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COMPARISON OF NATIONAL NOISE INDICES

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INTRODUCTION

Aircraft noise is an increasing noise nuisance despite the fact that the areas affected by and the population exposed around our UK airports have decreased owing to the requirement for new aircraft types to meet more stringent standards for noise certification. The Department of the Environment reports (1) that the number of complaints received by Environmental Health Officers for aircraft noise rose from 11 per million in 1975 to 25 per million in 1985/86. This trend is not confined to the UK but is a European and American problem also. Over the last 2 years, as a member of a NATO CCMS* study into aircraft noise it has become evident that this subject is even more sensitive in countries such as Germany.

A number of noise descriptors and indices have been introduced, over a period of time, in individual countries, to describe the noise environment around airports and major military airfields. This paper reports on a comparison study between a number of individual countries' noise indices and criteria. Outwardly there are differences; such as the descriptors L_{Aeq}, L_{dn} or Kostenunits, but the question asked was; do the various criteria produce the same ameliorating effect on the populace they were designed to protect or compensate? In addition, in all these countries aircraft noise around airports and military airfields does not appear to be adequately described by these established criteria and this paper discusses some of the available alternatives.

Note: NATO CCMS stands for:

NATO's Committee on the Challenges of Modern Society; and was created to give the Alliance a "social" dimension. Its purpose is to explore ways of improving the quality of life for our people.

NOISE INDICES

Although individual countries have developed their indices and models independently all of them show a common basic structure, the main features of which are constructed from 3 components:

a. The noise characteristics of the aircraft type.

b. A flight profile for the manoeuvre.

c. The number of aircraft movements carrying out that manoeuvre.

Most noise indices are now based on the L_{eq} noise scale to quantify noise over a defined period of time but with imposed executive limits such as day/night weightings. The aircraft noise indices used by a number of countries are summarised at Table 1 (page 3). Aircraft noise contours, which are an outline of constant value of noise scale or index, are drawn by computer models to enclose an area or "noise zone". The importance of noise zones is that they define areas in which:

- restriction of land use can be applied.

- structural requirements (such as sound insulation) can be enforced.

- schemes for compensation or protective measures can be introduced.

There are a number of ways in which comparisons between individual countries' noise indices can be carried out. However, these comparisons are usually carried out using only one computer model and restricting it to the mathematical formulae. A typical example which the CCMS study reviewed was that by Matshat and Muller (2) which looked at the mathematical relationship between indices so that one index could be converted into another. In this study, calculations were performed for 6 airports with different air traffic situations. The conversion calculation was formulated by means of regression calculations. This approach makes for a rather theoretical comparison since it does not take into account all the idiosyncrasies of individual nations' models and methods of handling their data.

TABLE 1

Country	Descriptor	Index	Zoning
Canada	EPNL	NEF NEP	30, 35, and 40 NEF
Germany	L_{Amax}	Modifed L_{eq} (q=4)	67 and 75 dB(A)
Italy	EPNL or SEL	ECPNL or L_{eq}	
Netherlands	L_{Amax}	B (Kostenunits)	35-65 KE in 5 KE steps
Norway	L_{Amax}	EFN	5 zones according to EFN
Portugal	L_{Amax}	Modified NNI	
UK civil UK mil	LPN SEL(L_{ax})	NNI LEQ	50 NNI 75 and 83 dB contours
US	SEL (L_{ax})	LDN	65 and above in 5 dB steps

NATO CCMS STUDY

Within the NATO CCMS study it was possible for 5 nations to carry out a comparison study using each individuals model but using a common input data set. In addition the comparison was not confined to a narrow mathematical relationship but included 4 other aspects. 2 of them being of a subjective nature. The 4 comparisons included in the study were:

TABLE 2

1	A mathematical correlation similar to the Matshat and Muller study and which is being conducted by Mahron in Berlin.
2	A visual comparison of noise contours.
3	A comparison of areas within Zones.
4	A comparison of modelling differences - being the result of a questionnaire.

