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AIRPORT NOISE - INTEGRATING TOTAL ANNOYANCE BY THE USE OF AN EXCHANGE RATE CONCEPT

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It is well established that community response to noise from aircraft in flight varies widely, and most studies have shown that if individual people's responses are rated on a numerical scale of annoyance scores, the distribution is generally Gaussian (1,2,3). For the purposes of providing a basis for political decisions, it is common practice to calculate a single quantity such as the average annoyance score for a range of values of the aircraft noise index in order to simplify the issues before the decision makers. For example, in public inquiries, it has become virtually standard practice to say that 35 NNI is 'low annoyance'; 45 NNI is 'moderate annoyance' and 55 NNI is 'high annoyance'.

However, simplifications such as these are made without any real justification. For instance, in arriving at an average annoyance score, a commonly used method involves multiplying the number of people in each cell by the numerical value of the annoyance score (on a scale from 0 to 6), summing the results and dividing them by the total number of people. This presupposes that a person responding with an annoyance score of, say, 6 is equal to six people each with an annoyance score of 1. No attempt is made to justify this 'exchange rate'.

Community response to noise is by no means the only area in which this question arises, and the politician is frequently faced with the question of whether, in attempting to solve a problem, it is right to improve the lot of a small number of badly affected people or a large number of moderately affected people. The problem could be made easier if there were a well-founded way of equating people suffering in various degrees of severity by means of an exchange rate. As far as aircraft noise is concerned, without attempting to determine what the exchange rates should be, mere application of the general principle using a wide range of possible values yields a consistent and important result.

Let the exchange rate be based on the value of one person responding with a score of 6, such that E_s people responding with a score s are equal to one person of score 6. Let the number of people living within each noise contour zone be

$$\sum_{s=0}^{s=6} \frac{F_{sz} P_z}{100}$$

where F_{sz} is the percentage of the population within zone z responding with score s and P_z is the total population living within the zone, i.e. who are exposed to more noise than the lower limit of the zone and less noise than the upper limit.

By weighting the population numbers according to the exchange rate E_s, the total impact in each zone can be expressed as a single figure which represents the equivalent number of people who respond with score 6. The total impact in zone z is given by

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$$I_z = P_z K_z$$

where $$K_z = \frac{1}{100}\left[\frac{F_{1z}}{E_1} + \frac{F_{2z}}{E_2} + \frac{F_{3z}}{E_3} + \frac{F_{4z}}{E_4} + \frac{F_{5z}}{E_5} + F_{6z}\right]$$

the total impact of the airport as a whole is

$$I_t = \sum_{z=z_1}^{z=z_n} I_z$$

which is the sum of the individual zone impacts I_z from the highest zone containing any population down to the lowest significant zone. What the lowest significant zone is may be a matter of contention but it is logical to argue that it should be the lowest zone for which there are reliable figures both for annoyance distribution and population. For most airports population figures are only available down to 35 NNI, so that the lowest zone for which the impact calculation can be performed is z = 40, i.e. the zone between 35 NNI and 45 NNI. However, annoyance distribution data exist for z=30 and the calculation could be extended to this zone if the population figures were available.

The values of the percentage F_{sz} are obtained from existing studies of the results of surveys such as reference 3 and are as follows, when expressed as a distribution rather than in the more usual cumulative form

	Annoyance score					
NNI	1	2	3	4	5	6
30	19	19	15	9	4	1·5
35	18	20	18	12	6	2·5
40	15	19	19	15	9	4·5
45	12	18	20	18	12	6
50	9	15	19	19	15	9
55	6	12	18	20	18	12
60	4	9	15	19	19	15

As to the values of E_s, it transpires that the precise value has remarkably little effect on the slope of the curve of K_z plotted against z (see figure 1). The important conclusions which emerges is that the fall in K_z with decreasing values of z is, for most airports, less steep than the rise in the population P_z with decreasing z, so that the total impact of an airport increases with distance from the airport.

Table 1 shows the impact of noise from UK airports using the exchange rate $E_s = 2^{(6-s)}$, by which a person of annoyance score 5 has half the value of one with annoyance score 6, and a person of annoyance score 4 has one quarter the value of a person with annoyance score 6, and so on.

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Airport	z	NNI	Population	I_z $(E_s = 2^{(6-s)})$
Heathrow	40	35-45	1,632,000	266,016
	50	45-55	300,000	73,800
	60	55-65	72,000	22,824
	Total		2,004,000	362,640
Gatwick	40	35-45	46,000	7,498
	50	45-55	3,000	738
	60	55-65	1,000	317
	Total		50,000	8,553
Luton	40	35-45	19,000	3,097
	50	45-55	5,000	1,230
	60	55-65	0	0
	Total		24,000	4,327
Manchester	40	35-45	89,000	14,507
	50	45-55	13,000	3,198
	60	55-65	3,000	951
	Total		105,000	18,656
Birmingham	40	35-45	19,000	3,097
	50	45-55	4,000	984
	60	55-65	0	0
	Total		23,000	4,081
Glasgow	40	35-45	105,000	17,115
	50	45-55	20,000	4,920
	60	55-65	0	0
	Total		125,000	22,035
Others	40	35-45	88,000	14,344
	50	45-55	21,000	5,166
	60	55-65	2,000	634
	Total		101,000	20,144

TABLE 1 Impact of noise from UK airports (1974 population figures) expressed in terms of the equivalent number of people with an annoyance score of 6

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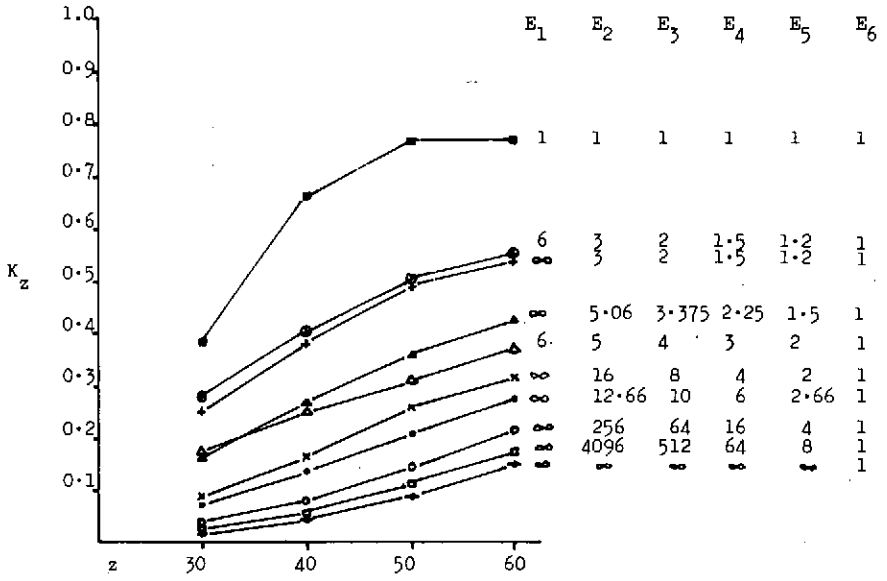

FIGURE 1 Values of K_z as a function of z and E_s

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