an increase in the response variable variance.



The above figures illustrate the position in a schematic way. The trend line has a set of sampling confidence bands about it - the shaded area might be the one standard deviation band, the unshaded area might be two standard deviations. The variability in the (x) stimulus value about the measured value means that the respondents in the area will produce responses within the parallelogram box shown.

However, if these responses are all allocated to the measured value - as in the figure on the right - then the parallelogram responses are 'squashed together' to produce an increased variance about the trend line. When several areas are plotted on the figure the general effect will therefore be an increase in the size of the confidence bands.

E.17 Several of the response variables used, e.g. ARCBOTH, are binomial in character. The implication of this additional variance component is that the binomial sampling confidence bands will not coincide - even for a perfect regression relationship - with those derived from the regression analysis error terms. However it can be seen from the analyses in Section 8 and in Appendix F that the estimated standard

error σ is - for the better regression fits - not dramatically greater than the typical binomial sampling values. This implies that the effect of the area measurement variability is not producing a large, distorting effect on the estimation of the trend line.

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Applied Regression Analysis
John Wiley and Son 1966

E2 Kendall, M G and Stuart A
The Advanced Theory of Statistics Vol. 1.
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Charles Griffin & Co Ltd. 1969

APPENDIX F

MULTIPLE REGRESSION ANALYSES

F.1 The SPSS (Ref F1) routine MULTIPLE REGRESSION allows variables to be entered into the regression equation either by forced inclusion, or as conditional on a given criterion. Either of these types of inclusion may be used hierarchically by admitting variables, or groups of variables, for consideration sequentially. They may also be mixed together. It is not possible to drop a variable once it is included in the equation.

F.2 The principal criterion for inclusion is the sequential 'F' test (Ref F2), which, in simple terms, tests how 'valuable' the explanatory contribution of a variable would be to the equation, were it to be added as a new variable to the set already there. Because it is not possible to drop variables from the equation using a parallel criterion for exclusion, it may happen that several very highly correlated variables are entered into the equation in succession, reducing the significance of variables already in the equation almost to nothing, and resulting ultimately in an overfitted equation. To help avoid this, a second criterion for admission is brought in. This 'tolerance' factor - denoted as 't'- here tests the proportion of the variance of new variable unexplained by variables already in the equation. This proportion must exceed a set amount for a new variable to be entered into the equation.

F.3 The independent variables can be divided into several sets, and an order defined in which the sets are to be considered. For each set, individually forced or conditional entry may be chosen. If a particular set is to be forced into the equation, the variables in it are entered as a block. If it is to be conditionally included, the variables are considered in turn until none are left which pass the entry criterion. However, those variables not entered at this stage will still be considered with any new set of variables to be conditionally included, and may enter the equation if they subsequently pass the entry criterion.

F.4 Two sets of variables are introduced in this section which are not defined elsewhere in this report. These are the 'STEP' and 'JUMP' variables : defined (for three-month and one-week data respectively) to be zero for those areas with an Leq below or equal to a set level, and one for areas with Leq above that level.

Specifically :

STEP56 = [0 IF M3LQ24 $\leqslant$ 56 dBA
[1 IF M3LQ24 $>$ 56 dBA

STEP58 = [0 IF M3LQ24 $\leqslant$ 58 dBA
[1 IF M3LQ24 $>$ 58 dBA

and so on at intervals of 2dBA to 64dBA
whereas

JUMP56 = [0 IF W1LQ24 $\leqslant$ 56 dBA
[1 IF W1LQ24 $>$ 56 dBA

JUMP57 = [0 IF W1LQ24 ≤ 57 dBA
[1 IF W1LQ24 > 57 dBA

and so on at intervals of 1dBA to 64dBA

Multiple Regression Analysis Sets

F.5 MRA I Testing the traditional annoyance scale AVOGAS against the components of NNI (Tables and Figures to accompany the MRAS are given in sequence). Compare with results of rank correlations shown in Table F1. (See Figure F1.)

Dependent variable : AVOGAS

Independent variables :

1st set	M3L80 LM3N80	forced entry

F.6 MRA II As above, but with the various 'confounding factors' which may be influencing response. (See Figure F2)

Dependent variable : AVOGAS

Independent variables :

1st set	M3L80 LM3L80	forced entry
2nd set	DGL SHIFT1 WORKAP NONMAN LRES FEMALE	conditional F = 2.92 (10%) *

F.7 MRA III As above, but now including the lower cut-offs at 75 & 70 PNdB. The 'tolerance' factor t=0.2 is brought in to prevent overfitting by inclusion of more than one of the highly correlated or logN variables. (See Figure F3.)

Dependent variable : AVOGAS

Independent variable :

1st set :	M3L80, M3L75, M3L70, LM3N80, LM3N75,LM3N70	conditional: F = 2.92 (10%) t = 0.2
2nd set :	Confounding set	conditional F = 2.92 t = 0.2

---

* Note that F-test levels quoted are approximate - because of the varying values of the number of degrees of freedom.

