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SINGLE EVENT AIRCRAFT NOISE PREDICTION BY NORTIM

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ABSTRACT

Models to predict aircraft noise around airports, traditionally compute long term averaged sound immission for land use planning purposes. The objective of this paper is to present how the Norwegian aircraft noise prediction model NORTIM is extended to predict short-term noise levels. The model is capable of predicting time histories with up to 1-second resolution, and includes the effects of local topography. This kind of model is an effective tool to understand and explain the different aspects of noise in the surrounding community, as well as to provide direct comparison with short term noise measurements.

1 - INTEGRATING VERSUS SIMULATION MODELS

There are two basically different classes of aircraft noise models: The integrating models and the simulation models. The integrating models cut all flights into a discrete number of straight lines and add the contributions from each of these line sources. In these models changes in aircraft flight directions and changes in flight operation parameters like flaps and engine settings determine the length of each segment. Consequently long flight paths can be modelled by a small number of noise sources, and low computational cost.

The simulation models divide the flight path into a number of discrete points, and disregard the flight path between these points. To calculate the integrated noise for a flight path, the distance between these points must be small, leading to a large number of points and possibly high computational costs. On the other hand this approach is able to account for more detailed modelling of parameters like noise source directivity and propagation attenuation.

The integrating models use fractions of the straight lined flyby to calculate contributions from each line segment. To this fraction a directivity adjustment is applied. By dividing each line segment into shorter lengths, it is possible to convert an integrating model into a quasi simulation model.

NORTIM is basically an integrating model based on INM, but extended to take account of effects from topography to the sound transmission. A special version has been developed where all line segments of a flight is being cut into lengths that correspond to 1-second duration. This enables calculation of a time history of the noise level for a fly by. Thus, a more detailed comparison can be made between calculated results and measurements.

2 - NOISE SOURCE DATA

The commonly available aircraft noise database from FAA give immission data from straight lined over flights of infinite length under steady speed, height and power conditions for each aircraft. Three noise source quantifiers are given: SEL, L_{MAX} and L_{EPNL}. They are extracted from measurements with microphone positioned approximately 1.5 meter above a horizontal acoustically soft ground. Measurements are normally taken for the flybys at a reference height and calculated for other heights.

A major challenge for simulation models is the lack of noise emission data. While traditional integrating models uses standardised noise immission data to describe the noise source, simulation models basically need emission data that does not include the effect of distance, weather and ground surface.

3 - EXAMPLES OF SIMULATIONS WITH NORTIM

NORTIM is based on the FAA database and uses the same algorithms as INM to model noise source, and −propagation. Certain extensions are added to account for topographical variations. When using NORTIM in simulation mode, two different algorithms are available. One is a quasi simulation based on short line segments, and *SEL* type source data. The other is an attempted simulation that uses L_{MAX} to describe the noise source. The formulas are:

$$SPL_{SEL} = L_{AE}\left(P,d\right) + \Delta L_{V} + \Delta L_{EGA}\left(\Lambda,d\right) + \Delta L_{TOPO} + 10^{*}\log\left(F\right) - 10^{*}\log\left(T\right) \qquad (1)$$

$$SPL_{MAX} = L_{MAX}\left(P,d\right) + \Delta L_{EGA}\left(\Lambda,d\right) + \Delta L_{TOPO} + \Delta L_{DIR} \qquad (2)$$

where:

- $L_{AE}\left(P,d\right)$ is the *SEL* level interpolated from the database according to the power setting (P) and distance (d) of the aircraft
- ΔL_{V} is correction for the speed of the aircraft when deviating from 160 kts
- $\Delta L_{EGA}\left(\Lambda,d\right)$ is correction for excess ground attenuation to the side of the aircraft flight path according to the elevation angle (Λ) and distance (d)
- ΔL_{TOPO} is the correction for topography and ground surface when the terrain is not horizontal and acoustically soft
- F is the sound exposure fraction (0-1) to account for segments that represent only a fraction of a total flyby
- T is the duration of the flight segment
- $L_{MAX}\left(P,d\right)$ is the L_{MAX} level interpolated from the database according to the power setting (P) and distance (d) of the aircraft
- ΔL_{DIR} is the correction to account for jet aircraft deviations from omnidirectional directivity.