The data set was developed, for convenience, from a single military aircraft type with the attendant source noise and flight profiles. A number of departure routes were drawn up for a typical single runway airfield together with numbers of movements. This is shown in figure 1. Each country produced a family of contours using its own computer model and methodology which was printed out at a scale of 1:50000. These were then digitised before being overlayed one upon another.

MATHEMATICAL CORRELATION

The results of the mathematical correlation exercise being carried out in Berlin are not yet available.

VISUAL COMPARISON OF CONTOURS

The individual countries contours' display a variety of shapes. They range from long fingers following the aircraft departure routes through to fatter foreshortened contours such as the Netherlands and especially the West German model where any indication of departure routes is almost suppressed. Another approach is to overlay contours of equal zoning value. The values chosen were:

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Germany	75 dB
Netherlands	40 KE
Norway	65 CNEL
UK	70 L_{Aeq}
US	65 LDN

The result is at figure 2.

AREAS

The areas enclosed by the family of contours produced by each country have been plotted against the noise index. A direct comparison between these can be seen at figures 3 and 4. The German 75, Norwegian 65, UK 70 and US 65 contours have all been given equal value. However, it was impossible to scale the Netherlands Kostenunits. The areas enclosed over the scale range display a remarkable similarity between the contours.

RANK ORDERING

The practice of rank ordering of noise sources by noise level is mainly practised in the United States. Four sites A, B, C, D and illustrated in figure 1 were subject to the rank ordering exercise by each country. Sites A and B lie directly underneath the take-off path from the runway whicle C and D are 750m and 1km to the side of the main flight path. The evaluation of ranking was calculated down to 15 places but since the lower orders have little effect on the overall level only the first 5 sources have been listed at tables 3 to 6 (see pages 6 and 7). At sites A and B there is, as one would expect, general agreement between the models as to which source is worse. However, the UK model shows a marked difference and is a result of the way the UK Military calculates the L_{Aeq} using the "worst mode". Sites C and D show greater divergence because they are to the side of the aircraft tracks so that little differences in the models are emphasised.

TABLE 3

Rank	UK	L_{eq}	Holland	KE	USA (A) DNL (SAE)	dB	Germany	dB
1	2701/9	88.4	2703	63.4	2703	82.3	2703	72.7
2	2703/11	85.5	0918	61.7	0918	78.7	2701	69.4
3	0920	79.8	2701	56.2	2701	77.0	2704	64.7
4	2704/12	79.7	2705	51.4	2705	76.3	2705	64.7
5	2704/12	79.7	2704	51.4	2704	76.3	0906	64.5

TABLE 4

Rank	UK	L_{eq}	Holland	KE	USA DNL (SAE)	dB	Germany	dB
1	2703/11	78.5	2703	50.0	2703	66.7	2703	65.4
2	2704/12	72.6	2701	41.6	2701	63.3	2701	62.3
3	2704/12	72.6	2705	37.8	2704	60.4	2704	57.2
4	2701/9	70.4	2704	37.8	2705	60.2	2705	57.2
5	203/11	68.6	2717	34.2	2717	57.8	2719	53.8

TABLE 5

Rank	UK	L_{eq}	Holland	KE	USA DNL (SAE)	dB	Germany	dB
1	2701/9	66.6	2701	41.0	2703	62.2	2703	65.6
2	0902/10	66.5	2703	41.0	2701	61.8	2701	62.2
3	2703/11	61.6	0906/07	30.7	0906	61.5	2719	56.3
4	2703/11	60.9	2704	28.9	0902	60.4	2906	50.7
5	0906/13	59.4	2705	28.9	2704	56.1	0902	49.0

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TABLE 6

Rank	UK	L_{eq}	Holland	KE	USA DNL (SAE)	dB	Germany	dB
1	2701/9	58.4	2703	21.3	0906	52.4	2701	59.3
2	0902/10	57.8	2701	21.0	0902	51.2	2703	58.7
3	0906/13	54.8	0906/07	12.7	2703	50.9	2719	57.4
4	2703/11	53.6	2704	9.3	2701	50.8	0906	48.6
5	2703/11	53.4	2705	9.3	0908	46.0	0902	46.8

LIST OF DIFFERENCES

The differences in approach to modelling techniques have been studied in some detail and the noise metrics have already been described. The remaining principle features are summarized.