F.8 MRA IV The Leq variable most closely paralleled by NNI is forced in, then L, logN and confounding variables are selected to give any necessary adjustments. (Residuals sorted by M3LQ24 are shown with analysis of variance tables in accompanying figures).
(See Figure F4)

Dependent variable : AVOGAS

Independent variable :

1st set	M3LQ24	forced
2nd set	M3L80, M3L75,M3L70 LM3N80, LM3N75,LM3N70	conditional F = 2.92 (10%) t = 0.2
3rd set	Confounding set	conditional F = 2.92 (10%) t = 0.2

F.9 MRA V As above, but STEP56 to STEP64 are brought into allow for apparent non-linearity in the residuals in MRA IV
(See Figure F5)

Dependent variable : AVOGAS

Independent variable :

1st set	M3LQ24	forced
2nd set	M3L80, M3L75,M3L70 LM3N80, LM3N75,LM3N70	conditional F = 2.92 (10%) t = 0.2
3rd set	STEP56 TO STEP64 +confounding set	conditional F = 2.92 (10%) t = 0.2

F.10 MRA VI Regression carried out on each of the four main annoyance measures; allowing free selection of any variable from:

full set of L at all cut-offs and over all periods
full set of N at all cut-offs and over all periods
full set of logN at all cut-offs and over all periods
full set of day, evening, night and 24hrs Leq variables
full set of confounding variables.
STEP56 ..... STEP64*

(See Figures F6 to F9)

Dependent variables A : AVOGAS
B : VMANN
C : ARCBOTH
D : ARCNA

---

* Note that whenever the format 'A... B' is used, it is implied that all variables lying between A and B on the data base are included in the order in which they appear in the data base.

Independent variables:
1st set M3L80, M1L80, W1L80, WML80,
M3L75.... WML75
M3L70.... WML70
M3N80, M1N80, W1N80, WMN80
M3N75..... WMN75
M3N70..... WMN70
LM3N80.... LWMN80
LM3N75.... LWMN75
LM3N70.... LWMN70
M3LEQ, M1LEQ, W1LEQ, WMLEQ
EM3LEQ.... EWMLEQ
NM3LEQ.... NWMLEQ
M3LQ24, M1LQ24, W1LQ24,WMLQ24
STEP56, STEP58, STEP60, STEP62, STEP64
+ Confounding set
conditional
F = 2.92 (10%)
t = 0.2

F.11 MRA VII Regression carried out on four annoyance scales forcing in W1LQ24 and WORKAP, choosing from set of JUMP56...JUMP64 and selecting as necessary from the remainder of the variable set above. F value at the 1% level is brought in to prevent random selection from very large variables set. (Residuals sorted by W1LQ24 are shown with analysis of variance tables in accompanying Figures F10 to F13).

Dependent variables: A : AVOGAS
B : VMANN
C : ARCBOTH
D : ARCNA

Independent variables:
1st set W1LQ24, WORKAP forced

2nd set JUMP56, JUMP57...JUMP63, JUMP64
conditional
F = 7.82 (1%)
t = 0.2

3rd set M3L80.....WML70
M3N80.....WMN70
LM3N80....LWMN70
M3LEQ.....M1LQ24, WMLQ24
+DGL,SHIFT1 ... FEMALE
conditional
F = 7.82 (1%)
t = 0.2

F.12 MRA VIII Regression carried out on four annoyance scales forcing in WORKAP, selection first from the set of L, then from combined set of N and logN, then from confounding and JUMP variables as necessary. (See Figures F14 to F17)

Dependent variables
A : AVOGAS
B : VMANN
C : ARCBOTH
D : ARCNA

Independent variables:

1st set	WORKAP	forced
2nd set	M3L80 to WML70	conditional F = 7.2 (1%) t = 0.2
3rd set	M3N80 ....WMN70 LM3N80....LWMN70	conditional F = 7.82(1%) t = 0.2
4th set	JUMP56, JUMP57..JUMP64 +DGL,SHIFT1 ... FEMALE	conditional F = 7.82 (1%) t = 0.2

F.13 MRA IX Regression carried out on two annoyance scales, forcing in WORKAP and W1L70, then logW1N70, then allowing to choose any other noise variable, JUMP or confounding factor as necessary. (*Note that for VMANN and ARCNA, this is identical to MRAVIII*).
(See Figures F18 to F19)

Dependent variables
A : AVOGAS
D : ARCBOTH

Independent variables :

1st set	WORKAP, W1L70	(4)	forced
2nd set	LW1N70	(2)	forced
3rd set	M3L80....M1L70,WML70 M3N80....LM1N70, LWMN70 JUMP56 to JUMP64 + confounding set.		conditional F = 7.82 (1%) t = 0.2

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Statistical Package for the Social Sciences (SPSS)
(Second Edition)
McGraw-Hill Book Company 1975

F2 Draper, N R and Smith, H
Applied Regression Analysis (First Edition)
John Wiley and Sons 1966

Table F1: Rank Correlation of M3L80 + k log M3N80 against AVOGAS

M3L80	k=										
+ k log M3N80,	5	6	7	8	9	10	11	12	13	14	15
AVOGAS	0.8661	0.8743	0.8763	0.8798	0.8765	0.8428	0.8093	0.7943	0.7854	0.7730	0.7423

TABLE F2 Correlation matrix (MRAV)

	AVOGAS	M3LQ24	M3L80	M3L75	M3L70	LM3N80	LM3N75	LM3N70	DGL	SHIFT	WORKAP	NONMAN	LRES	FEMALE
AVOGAS	1													
M3LQ24	.7739	1												
M3L80	.7280	.6823	1											
M3L75	.7333	.6942	.9958	1										
M3L70	.7509	.7069	.9901	.9981	1									
LM3N80	.2956	.6438	¯.0993	¯.0738	¯.0440	1								
LM3N75	.1596	.4985	¯.2724	¯.2600	¯.2346	.9730	1							
LM3N70	.0818	.4374	¯.3363	¯.3304	¯.3109	.9444	.9926	1						
DGL	.1167	.5455	.0562	.0430	.0433	.6437	.6446	.6504	1					
SHIFT1	¯.0275	.3110	.2486	.2597	.2613	.1868	.1160	.0971	.4769	1				
WORKAP	¯.1547	.3175	¯.1308	¯.1286	¯.1289	.5273	.5388	.5571	.8013	.5003	1			
NONMAN	.1427	.0490	¯.1595	¯.1824	¯.1859	.2423	.3085	.3316	.0977	¯.2654	¯.0603	1		
LRES	.0648	.0029	¯.1987	¯.1877	¯.1818	.1487	.1648	.1712	¯.0226	¯.3714	.1393	.0330	1	
FEMALE	¯.1638	¯.3541	¯.1125	¯.1452	¯.1620	¯.3930	¯.3117	¯.2754	¯.3030	.0440	¯.3546	¯.1933	¯.0751	1