Figure 1 shows the resulting time histories for the two different algorithms, applied to a single straight-lined level flight by a jet aircraft. The aircraft is an F16 flying at 2000 ft with military engine power setting and a speed of 160 knots. The figure shows a deviation between the two algorithms that is general for most of the situations. The reason for the deviation is mainly that the directivity effect of the noise source and corresponding measurement geometry is implicitly included in several of the terms in the equations (1) and (2). Thus the directivity effects are treated differently in the two algorithms. The basic concept for the source data and propagation algorithms is however not intended for this kind of short-term time history calculations. It might therefore be assumed that neither of them is more precise than the other.

To illustrate the use of NORTIM for general-purpose noise simulations, three examples are given. The figures show measurements (thin line) and simulations with the *SEL* algorithm (thick line) and the L_{MAX} algorithm (dotted line).

Figure 2 shows an F16 on a low pass at Narvik airport. The measurement position is on the extended centerline ahead of the aircraft on descend and of the first part of the climb. The aircraft makes a 180° turn before reaching the microphone position.

Figure 3 shows two examples from Oslo airport Gardermoen. The measurements are taken at a position approximately 500 m aside the ILS course and 10 km before touch down. Both aircraft are on a stabilized 3° glideslope.

All these three examples are chosen as typical of the results seen so far, when comparing simulations by NORTIM and actual measurements. It should be noted that for the civil airliners, some of the aircraft types show good agreement between simulated and measured results. The normal case is that the simulated result underestimates the measurements.

4 - CONCLUSIONS

The possibility to use NORTIM to simulate short-term time histories is demonstrated. This includes the possibility to use the commonly available aircraft noise source database from FAA. The accuracy of the simulation results is however limited by the fact that these noise source data are not intended

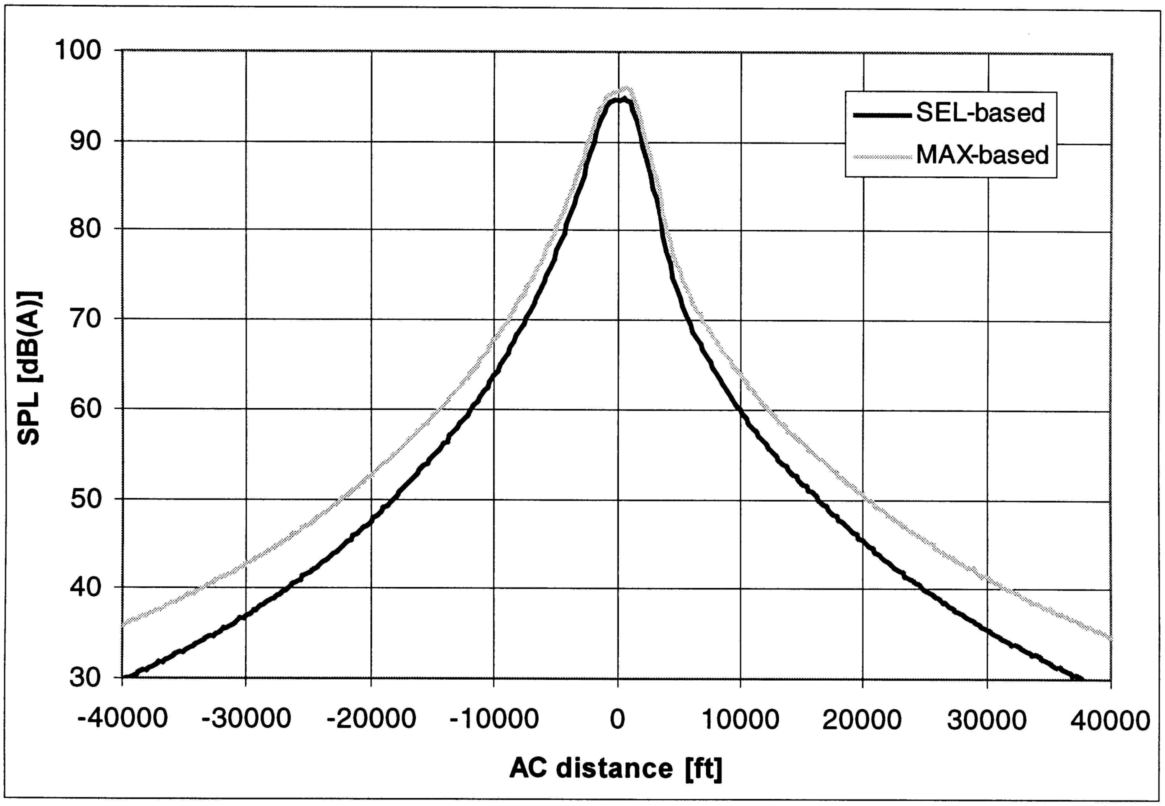

Figure 1: Simulated time history for a level overflight.

for simulation purposes. Consequently a need is raised for noise source emission data, that does not implicitly include effects of propagation effects like distance, ground attenuation and meteorology.

