THE IMPACT OF AIRCRAFT NOISE ON MILITARY EXERCISE AND TRAINING AREAS

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ABSTRACT Gardermoen is chosen as the location for a new major airport for the Oslo area. The site is surrounded by various units and camps operated by the Norwegian national defence. A study was carried out to evaluate whether the occurrence of aircraft noise may result in the national defence having to restrict operations in established camps, and in areas where outdoor exercise, training and instruction are beeing carried out.

When describing the impact of aircraft noise on outdoor instruction, the conventional calculation methods based on L_{eq}-contours was difficult to apply. During outdoor tuition any aircraft take-off is likely to interrupt instruction. In order to assess the usability of the areas during periods of aircraft noise exposure, it was necessary to use a method of calculation and analysis based on the actual noise emitted from each aircraft.

The paper describes a method for determining which areas that are unsuitable for outdoor instruction as a function of the number of take-offs per hour.

1. INTRODUCTION

In calculating the impact of aircraft noise on outdoor instruction, the conventional noise-calculation methods based on L_{eq}-contours will be difficult to apply. During outdoor tuition any aircraft take-off is likely to interrupt instruction.

It has therefore been necessary to use a method of analysis and calculation based on the actual noise emitted from each aircraft. This is normally done by using the time history model in the INM Version 3 database 9 to calculate time above treshold values (TA-values). Calculating TA-values this way is resource- and time demanding, and can in Norway only be executed by Acoustic Research Center in Trondheim.

This paper, however, describes a simple analytic methodology for determining which areas that will be unsuitable for instruction as a function of the number of take-offs per hour. The method is based on the actual noise emitted from each aircraft operation expressed by standard maximum noise level (MFN) contours for different kinds of aircraft. MFN is the local noise measurement unit, very similar to L_{Amax}.

2. METHODOLOGY

The Gardermoen Study carried out numerous observations of maximum aircraft noise at several different airports. During thorough examination of the noise data it was found that for a given type of aircraft there is at any point on the ground a specific, unambiguous connection between the *time above a certain threshold* and the *maximum noise level*. This connection can be determined by noise measurements at different ground positions.

A number of noise measurements of different types of aircraft have shown that with an increase in distance from the runway, the maximum noise level decreases, whereas the time above 60 dBA remains more or less constant for each type of aircraft. Time above 60 dBA varies with type of aircraft; 80-85 seconds for DC 9, 60-65 seconds for MD-80 and approx. 40 seconds for B-727. This is found to be correct for all ground positions within the actual training area where the maximum noise levels exceeds 65 dBA.

3. TYPICAL NOISE CONTOUR MAPS

By drawing (for a given aircraft) the connection between dBA and time above treshold for two different ground positions as straight lines in an XY-diagram in which dBA is indicated along the Y-axis and time above threshold (in seconds) along the X-axis, the diagram shown in figure 1 appears:

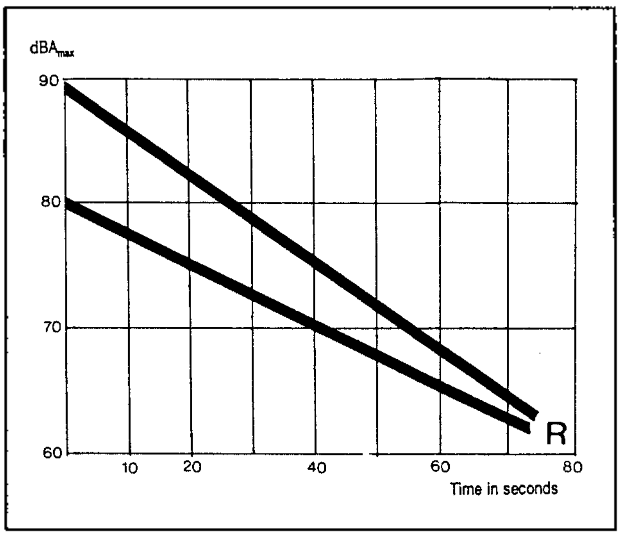

Figure 1. Connection between dBA_{max} and time above treshold for DC-90

When this common rotationary area (or point) "R" has been established for a given type of aircraft, new graphs or lines referring to other ground positions can be drawn without further observations.

This method can be applied to illustrate typical noise contour maps or the connection between maximum noise levels and time above threshold for several types of aircraft based on a relatively small number of measurements.

This report will concentrate on the typical noise contour maps for the aircraft type MD-80, which for the time being is used as the reference aircraft type.