Figure F 1 MRA I: Analysis of Variance Table

```
MULTIPLE R           0.81654                   ANALYSIS OF VARIANCE     DF      SUM OF SQUARES       MEAN SQUARE           F
R SQUARE             0.66674                   REGRESSION                2.          14.87208           7.43604        23.00766
ADJUSTED R SQUARE    0.63776                   RESIDUAL                 23.           7.43356           0.32320
STANDARD ERROR       0.56851

---------------- VARIABLES IN THE EQUATION -----------------

VARIABLE            B            BETA      STD ERROR B        F

LNSH80      0.9521309         0.37160        0.30995       9.435
RSE80       0.1481446         0.76492        0.02343      39.983
(CONSTANT)  -15.05671
```

Figure F 2 MRA II: Analysis of Variance Table

```
MULTIPLE R           0.87122                    ANALYSIS OF VARIANCE     DF      SUM OF SQUARES       MEAN SQUARE              F
R SQUARE             0.75902                    REGRESSION                3.         16.93049           5.64350           23.09831
ADJUSTED R SQUARE    0.72616                    RESIDUAL                 22.          5.37515           0.24433
STANDARD ERROR       0.49430

----------------- VARIABLES IN THE EQUATION -----------------

VARIABLE              B              BETA       STD ERROR B         F

M3L60       0.1649421          0.85105        0.02118        60.665
LM3N60       1.128059          0.44027        0.27622        16.678
SHIFT1     -0.37744140D-01    -0.32146        0.01300         8.425
(CONSTANT)  -14.34052
```

Figure F.3 MRA III: Analysis of Variance Table

```
MULTIPLE R           0.88015                    ANALYSIS OF VARIANCE     DF      SUM OF SQUARES       MEAN SQUARE              F
R SQUARE             0.77466                    REGRESSION                3.         17.27936           5.75979           25.21052
ADJUSTED R SQUARE    0.74394                    RESIDUAL                 22.          5.02629           0.22847
STANDARD ERROR       0.47798

----------------- VARIABLES IN THE EQUATION -----------------

VARIABLE              B              BETA       STD ERROR B         F

M3L70       0.1568203          0.93170        0.01836        72.936
LM3N75       1.070916          0.41513        0.27350        15.332
SHIFT1     -0.37468800D-01    -0.31911        0.01254         8.933
(CONSTANT)  -13.36210
```

Figure F 4 MRA IV: Analysis of Variance Table

```
MULTIPLE R          0.88503                     ANALYSIS OF VARIANCE    DF      SUM OF SQUARES       MEAN SQUARE              F
R SQUARE            0.78328                     REGRESSION               3.           17.47149           5.82383            26.50396
ADJUSTED R SQUARE   0.75372                     RESIDUAL                22.            4.83416           0.21973
STANDARD ERROR      0.46876

----------------- VARIABLES IN THE EQUATION ------------------

VARIABLE           B          BETA     STD ERROR B        F

M3LQ24      0.1481304        0.80828       0.03164      21.923
M3L70       0.2166418D-01    0.12871       0.02778       0.608
WORKAP     -0.4575487D-01   -0.39477       0.01427      10.278
(CONSTANT)  -7.971436
```

Residuals sorted by MSLQ24

```
            OBSERVED         PREDICTED                                     PLOT OF STANDARDIZED RESIDUAL
SEQNUM        AVOGAS            AVOGAS       RESIDUAL              -2.0      -1.0      0.0       1.0       2.0

     1      1.369565         0.9678605      0.4017053                                    I        *
     2      1.653333          1.341003      0.3123289                                    I      *
     3      1.325842          1.096611      0.2292306                                    I    *
     4      1.393939          1.809049     -0.4151100                           *        I
     5      1.454545          2.041000     -0.5864553                       *            I
     6      1.148935          1.465121     -0.3161856                             *      I
     7      2.028985          2.338793     -0.3098084                             *      I
     8      1.599999          2.414218     -0.8142186                   *                I
     9      1.687500          2.275566     -0.5880669                       *            I
    10      1.233766          1.709536     -0.4757701                          *         I
    11      3.129869          2.711266      0.4186035                                    I        *
    12      3.319444          2.741352      0.5780913                                    I           *
    13      3.115942          2.858635      0.2573065                                    I    *
    14      1.646464          1.183222      0.4632424                                    I         *
    15      2.863636          2.603449      0.2601865                                    I     *
    16      3.041666          2.935426      0.5623937E-01                                I*
    17      2.797752          2.509184      0.2885678                                    I     *
    18      1.938272          2.062215     -0.1239434                                 *  I
    19      3.929411          3.254228      0.6751830                                    I             *
    20      3.920454          3.306222      0.6142319                                    I            *
    21      2.750000          3.093615     -0.3436151                             *      I
    22      3.131578          3.060723      0.7085484E-01                                I *
    23      2.743243          2.880829     -0.1375861                                 *  I
    24      4.028169          3.594504      0.4336625                                    I        *
    25      3.462687          3.902256     -0.4395700                           *        I
    26      3.325301          3.834405     -0.5091050                         *          I
```

