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INVESTIGATION OF THE LONG-RANGE LOW-FREQUENCY NOISE OF A PROPFAN AIRCRAFT TEST PREDICTED BY THE INTEGRATED NOISE MODEL

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INTRODUCTION

The prediction of aircraft noise using the Integrated Noise Model, INM[1] (referring to the SAE/AIR 1751 Lateral Attenuation algorithm[2]), does not take into account real meteorological and ground effects, although they are of special importance.[3]

Present paper uses the INM model for the simulation of the propfan aircraft flight tests at Alabama, U.S.A., 1987[4], and for the prediction of ground noise at specific sites. Based on a statistical regression analysis of the recorded data at Alabama (ground and source aircraft noise, meteorological and flight path data), there has been developed a revised Lateral Attenuation algorithm and a revised INM model. The comparison of the ground noise predicted by the application of the original and revised INM model, with the corresponding measured data at Alabama, leads to certain conclusions about the prediction accuracy of both models.[5]

INM MODEL APPLICATIONS AT ALABAMA

Based on the recorded propfan aircraft data at Alabama and on the INM model analysis[4] (Noise-Distance-Power curves, linear noise propagation regarding the Closest Point of Approach, relevant spherical divergence effects and atmospheric absorption regarding reference atmospheric conditions[6]), there have been developed the relevant propfan aircraft NDP curves.

According to the simulation of the aircraft flight tests of 30 and 31 October, 1987, in Alabama, the results from the corresponding application of the INM model for the noise prediction at specific sites on ground level (on flight track and ±5 miles at both sides from it), compared with the corresponding measured ground noise data, show big differences (average deviations of about 8,5 dB(A)). (Fig.1)

STATISTICAL INVESTIGATION OF ALABAMA DATA - DEVELOPMENT OF A REVISED LATERAL ATTENUATION ALGORITHM

With the scope of the investigation of the ground noise sensitivity to the meteorological effects, and based on a statistical regression analysis of the recorded data at Alabama, there have been resulted the following relations:

- Ground noise recorded during each flight test depends especially on the maximum measured ground noise.
- The maximum recorded ground noise depends strongly on aircraft elevation angle (BETAcpa, deg) and slant range (SLRcpa, m), both referring to the Closest Point of Approach (r^2=0,995, standard error 4,79 dB(A)). Furthermore, it also depends on ground meteorological data, as temperature T_{10} (°C), relative humidity HUM_{10} (%) and wind intensity W_{10} (knots) (regarding all mentioned parameters: r^2=0,999, standard error 2,36 dB(A)).
- The maximum recorded ground noise depends totally on the ground noise calculated according to the relevant NDP-curves, and on the difference between measured and NDP-calculated ground noise data. Regarding the INM model analysis, this difference refers to lateral attenuation effects.
- Further statistical investigation leads to the following highly correlated revised lateral attenuation algorithm for aircraft elevation angles greater than 30 deg (limitation due to available data at Alabama):

$$LA = 0{,}193 \times HUM_{10} - 0{,}0011 \times SLPcpa \times EXP(W_{10}/T_{10}) - 0{,}0378 \times BETAcpa \times EXP(W_{10}/T_{10})$$

It has to be mentioned, that this analysis refers to the investigation of meteorological and not of ground cover absorption effects, because during the measurements at Alabama all microphones were placed on metal plates. This constraint does not especially affect this analysis and the revised LA algorithm, because it leads to safe results (simulation of acoustical harder grounds).

REVISED INM MODEL APPLICATIONS AT ALABAMA

Based on the above mentioned revised lateral attenuation algorithm, there has been developed a revised INM model, that takes into account real meteorological effects. The results from the application of the revised INM for the aircraft noise prediction at Alabama, compared with the corresponding measured ground noise data, shows infinitesimal small deviations (average deviations of about 0,42 dB(A)). (Fig 1)

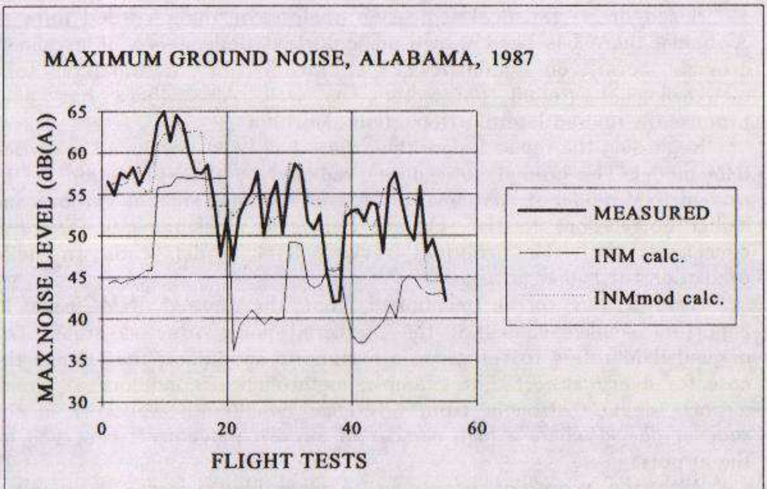

Fig 1: Comparison between ground noise data predicted by the application of the original and the revised INM model, with the relevant measured data at Alabama, 1987.

Also, there has been observed a higher statistical correlation between the noise data predicted by the application of the original INM with the relevant measured data, than the corresponding correlation referring to the noise data predicted by the revised INM model application.

Regarding noise curves and affected areas, it has been observed that the application of the revised INM model leads to important smaller values, compared to the original INM. According to further investigation, there is shown a strong dependence of the noise predicted by the revised INM on the ground meteorological parameters. Especially for reference atmospheric conditions, the resulted values approach the corresponding values predicted by the original INM model[5].

CONCLUSIONS

The INM model and the relevant SAE/AIR 1751 Lateral Attenuation algorithm do not take into account real meteorological conditions. According to the simulation of the Alabama propfan aircraft flight tests, the ground noise predicted by the application of the INM presents big deviations from the relevant measured data.

Based on a statistical regression analysis of the recorded data at Alabama, there has been shown an important dependence of maximum ground noise on geometrical aircraft flight parameters, and meteorological ground parameters, as well. Also, there has been proposed a revised lateral attenuation algorithm.

Regarding the revised algorithm, there has been developed a revised INM model. The ground noise data predicted by the application of the revised INM model at Alabama, present infinitesimal small deviations and higher correlations to the relevant full scale measurements. There is concluded, that the proposed revised INM model leads to noise predictions of higher accuracy.

Also, it has to be mentioned, that the revised INM leads to important smaller values of the predicted noise affected areas. The original INM refers to reference atmospheric conditions, that is not the case for every airport. For example, meterological conditions at Greek airports deviate strongly from reference conditions, especially in the summer period where a high number of aircraft movements is served by the airport.

With the scope of proposing a generalised Lateral Attenuation algorithm and a generalised revised INM model, there have to be made further noise measurements and relevant statistical investigations, regarding the ground noise sensitivity to:

- Various ground cover effects in correlation with meteorological effects.
- Aircraft elevation angles less than 30 deg.

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