4. TYPICAL NOISE CONTOUR MAPS FOR MD-80

During the Gardermoen Study, TA-values have been recorded both in Denmark and Norway:

Measurements at Kastrup Airport outside Copenhagen carried out and recorded by DAI (Danish Acoustical Institute)

Measurements at Fornebu Airport outside Oslo, on Kadettangen and Høvik, carried out and recorded by DELAB (Norwegian Acoustics Research Centre).

Based on these measurements the above mentioned point "R" has been established for the aircraft type MD-80. The time above 60 dBA for all ground positions in the study area was found to be 64 seconds. The connection lines between time above threshold and maximum noise contour for the aircraft type MD-80 can then be drawn. The result is shown in figure 2.

Based on the diagram in figure 2 it is possible to establish every ground area (as defined by the area covered by the maximum noise level) where time above a given noise tolerance level varies between zero and sixty seconds.

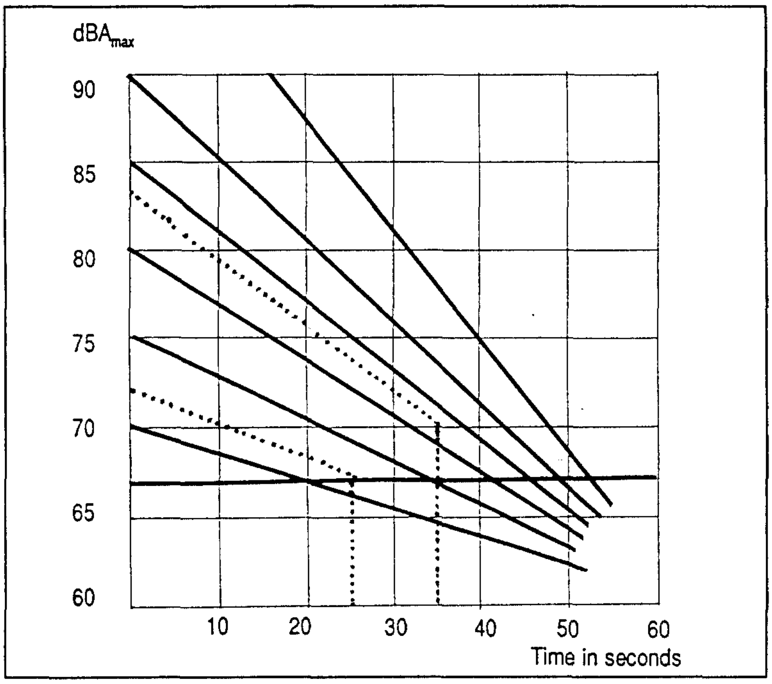

Figure 2. Connection between time above treshold and max. noise contours for take-off by MD-80.

Example 1

The diagram shows that by one take-off with the MD-80, the ground area in which maximum noise is higher than 67 dBA for 25 seconds is similar to the area covered by the maximum noise contour for 72 dBA.

Example 2

The diagram also shows that the ground area in which maximum noise is higher than 70 dBA for 35 seconds is similar to the area covered by the maximum noise contour for 83 dBA.

5. NOISE TOLERANCE CRITERIA

The noise tolerance level during outdoor instruction will to a large extent depend on the three factors, noise level, length of interruption and the number of interruptions.

Based on theoretical and practical studies, the national defence decided to use the tolerance level of 67 dBA as a common criteria for the level of noise that can be tolerated during outdoor instruction. During the periods when the noise is higher than 67 dBA, the instruction must be postponed.

After supplementary studies the national defence concluded that for **calculating purposes** one can tolerate a **total break** of up to 5 minutes pr. hour or 8 % of the total time spent. The interruption time of 5 minutes could consist of few, long lasting interruptions or of many, abrupt interruptions.

6. NUMBER OF DEPARTURES/TAKE-OFFS

If the national defence can tolerate a total interruption time (= time above "tolerance level") of 5 minutes (300 seconds) per hour, the correlation between the number of take-offs and the corresponding maximum noise level can be determined on the basis of the linear curve diagram in figure 2.

Departures per hour	Time above tolerance level	Maximum noise level at a tolerance level of 67 dBA
5	60 sec	> 100 dBA
7	42 sec	81 dBA
8	38 sec	77 dBA
10	30 sec	73 dBA
12	25 sec	71 dBA
15	20 sec	70 dBA
20	15 sec	69 dBA
30	10 sec	68 dBA

Table 1. Correlation between number of take-offs and maximum noise levels

The table shows for instance that at 7 take-offs per hour the defence can conduct outdoor instruction and tuition within all areas in which the max. noise level does not exceed 81 dBA.