Figure F.5 MRA V: Analysis of Variance Table

```
MULTIPLE R           0.95566                      ANALYSIS OF VARIANCE     DF      SUM OF SQUARES         MEAN SQUARE             F
R SQUARE             0.91329                      REGRESSION                6.           20.37162            3.39527            33.35529
ADJUSTED R SQUARE    0.88591                      RESIDUAL                 19.            1.93403            0.10179
STANDARD ERROR       0.31905

----------------- VARIABLES IN THE EQUATION ------------------

VARIABLE            B          BETA     STD ERROR B         F

M3LQ24     -0.2320862D-01   -0.12664       0.04454        0.272
M3L70       0.4576092D-01    0.27187       0.02224        4.235
WORKAP     -0.5470511D-01   -0.47199       0.01005       29.649
STEP58         1.147933      0.58961       0.26805       18.341
STEP60      0.6130562        0.33094       0.25844        5.627
STEP64      0.5771124        0.19906       0.31379        3.383
(CONSTANT) -0.9637138
```

Figure F.6 MRA VIA: Dependent Variable AVOGAS - Analysis of Variance Table

```
MULTIPLE R            0.98015                 ANALYSIS OF VARIANCE      DF      SUM OF SQUARES        MEAN SQUARE           F
R SQUARE              0.96069                 REGRESSION                 8.          21.42879            2.67860        51.93100
ADJUSTED R SQUARE     0.94219                 RESIDUAL                  17.           0.87686            0.05158
STANDARD ERROR        0.22711

---------------- VARIABLES IN THE EQUATION -----------------

VARIABLE              B            BETA      STD ERROR B        F

W1LQ24       0.3207649D-01     0.18626       0.02334        1.888
WORKAP      -0.4390113D-01    -0.37877       0.00747       34.562
STEP58       0.9053910         0.46504       0.20044       20.403
STEP64       0.4436590         0.15303       0.19796        5.023
M3N70       -0.3167326D-02    -0.31368       0.00075       17.715
NWMLEQ       0.2085758D-01     0.27786       0.00611       11.659
STEP60       0.5937530         0.32052       0.19086        9.678
LRES        -0.2635163D-01    -0.12187       0.01447        3.317
(CONSTANT)  -0.7911916D-01
```

Summary Table

```
                                                                SUMMARY TABLE

VARIABLE                                          MULTIPLE R  R SQUARE  RSQ CHANGE  SIMPLE R          B                 BETA

W1LQ24      ONE  WEEK 24HR LEQ                     0.83048    0.68969   0.68969     0.83048     0.3207649D-01        0.18626
WORKAP      %WORK CONNEC   TED WITH A-PORT         0.91289    0.83337   0.14368    -0.15473    -0.4390113D-01       -0.37877
STEP58                                             0.94095    0.88538   0.05201     0.74236     0.9053910            0.46504
STEP64                                             0.95018    0.90285   0.01747     0.44540     0.4436590            0.15303
M3N70       THREE MONTH N70                        0.95821    0.91816   0.01531     0.08692    -0.3167326D-02       -0.31368
NWMLEQ      WORSTMODE NIGHTLEQ                     0.96640    0.93393   0.01577     0.60453     0.2085758D-01        0.27786
STEP60                                             0.97623    0.95302   0.01909     0.62773     0.5937530            0.32052
LRES        AV    LENGTHOF RESIDENCE               0.98015    0.96069   0.00767     0.06479    -0.2635163D-01       -0.12187
(CONSTANT)                                                                                     -0.7911916D-01
```

Figure F.7 MRA VI B: Dependent Variable VMANN

Analysis of Variance Table

```
MULTIPLE R           0.97776              ANALYSIS OF VARIANCE     DF      SUM OF SQUARES       MEAN SQUARE            F
R SQUARE             0.95601              REGRESSION               7.          5458.01319         779.71617         55.88524
ADJUSTED R SQUARE    0.93890              RESIDUAL                18.           251.13773          13.95210
STANDARD ERROR       3.73525

----------------- VARIABLES IN THE EQUATION ------------------

VARIABLE          B              BETA       STD ERROR B       F

W1L70         2.743044         0.99747        0.24773     122.604
NW1LEQ       0.4956041         0.39996        0.08400      34.815
NONMAN       0.2144848         0.17804        0.07026       9.320
STEP64       -17.15172        -0.36979        3.63982      22.205
WMN75        0.5943461D-01     0.39165        0.01154      26.541
WORKAP      -0.3498030        -0.18865        0.11473       9.297
STEP56       -7.696278        -0.21883        3.25114       5.604
(CONSTANT)   -256.6769
```

Summary Table

```
                                                                   SUMMARY TABLE

VARIABLE                                                MULTIPLE R  R SQUARE  RSQ CHANGE   SIMPLE R            B                   BETA

W1L70       ONE   WEEK  L70                               0.80536    0.64860    0.64860    0.80536        2.743044               0.99747
NW1LEQ      ONE  WEEK NIGHTLEQ                            0.88071    0.77565    0.12705    0.50447       0.4956041               0.39996
NONMAN      %NON- MANUAL                                  0.91831    0.84330    0.06765    0.18155       0.2144848               0.17804
STEP64                                                    0.93593    0.87596    0.03266    0.37838       -17.15172              -0.36979
WMN75       WORST MODE  N75                               0.95040    0.90327    0.02731    0.35922       0.5943461D-01           0.39165
WORKAP      %WORK CONNEC   TED WITH A-PORT                0.97073    0.94232    0.03905   -0.24559      -0.3498030              -0.18865
STEP56                                                    0.97776    0.95601    0.01369    0.58721       -7.696278              -0.21883
(CONSTANT)                                                                                              -256.6769
```