Air to Ground Attenuation Factors. Each country uses a different data reference to calculate the air to ground attenuation:

Germany - $O_n(S) = O_n - 20 \log (S/S_o) - R_n * d_n (S - S_o)$
Norway - INM data base
UK - ICAO method
US - SAE 866

Horizontal Spreading. Germany and Netherlands take account of a horizontal spread but both use different formulae, whereas Norway, UK and the US do not normally make any allowance.

Thrust Reverse. Only Norway takes revers thrust noise into account. It is defined in the approach parameter and is normally set to 40% of takke-off power.

Take-off and Landing Roll. The UK and US take into consideration take-off roll only but Germany and Norway take accoung of landing roll in addition. The Netherlands has a complicated method to account for start of roll noise and the UK includes additional corrections for sideline noise duration.

Grid Spacing Used in the Plotting Package. Most nations used 250 x 250 metres though Norway and the US are using feet. The biggest problem in the comparison study was that each nation used a different point of reference or origin to contruct their grid.

Reference Time for Calculating Number of Events. Again each nation has its own ideas, from summing all the aircraft passes in a year to selecting an average busy day. Details are listed at Table 7.

TABLE 7

Germany	Six busiest months of a year.
Netherlands	Calculated on the total number of Aircraft passes in a year.
Norway	EFN is defined as the average $L_{eq,24hr}$ for the 7 week-days. The 4 weeks most active summertime period form the basis for averaging the most hectic Summer week.
United Kingdom	$L_{Aeq,12hr}$ Mean Daily Movements average over a year's data, weekends and major holidays excluded.
United States of America	Average "Busy Day" - usually weekdays of flying averaged over calendar year.

DISCUSSION

The overall effect of these different approaches to the mathematical modelling of aircraft noise, though not large, is significant enough to make it difficult to make comparisons between the effects on the population of say around similar airports in different countries, such as Dusseldorf and Rotterdam. Part of this is due to executive decisions made by governments who have enshrined their respective methodologies in law. For example, in the UK, a recommendation (3) has been made to calculate the noise zones around airports in terms of L_{Aeq} (24 hours) instead of NNI but it is the Government which sets the action levels.

For the future there would, therefore, appear to be little room to harmonize European airport noise indices. The present criteria are accepted and are working satisfactorily for major airports and military airfields, though the householder living just outside a zone still feels that he or she is being discriminated against because sound attenuation with distance does not have any step factors. Around military airfields, where the background noise level is low, the householder cannot understand why the criterion limit is not lower or even at an inaudiobility level as suggested for clubs and discos.

There is a view that noise impact around airports should be expressed in terms including the number of people affected; ie a population weighted rating. One way of achieving this would be to include a term for housing density in the calculation.

In rural areas also aircraft noise has become a noise nuisance. Much of the noise is from light aircraft involved in business flying or leisure activities such as parachute jumping, glider towing or microlite aviation. In none of these areas are there any clear criteria whether it is for small airfields which are growing and giving rise to complaints or for use in assessing planning applications for new developments. Military ground running, particularly in the early evening, and low flying are specific problems for which there are few guidelines and do not fit into the MOD L_{Aeq} 70 dB criteria.

At Milton Keynes plans for a heliport laid down a very tight environmental noise specification of 35 NNI, which for this situation was calculated by Ollerhead (4) to corrospond to approximately 59 $dB(A)_{Leq}$, within a very small (400 Hectares) noise impact area. Is this a reasonable starting point for light aircraft noise contours?