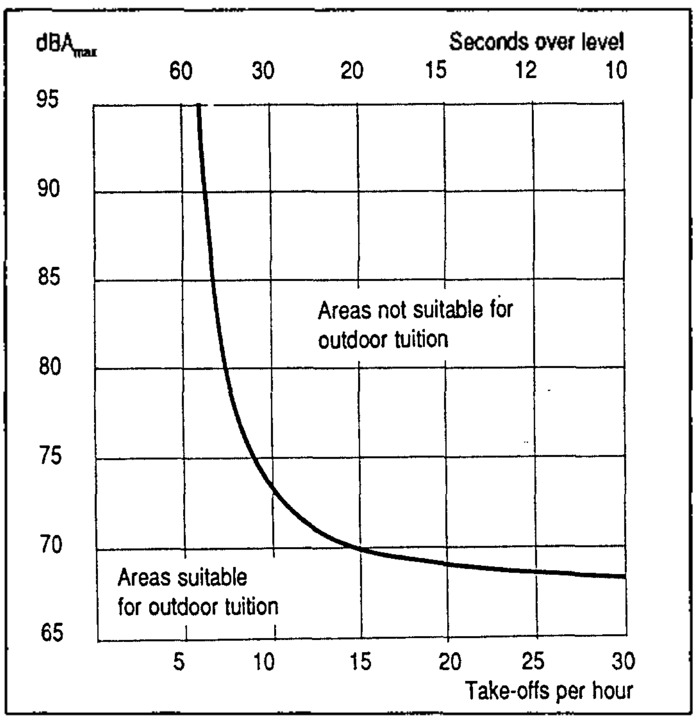

Figure 3. Correlation between max. noise level and areas suitable for outdoor tuition by varying number of take-offs per hour (MD-80)

Correspondingly the table indicates that at 20 take-offs per hour the national defence can carry out outdoor tuition in all areas where the maximum noise level does not exceed 69 dBA, on the prerequisite of a tolerance level of 67 dBA.

To ease accessability of this information table 1 is transformed into a graph in figure 3.

7. MAXIMUM NOISE LEVEL CONTOURS

To finally conclude on the possibility of outdoor tuition, the national defence needed access to MNF-contours. MFN-contours, comparable to L_{Amax} are available for most aircraft types that trafficate Norwegian airports. These have been calculated on the basis of the American INM program using Database 9.

During the study the national defence uncovered large deviations from calculated maximum noise level contours for Chapter 3 aircrafts based on the INM program and noise measurements and recordings in Denmark and Norway.

According to the calculated maximum noise levels (INM program), the noise impact from the Chapter 3 aircraft MD-80 should be 5 to 10 dBA lower (in areas adjacent to the runway) than those from the Chapter 2 aircraft DC-9.

As shown in the noise recordings below, the maximum noise level from the MD-80 is only slightly lower than the noise level from the DC-9.

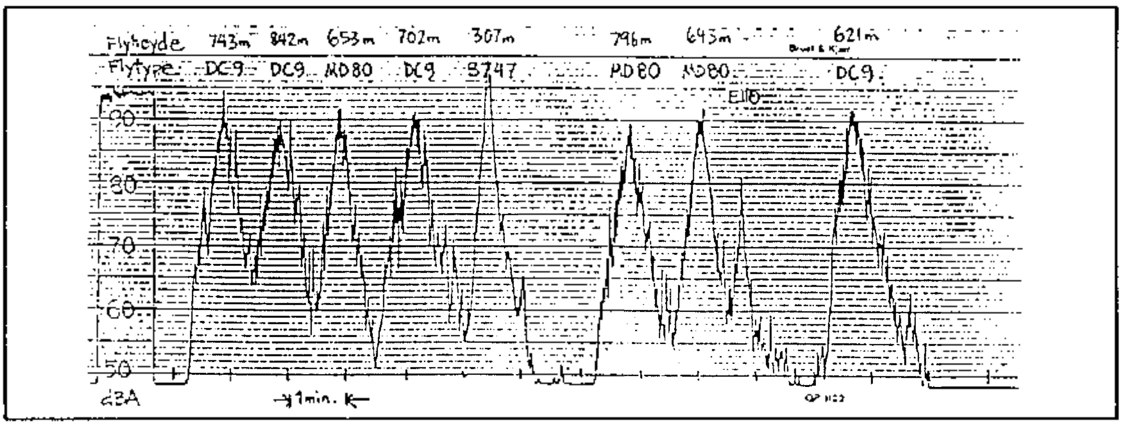

Figure 4. Noise recordings at Kastrup Airport 29th of May 1991

The deviations were such that the Danish Acoustical Institute (DAI) in Copenhagen were commissioned to investigate possible explanations. The Institute prepared a report (LI 566/91) which has been submitted to the FAA in USA for their information and comments.