Figure F.8 MRA VI C: Dependent Variable ARCNA

Analysis of Variance Table

```
MULTIPLE R           0.98948          ANALYSIS OF VARIANCE    DF     SUM OF SQUARES      MEAN SQUARE          F
R SQUARE             0.97906          REGRESSION               9.        9173.59229       1019.28803     83.13855
ADJUSTED R SQUARE    0.96729          RESIDUAL                16.         196.16181         12.26011
STANDARD ERROR       3.50144

---------------- VARIABLLS IN THE EQUATION ----------------

VARIADLE           D            DETA      STD ERROR D        F

W1LQ24        1.720912        0.48756      0.42095      16.713
WORKAP       -0.5799186      -0.24413      0.12130      22.857
NWMLEO        0.5943120       0.38630      0.08459      49.367
M1L80         2.192811        0.53754      0.37846      33.571
W1N80         0.7569112D-01   0.29316      0.02444       9.594
STEP56      -12.78358        -0.28372      3.31007      14.915
STEP64      -13.37066        -0.22502      3.90023      11.752
SHIFT1        0.3268671       0.13583      0.13115       6.212
NONMAN        0.1422723       0.09218      0.06594       4.655
(CONSTANT)  -302.6381
```

Summary Table

```
                                                                  SUMMARY TADLE

                                                                                                                       B                 BETA
VARIABLE                                            MULTIPLE R   R SQUARE   RSQ CHANGE   SIMPLE R

W1LQ24      ONE  WEEK 24HR LEQ                       0.89439     0.79993     0.79993     0.89439          1.720912            0.48756
WORKAP      %WORK CONNEC   TED WITH A-PORT           0.94099     0.88546     0.08553    -0.05471         -0.5799186          -0.24413
NWMLEQ      WORSTMODE NIGHTLEQ                       0.95346     0.90908     0.02362     0.61761          0.5943120           0.38630
M1L80       ONE   MONTH L80                          0.96883     0.93363     0.02954     0.72829          2.192811            0.53754
W1N80       ONE   WEEK  N80                          0.97502     0.95067     0.01204     0.59941          0.7569112D-01       0.29316
STEP56                                               0.97895     0.95833     0.00767     0.64456        -12.78358            -0.28372
STEP64                                               0.98364     0.96755     0.00922     0.53785        -13.37066            -0.22502
SHIFT1      % IN  WORK EON     SHIFT                 0.98639     0.97297     0.00542     0.10745          0.3268671           0.13583
NONMAN      %NON- MANUAL                             0.98948     0.97906     0.00609     0.14281          0.1422723           0.09218
(CONSTANT)                                                                                             -302.6381
```

Figure F.9 MRA VI D: Dependent Variable ARCBOTH

Analysis of Variance Table

```
MULTIPLE R           0.96803               ANALYSIS OF VARIANCE     DF       SUM OF SQUARES        MEAN SQUARE          F
R SQUARE             0.93708               REGRESSION               5.          11522.83900         2304.56780     59.57456
ADJUSTED R SQUARE    0.92135               RESIDUAL                20.            773.67515           38.68376
STANDARD ERROR       6.21963

----------------- VARIABLES IN THE EQUATION -----------------

VARIABLE            B            BETA      STD ERROR B         F

W1LQ24      1.750962         0.43303       0.47305       13.700
WORKAP    -0.6445199        -0.23684       0.18917       11.608
STEP58      19.59665         0.42870       4.80162       16.657
M1L70      0.9486656         0.23576       0.35473        7.152
NONMAN     0.2496038         0.14117       0.10924        5.221
(CONSTANT) -151.0319
```

Summary Table

```
                                                              SUMMARY TABLE

VARIABLE                                          MULTIPLE R  R SQUARE  RSQ CHANGE   SIMPLE R            B                  BETA

W1LQ24     ONE  WEEK 24HR LEQ                      0.89062    0.79321    0.79321     0.89062       1.750962              0.43303
WORKAP     %WORK CONNEC   TED WITH A-PORT          0.92339    0.85265    0.05945    -0.00864     -0.6445199             -0.23684
STEP58                                             0.95334    0.90887    0.05621     0.82009       19.59665              0.42870
M1L70      ONE   MONTH L70                         0.95951    0.92066    0.01179     0.74508      0.9486656              0.23576
NONMAN     %NON- MANUAL                            0.96803    0.93708    0.01642     0.15687      0.2496038              0.14117
(CONSTANT)                                                                                      -151.0319
```

Figure F 10 MRAVII A: Dependent Variable AVOGAS

Analysis of Variance Table

```
MULTIPLE R          0.94095                     ANALYSIS OF VARIANCE    DF       SUM OF SQUARES       MEAN SQUARE              F
R SQUARE            0.88538                     REGRESSION               3.            19.74904           6.58301            56.64797
ADJUSTED R SQUARE   0.86975                     RESIDUAL                22.             2.55660           0.11621
STANDARD ERROR      0.34089


----------------- VARIABLES IN THE EQUATION ------------------

VARIABLE           B          BETA     STD ERROR B        F

W1LQ24      0.1034986        0.60097       0.02208      21.963
WORKAP     -0.5416178D-01   -0.46730       0.00908      35.565
JUMP57      0.8234453        0.42295       0.26061       9.984
(CONSTANT) -3.735273
```