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In the crowded South East of England there is an increasing demand to use what countryside is left for leisure activities whether it is clay pidgeon shooting, water sports or flying. Most of them have noisy side effects. Should the inaudiability of the noise be the rule? Clearly there is a need for further guidance on the nuisance level of these types of sounds and therefore the planned DOE survey of attitudes to noise to be carried out by the building research establishment during 1989 could be very useful indeed. Finally, as has already been mentioned, these problems are common to our European partners as well so that there is also the opportunity to obtain some international uniformity.

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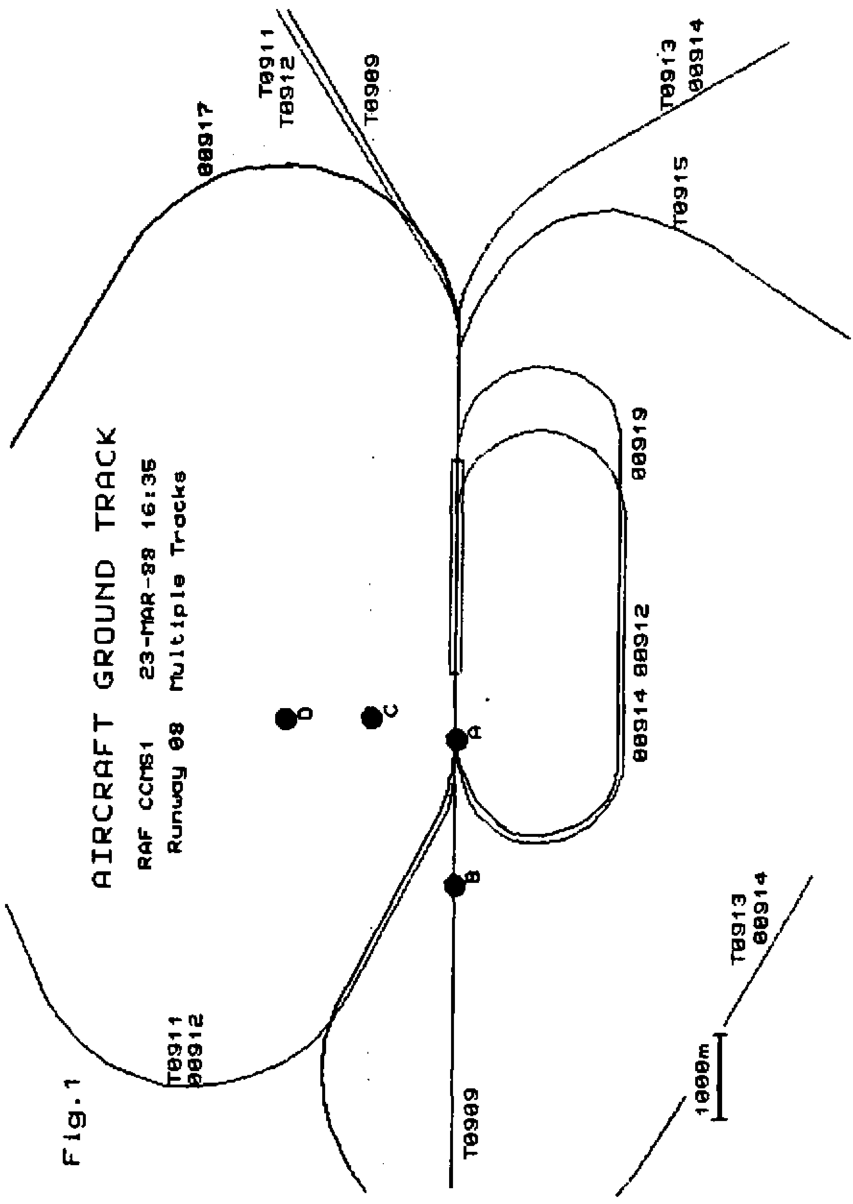
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RAF CCMS1 23-MAR-88 16:35
Runway 08 Multiple Tracks
00917
T0911
T0912
T0989
T0913
00914
T0915
00919
00914 00912
A
B
C
D
T0911
00912
T0989
T0913
00914
1000m