DAI's conclusion is that for the aircraft type in question (MD-80) the deviations between observed values and values calculated on the basis of INM's database were so great that the calculated values ought not to be used for verification of the noise areas in question.

The alterations has been discussed with FAA. FAA's preliminary conclusion is, however, that until the source for the deviation between measured and calculated noise is found, the national defence should in their study, add 5 dBA when calculating TA for the MD-80.

8. PRACTICAL USE OF THE ANALYTIC METHOD

To control the accuracy of the analytic method the national defence wanted to compare the results of the method with traditional TA-contours based on the INM database 9. Due to reasons described above, it was found that for the MD-80 the INM database 9 gave unsatisfactory results.

However, the Danish national program for calculating aircraft noise, DANSIM, was found to give a much better concordance with measured values. Therefore, it was decided to use DANSIM for the comparative calculations. Both maximum noise contours and time above threshold for the aircraft in question, the MD-80, have been calculated through DANSIM.

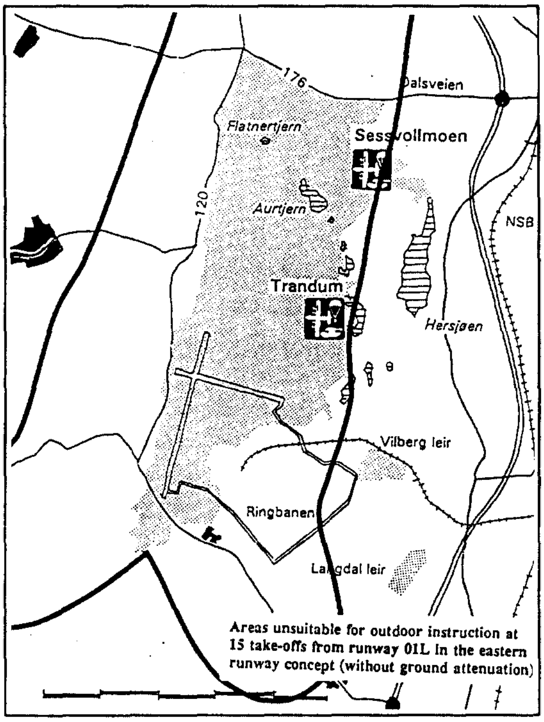

Figure 5. Unsuitable areas for outdoor tuition calculated by the analytic method

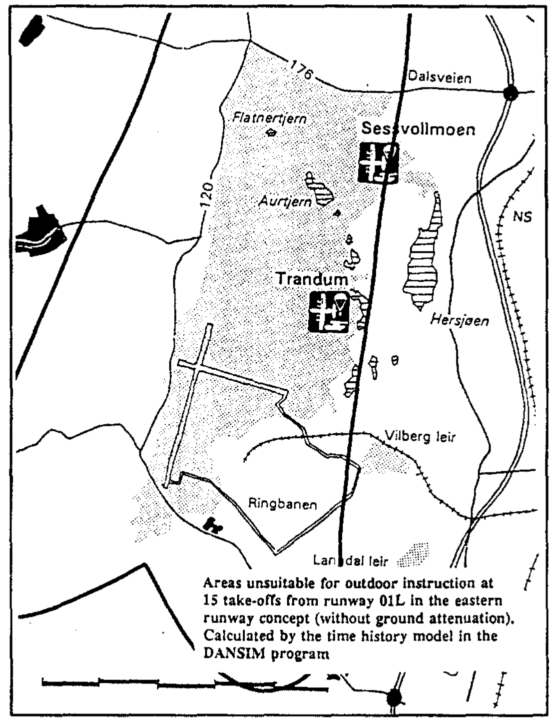

Figure 6. Unsuitable areas calculated by the DAMSIM time history model

Figure 5 shows the areas unsuitable for outdoor instruction at 15 take-offs per hour from runway 01L at Gardermoen new Airport. 15 departures per hour is assumed to represent an average daily departure frequency during the airport's opening year (2000). The contour line correspond to the maximum contour line for 70 dBA as calculated in table 1.

Figure 6 shows the areas in which noise above 67 dBA lasts more than 20 seconds calculated by the time history model in the DANSIM program. The contour line for 20 seconds should correspond with the contour line in figure 5. The conformity is very good.

Prior to this study, we used our international contacts to find out whether or not corresponding studies had been carried out at other airports. The result was negative. We therefore had to develop the methodology without any references to similar studies from elsewhere.

We do, however, believe that the method described in this paper could be of general interest. It may be used to study the problem with interruption of speech and instruction, not only at other airports, but even for other noise sources than aircraft.