Residuals sorted by W1LQ24

```
            OBSERVED         PREDICTED                                     PLOT OF STANDARDIZED RESIDUAL
SEQNUM        AVOGAS            AVOGAS       RESIDUAL              -2.0      -1.0       0.0       1.0       2.0

     1      1.369565         0.8765949      0.4929701                                    I             *
     2      1.393939          1.439656     -0.4571690E-01                               *I
     3      1.653333          1.585020      0.6831181E-01                                I *
     4      1.325842          1.148355      0.1774877                                    I    *
     5      1.454545          1.756747     -0.3022030                           *        I
     6      1.148935          1.270494     -0.1215590                                *   I
     7      1.599999          1.875085     -0.2750860                            *       I
     8      1.687500          1.710958     -0.2345891E-01                               *I
     9      2.028985          1.999730      0.2925425E-01                                I*
    10      3.129869          2.911119      0.2187496                                    I     *
    11      3.319444          2.868602      0.4508414                                    I            *
    12      3.115942          3.007434      0.1085073                                    I  *
    13      1.233766          2.210105     -0.9763393              X                     I
    14      1.646464          1.321177      0.3252871                                    I         *
    15      2.797752          2.737688      0.6006410E-01                                I *
    16      2.863636          2.902479     -0.3884403E-01                               *I
    17      1.938272          2.166941     -0.2286695                             *      I
    18      3.041666          3.432634     -0.3909694                         *          I
    19      2.743243          2.823479     -0.8023584E-01                              * I
    20      3.131578          3.047971      0.8360678E-01                                I *
    21      2.750000          3.260733     -0.5107331                     *              I
    22      3.920454          3.858081      0.6237236E-01                                I *
    23      3.929411          3.796534      0.1328767                                    I   *
    24      4.028169          3.599754      0.4284130                                    I            *
    25      3.325301          3.054098      0.2712021                                    I       *
    26      3.462687          3.378816      0.8387077E-01                                I *
```

Figure F.11 MRA VII B: Dependent Variable VMANN

Analysis of Variance Table

```
MULTIPLE R           0.91762                  ANALYSIS OF VARIANCE   DF      SUM OF SQUARES        MEAN SQUARE            F
R SQUARE             0.84202                  REGRESSION              2.         4807.24199         2403.62099      61.29586
ADJUSTED R SQUARE    0.82829                  RESIDUAL               23.          901.90893           39.21343
STANDARD ERROR       6.26206
```

```
VARIABLE           B           BETA      STD ERROR B        F

W1LQ24       2.519299        0.91437        0.23615    113.810
WORKAP     -0.8877737       -0.47877        0.15893     31.202
(CONSTANT)  -119.4252
```

Residuals sorted by W1LQ24

```
           OBSERVED        PREDICTED                                   PLOT OF STANDARDIZED RESIDUAL
SEQNUM       VMANN          VMANN       RESIDUAL               -2.0      -1.0     0.0        1.0       2.0

    1.     6.382978     -4.417480      10.80047                                   I                *
     2     10.60606      6.539692      4.066368                                   I     *
     3     6.666666      11.22634     -4.559672                            *      I
     4     3.333333      4.233442    -0.9001021                                  *I
     5     6.060606      15.11083     -9.050219                     *             I
     6     4.123711      7.305146     -3.181435                              *    I
     7     10.60606      17.79106     -7.185013                        *          I
     8     16.66666      15.10085      1.565806                                   I  *
     9     17.10526      20.73926     -3.634011                             *     I
    10     37.66232      23.99101      13.67130                                   I                     X
    11     29.11392      23.45866      5.655248                                   I        *
    12     25.00000      25.73428    -0.7342963                                  *I
    13     3.749999      13.32342     -9.573420                    *              I
    14     6.060606     -1.164842      7.225458                                   I           *
    15     17.77777      22.67622     -5.098458                           *       I
    16     25.35211      25.74191    -0.3898094                                  *I
    17     9.876543      13.76788     -3.891338                             *     I
    18     29.16666      35.00777     -5.841117                          *        I
    19     31.57893      25.84583      5.733093                                   I        *
    20     29.37012      30.67749    -0.8073820                                  *I
    21     30.55554      34.41174     -3.856215                             *     I
    22     52.27272      46.34235      5.930362                                   I        *
    23     51.72414      45.33351      6.390611                                   I         *
    24     43.66196      42.10809      1.553858                                   I *
    25     28.91565      33.57558     -4.659929                            *      I
    26     40.24390      39.47404     0.7698409                                   I*
```

Figure F.12 MRA VII C: Dependent Variable ARCNA

Analysis of Variance Table

```
MULTIPLE R          0.94099                     ANALYSIS OF VARIANCE    DF      SUM OF SQUARES         MEAN SQUARE             F
R SQUARE            0.88546                     REGRESSION               2.         8296.56900          4148.23450           68.90409
ADJUSTED R SQUARE   0.67550                     RESIDUAL                23.         1073.18510            46.66022
STANDARD ERROR      6.83033
```

```
----------------- VARIABLES IN THE EQUATION -------------------

VARIABLE           B          BETA     STD ERROR B        F

W1LQ24       3.429144        0.97152       0.25760      177.207
WORKAP     -0.7184970       -0.30246       0.17337       17.176
(CONSTANT)  -163.7912
```

Residuals sorted by W1LQ24

```
            OBSERVED         PREDICTED                                     PLOT OF STANDARDIZED RESIDUAL
SEQNUM        ARCNA            ARCNA        RESIDUAL          .    -2.0      -1.0       0.0       1.0       2.0

     1      5.319164         -4.121423       9.440598                                     I             *
     2      15.15154          7.665949       7.485595                                     I          *
     3      13.33334          15.35156      -2.018216                                  *  I
     4      12.35957          9.970088       2.389494                                     I  *
     5      7.920795          20.30263      -12.38183                   *                 I
     6      10.30928          14.26336      -3.954083                               *     I
     7      15.15152          23.72302      -8.571503                        *            I
     8      24.24243          21.54576       2.696668                                     I   *
     9      22.66667          27.63829      -4.971622                              *      I
    10      41.55846          33.32849       8.229952                                     I           *
    11      40.50633          33.17569       7.330630                                     I          *
    12      41.25002          35.01741       6.232595                                     I        *
    13      17.50002          26.08516      -8.585152                        *            I
    14      18.18182          14.49846       3.683360                                     I    *
    15      31.11111          35.34570      -4.234598                               *     I
    16      40.84508          37.94302       2.902051                                     I   *
    17      19.75308          28.39116      -8.638090                        *            I
    18      38.88889          46.41527      -7.526387                          *          I
    19      46.05264          40.39050       5.662132                                     I       *
    20      40.25975          46.24718      -5.987430                            *        I
    21      41.66667          49.68646      -8.019804                         *           I
    22      64.77274          62.95673       1.815989                                     I  *
    23      67.04546          62.14024       4.905184                                     I      *
    24      59.15492          59.52985     -0.3749325                                    *I
    25      60.24097          53.31937       6.921561                                     I         *
    26      64.63416          59.06631       5.567822                                     I       *
```