Fig. 1

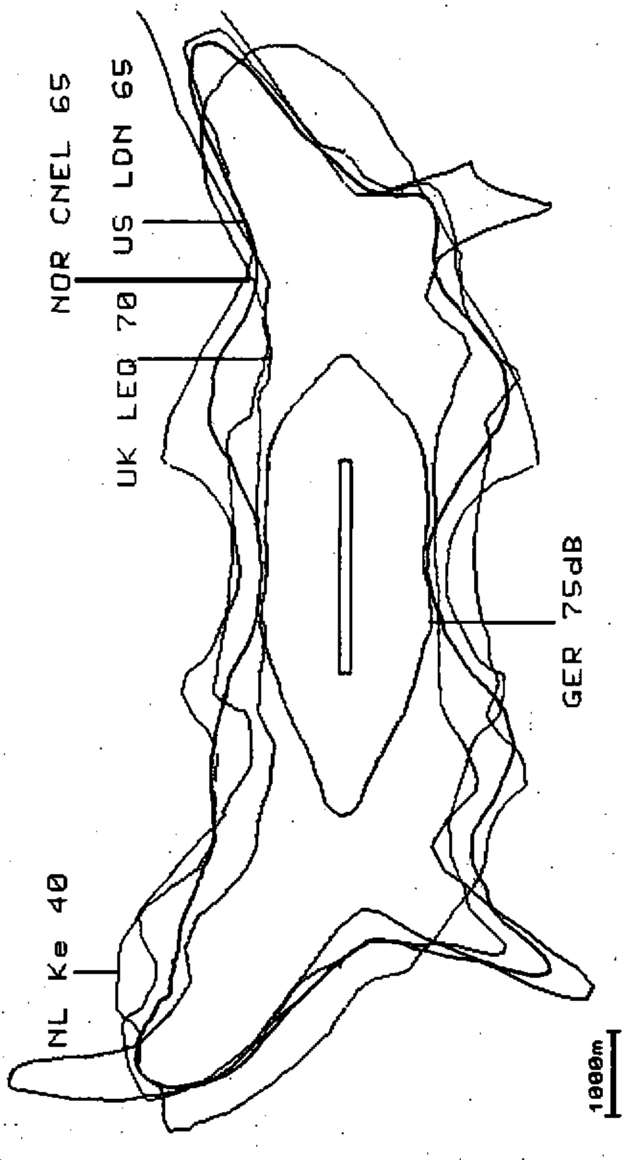
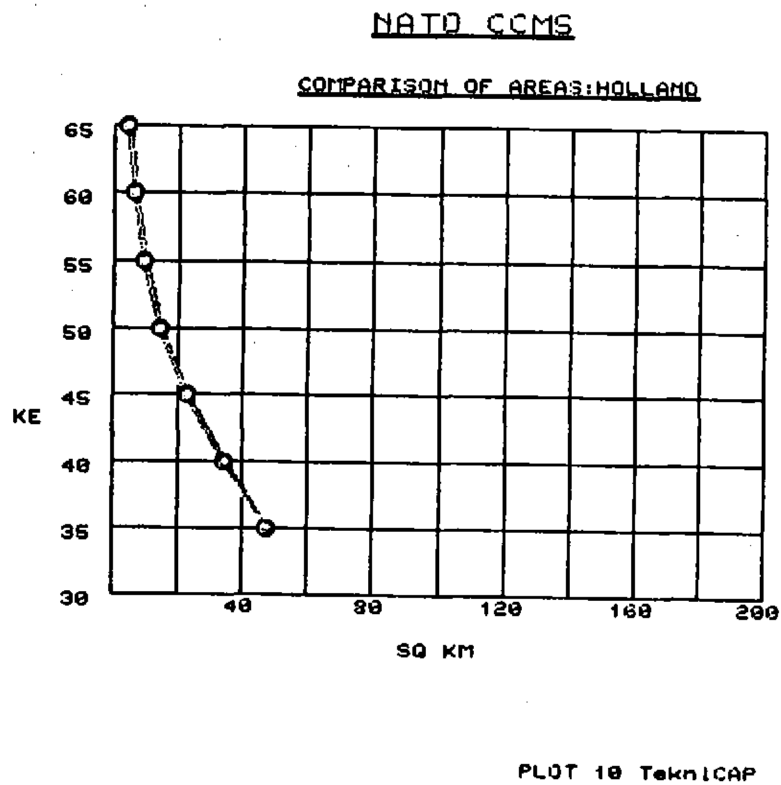