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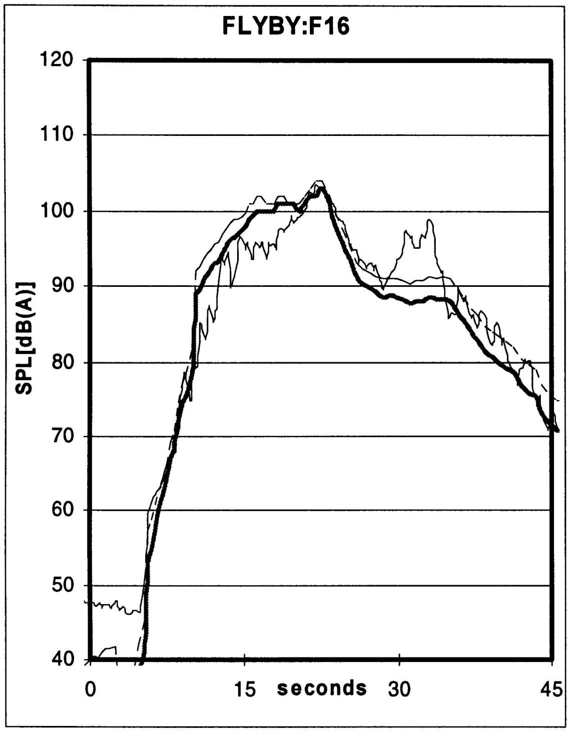

Figure 2: Time history of a flyby measured and simulated.

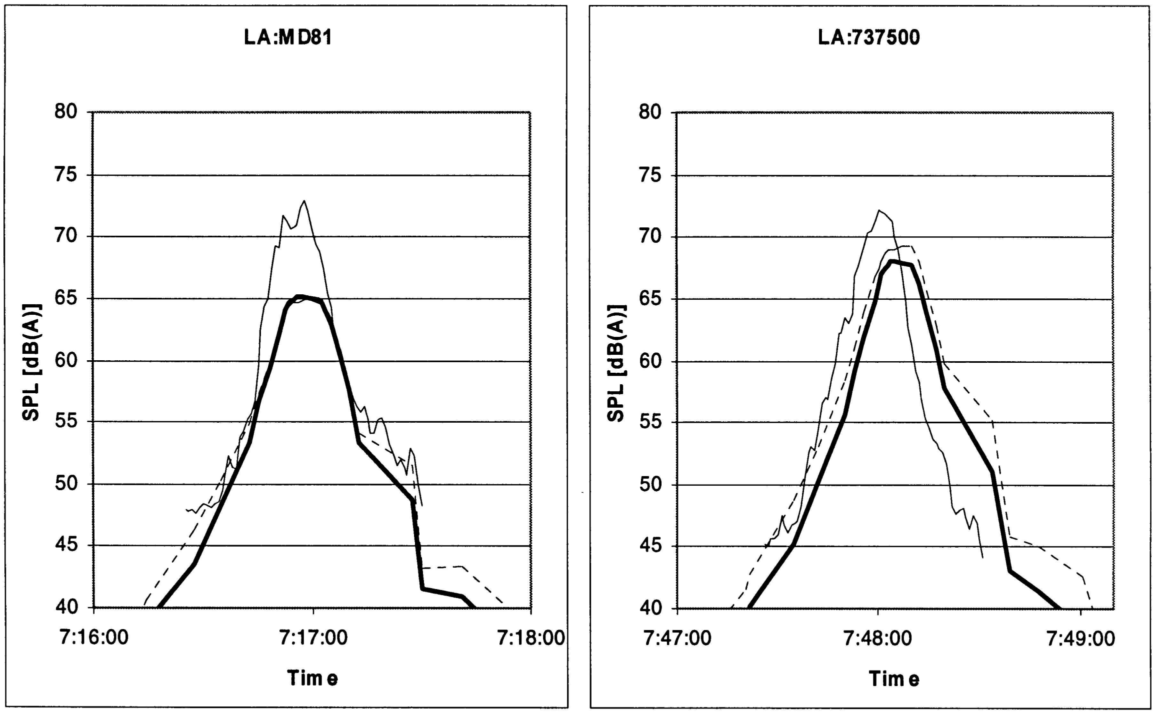

Figure 3: Time history of two approaches.