Figure F.13 MRA VII D: Dependent Variable ARCBOTH

Analysis of Variance Table

```
MULTIPLE R          0.95334              ANALYSIS OF VARIANCE   DF       SUM OF SQUARES        MEAN SQUARE            F
R SQUARE            0.90387              REGRESSION              3.         11175.88885         3725.29628         73.13463
ADJUSTED R SQUARE   0.89644              RESIDUAL               22.          1120.62530           50.93751
STANDARD ERROR      7.13705

----------------- VARIABLES IN THE EQUATION -----------------

VARIAOLE               B             DETA      STD ERROR B         F

W1LQ24        2.476298           0.61241        0.46237       28.683
WORKAP      -0.8992026          -0.33043        0.19014       22.364
JUMP57        20.09937           0.43969        5.45616       13.57D
(CONSTANT)   -95.85129
```

Residuals sorted by W1LQ24

```
            OBSERVED         PREDICTED                                      PLOT OF STANDARDIZED RESIDUAL
SEQNUM        ARCBOTH            ARCBOTH      RESIDUAL              -2.0      -1.0       0.0       1.0       2.0

     1      19.35483           17.02377       2.331041                                    I  *
     2      23.80951           27.96361      -4.154108                              *     I
     3      35.61642           32.49939       3.117037                                    I    *
     4      34.88371           25.40137       9.482339                                    I             *
     5      45.45454           36.33582       9.118725                                    I             *
     6      20.83333           28.41457      -7.581237                          *         I
     7      33.84615           38.98268      -5.136535                              *     I
     8      43.93939           36.25781       7.681566                                    I           *
     9      27.02702           41.88585      -14.85883                *                   I
    10      69.33333           65.11287       4.220448                                    I      *
    11      64.55696           64.55859    -0.1633883E-02                                 *
    12      72.15189           66.56351       5.286372                                    I       *
    13      44.99998           54.23251      -9.232532                        *           I
    14      41.41414           39.55019       1.863953                                    I   *
    15      69.31818           63.82532       5.492845                                    I        *
    16      59.42029           60.71281      -7.292540                           *        I
    17      43.75000           54.57709      -10.82710                      *             I
    18      71.83098           76.04515      -4.214183                               *    I
    19      67.99998           66.68983       1.310137                                    I  *
    20      75.99998           71.47609       4.521882                                    I      *
    21      81.15941           75.23779       5.921604                                    I        *
    22      81.39534           87.12585      -5.730529                             *      I
    23      81.60919           86.10403      -4.494857                               *    I
    24      89.99998           82.83708       7.162886                                    I          *
    25      80.24690           74.15701       6.089883                                    I         *
    26      79.99998           80.07860    -0.7864153E-01                                 *
```

Figure F 14 MRA VIII A: Dependent Variable AVOGAS

Analysis of Variance Table

```
MULTIPLE R          0.95323                          ANALYSIS OF VARIANCE   DF      SUM OF SQUARES        MEAN SQUARE             F
R SQUARE            0.90864                          REGRESSION              4.          20.26791            5.06698           52.21809
ADJUSTED R SQUARE   0.89124                          RESIDUAL               21.           2.03773            0.09703
STANDARD ERROR      0.31150

---------------- VARIABLES IN THE EQUATION -----------------

VARIABLE    .        B             BETA      STD ERROR B       F

WORKAP     -0.4435497D-01    -0.38269       0.00949       21.867
W1L70       0.9483787D-01     0.55173       0.01741       29.685
LW1N75      0.8017967         0.34302       0.21485       13.927
JUMP57      0.7962523         0.40898       0.22880       12.111
(CONSTANT) -7.831386
```

Summary Table

```
                                                               SUMMARY TABLE

VARIABLE                                               MULTIPLE R  R SQUARE  RSQ CHANGE   SIMPLE R          .    B                BETA

WORKAP     %WORK CONNEC   TED WITH A-PORT                0.15473    0.02394   0.02394    -0.15473     -0.4435497D-01          -0.38269
W1L70      ONE    WEEK  L70                              0.80078    0.64125   0.61730     0.80038      0.9483787D-01           0.55173
LW1N75                                                   0.92518    0.85596   0.21471     0.30384      0.8017967               0.34302
JUMP57                                                   0.95323    0.90864   0.05269     0.74236      0.7962523               0.40898
(CONSTANT)                                                                                            -7.831386
```

Figure F 15 MRA VIII B: Dependent Variable VMANN

Analysis of Variance Table

```
MULTIPLE R          0.92210                ANALYSIS OF VARIANCE    DF      SUM OF SQUARES        MEAN SQUARE            F
R SQUARE            0.85027                REGRESSION               3.         4854.30554         1618.10185      41.64290
ADJUSTED R SQUARE   0.82985                RESIDUAL                22.          354.84539           38.85661
STANDARD ERROR      6.23351

---------------- VARIABLES IN THE EQUATION -----------------

VARIABLE            B             BETA      STD ERROR B        F

WORKAP     -0.6671353       -0.35978          0.17694     14.216
W1L70       2.353318         0.85575          0.23278    102.205
LW1N70      20.06007         0.50660          3.81575     27.638
(CONSTANT) -225.8952
```