Fig.2

Fig. 3


NATO CCMS
COMPARISON OF AREAS:HOLLAND
65
60
55
50
45
KE
40
35
30
40
80
120
160
200
SQ KM
PLOT 10 TekniCAP

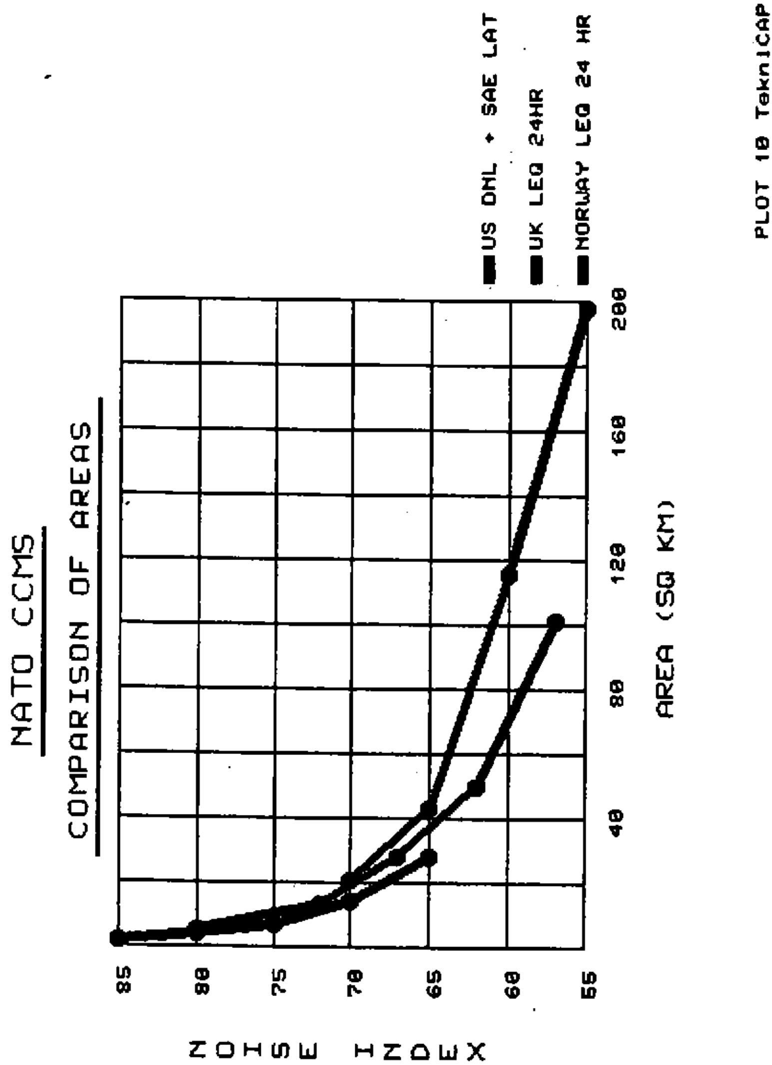

NATO CCMS
COMPARISON OF AREAS
NOISE INDEX
85
80
75
70
65
60
55
AREA (SQ KM)
40
80
120
160
200
US DNL + SAE LAT
UK LEQ 24HR
NORWAY LEQ 24 HR
PLOT 10 TekniCAP

Fig.4