Summary Table

```
                                                                        SUMMARY TABLE

VARIABLE                                               MULTIPLE R  R SQUARE  RSQ CHANGE   SIMPLE R             B                 BETA

WORKAP     %WORK CONNEC   TED WITH A-PORT                0.24559    0.06032    0.06032    -0.24559     -0.6671353            -0.35978
W1L70      ONE   WEEK  L70                               0.81373    0.65216    0.60185     0.80536       2.353318             0.85575
LW1N70                                                   0.92210    0.85027    0.18810     0.14349       20.06007             0.50680
(CONSTANT)                                                                                             -225.8952
```

Figure F.16 MRA VIII C: Dependent Variable ARCNA

Analysis of Variance Table

```
MULTIPLE R              0.94977                 ANALYSIS OF VARIANCE     DF       SUM OF SQUARES        MEAN SQUARE             F
R SQUARE                0.90206                 REGRESSION                3.         8452.09341         2817.36447         67.54350
ADJUSTED R SQUARE       0.88671                 RESIDUAL                 22.          917.66069           41.71185
STANDARD ERROR          6.45847

---------------- VARIABLES IN THE EQUATION -----------------

VARIABLE               B           BETA      STD ERROR B        F

WORKAP      -0.5266362        -0.22170        0.18332        8.253
W1L70        3.104192          0.88112        0.24118      165.659
LW1N70      31.47826           0.62078        3.95346       63.397
(CONSTANT) -307.4277
```

Summary Table

```
                                                           SUMMARY TABLE

VARIABLE                                             MULTIPLE R  R SQUARE  RSQ CHANGE   SIMPLE R           B                 BETA

WORKAP     %WORK CONNEC   TED WITH A-PORT              0.05471    0.00299    0.00299    -0.05471     -0.5266362           -0.22170
W1L70      ONE   WEEK  L70                             0.78730    0.61983    0.61684     0.78386      3.104192            0.88112
LW1N70                                                 0.94977    0.90206    0.28223     0.32097     31.47826             0.62078
(CONSTANT)                                                                                          -307.4277
```

Figure F 17 MRA VIII D: Dependent Variable ARCBOTH

Analysis of Variance Table

```
MULTIPLE R           0.95949                  ANALYSIS OF VARIANCE     DF       SUM OF SQUARES        MEAN SQUARE           F
R SQUARE             0.92062                  REGRESSION                4.         11320.38154         2830.09539     60.88517
ADJUSTED R SQUARE    0.90550                  RESIDUAL                 21.           776.13261           46.48251
STANDARD ERROR       6.81781

---------------- VARIABLES IN THE EQUATION ----------------

VARIABLE             B            BETA      STD ERROR B        F

WORKAP      -0.6773526       -0.24890        0.20744       10.663
W1L70         1.923647        0.47664        0.35709       29.019
LW1N80        17.97144        0.34477        4.58314       15.376
JUMP57        19.70343        0.43103        5.13083       14.747
(CONSTANT)   -158.0726
```

Summary Table

```
                                                                     SUMMARY TABLE

VARIABLE                                              MULTIPLE R  R SQUARE  RSQ CHANGE   SIMPLE R             B                  BETA

WORKAP     %WORK CONNEC   TED WITH A-PORT                0.00864   0.00007     0.00007   -0.00864    -0.6773526              -0.24890
W1L70      ONE    WEEK  L70                              0.79586   0.63339     0.63331    0.78666      1.923647               0.47664
LW1N80                                                   0.92998   0.86487     0.23148    0.55118      17.97144               0.34477
JUMP57                                                   0.95949   0.92062     0.05575    0.82009      19.70343               0.43103
(CONSTANT)                                                                                            -158.0726
```

Figure F.18 MRA IX A: Dependent Variable AVOGAS

Analysis of Variance Table

```
MULTIPLE R            0.95241              ANALYSIS OF VARIANCE    DF     SUM OF SQUARES      MEAN SQUARE           F
R SQUARE              0.90709              REGRESSION               4.          20.23322          5.05831       51.25612
ADJUSTED R SQUARE     0.88939              RESIDUAL                21.           2.07242          0.09869
STANDARD ERROR        0.31414

----------------- VARIABLES IN THE EQUATION -----------------

VARIABLE             B              BETA      STD ERROR B        F

W1L70       0.93440250D-01      0.57269        0.01808       29.652
WORKAP     -0.45567440D-01     -0.39315        0.00962       22.448
LW1N70      0.8410046           0.35993        0.23024       13.342
JUMP57      0.8353763           0.42708        0.22568       13.701
(CONSTANT) -8.306754
```

Figure F 19 MRA IX C: Dependent Variable ARCBOTH

Analysis of Variance Table

```
MULTIPLE R            0.95776              ANALYSIS OF VARIANCE    DF     SUM OF SQUARES      MEAN SQUARE           F
R SQUARE              0.91730              REGRESSION               4.       11279.60048       2819.90012       58.23297
ADJUSTED R SQUARE     0.90155              RESIDUAL                21.        1016.91368         48.42446
STANDARD ERROR        6.95877

----------------- VARIABLES IN THE EQUATION -----------------

VARIABLE          B              BETA      STD ERROR B        F

W1L70        2.235945          0.55402        0.40045       31.177
WORKAP      -0.7080559        -0.26019        0.21305       11.046
LW1N70       19.02661          0.32754        5.10021       13.917
JUMP57       21.59077          0.47232        4.99921       18.652
(CONSTANT) -192.8628
```