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PREDICTION OF THE NOISE POLLUTION CAUSED BY MILITARY AIRCRAFT FLYOVERS

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ABSTRACT
The authors are engaged in the experimental collection of data during military aircraft operations in order to obtain the information required by existing predictive models for aircraft noise (e.g. INM − Integrated Noise Model). First comparisons between predicted and measured values are reported in this paper.

1 - INTRODUCTION

Military aircraft operations in the surroundings of airports may give rise to strong complaints by people living nearby. If possible, the operation should be scheduled and carried out in a way that minimizes the noise impact on inhabited areas. The Italian Air Force is interested in tackling the problem. Therefore CIRA (Italian Aerospace Research Center) has been requested to perform an "ad hoc" study.
Predictive noise models can be useful tools to schedule optimal aircraft operations. The model that is used mostly appears to be INM-Integrated Noise Model [1].
A basic information required by INM is a set of curves (Noise Power Distance) that characterize the noise due to a specific aircraft standard-operation. Therefore CIRA is carrying on experiments to acquire this basic information for the Italian Military air-fleet. Furthermore, INM will be used to predict received noise levels in areas near the airport.
Noise laws, issued recently in Italy, require that aircraft noise pollution be described in terms of a descriptor named L_{VA}. Therefore, special attention has been paid in characterizing aircraft in terms of SEL (Single Event Level). In fact, L_{VA} is an equivalent A-weighted sound pressure level averaged over day-night period. It can be calculated by cumulating the sound energy of a number of SEL's related to the L_{VA} integration time.

$$L_{VA} = 10\log\left[\frac{17}{24}10^{L_{VAd}/10} + \frac{7}{24}10^{L_{VAn}/10}\right] \ \text{(dBA)} \tag{1}$$

$$L_{VAd} = 10\log\left[\frac{1}{T_d}\sum_{i=1}^{N_d}10^{SEL_i/10}\right] \ \text{(dBA)} \tag{2}$$

$$L_{VAn} = 10\log\left[\frac{1}{T_n}\sum_{i=1}^{N_n}10^{SEL_i/10}\right] + 10 \ \text{(dBA)} \tag{3}$$

T_d=61200 s = number of seconds in the day period (06.00 a.m.- 11.00 p.m.), T_n=25200 s = number of seconds in the night period (11.00 p.m.-06.00 a.m.).
Numerous standard flight operations have been observed in order to obtain detailed experimental NPD curves for various aircraft types. INM allows extrapolating NPD curves from data collected at a single

ground location, the aircraft flying at a single altitude over the ground according to SAE-AIR 1845 [2]. In order to verify if a lesser number of observations could yield an acceptable accuracy, detailed NPD curves where compared with those stemming by SAE-AIR 1845 procedure.
This paper presents the first case-study referred to F104.

2 - EXPERIMENTAL DETAILED NPD CURVES

Measurements were carried out at a military airport, at sea level, having one runway (length = 2990 m, width = 30 m). The observation point was located 1120 m ahead the runway along its axis, 3 m above the ground. Calibrated digital recordings were made for overflights at 11 different heights between 400 and 8000 ft, each for 4 thrusts: A) maximum thrust with afterburner (as used for takeoff); B) 100% static thrust; C) 93% static thrust and D) 86% static thrust. Analysis of recordings yielded corresponding SEL values. SEL's were evaluated from $L_{Aeq,1"}$ time histories by considering a time integration defined by a threshold 10 dBA below the maximum. Adjustments were applied to the measured SEL's according to INM to obtain the NPD values. Namely, air impedance adjustment, noise fraction adjustment and airspeed adjustment. Fig. 1 shows the NPD values as obtained by adjusted measurements. Values below 400 ft and above 8000 ft have been extrapolated using the procedure suggested by INM.

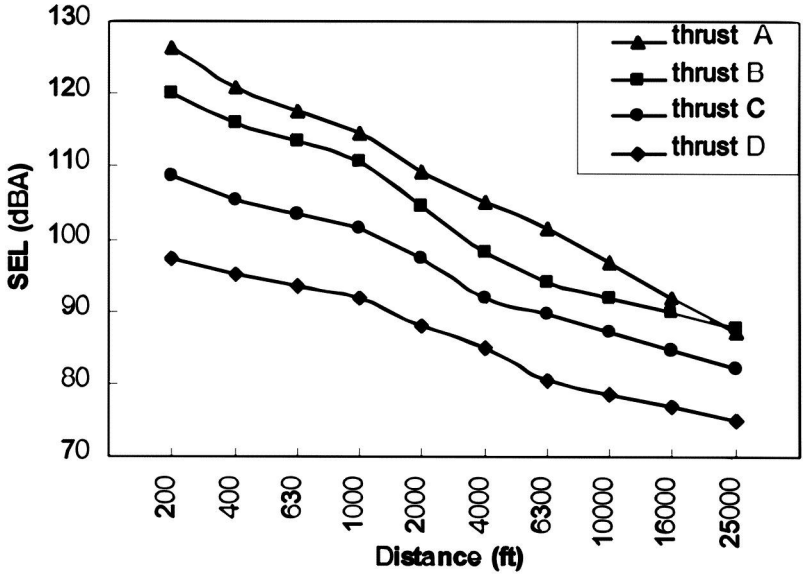

Figure 1: Detailed experimental NPD curves.

3 - COMPARISON OF PREDICTED NOISE LEVELS AND FIELD MEASURED NOISE LEVELS

Data in Fig. 1 was used to predict noise levels at 7 locations around the airport (Fig. 2).
At these locations digital recordings, synchronous with those recorded at the standard point (P21), were available.
The same analysis procedure was used to obtain SEL values at distant points. Fig. 3 shows predicted values versus measured values for all receivers, tested thrusts and heights. It can be noted that the absolute difference is within 2 dBA for the 76% of data and within 3 dBA for the 88% of data.

4 - NPD CURVES EVALUATED WITH SAE-AIR 1845 PROCEDURE

With reference to the experimental data acquired only at the 1000 ft. height, the procedure suggested by SAE was applied. To predict the SEL's values at other heights the procedure requires the knowledge of the 1/3-octave-band A-weighted maximum sound levels measured during the flight at the reference height. NPD curves were calculated for each thrust. Fig. 4 reports the comparison between experimental and calculated according to SAE-AIR NPD curve for the thrust B. A good agreement appears up to 4000 ft height. Similar differences were found for the other thrusts.
In the same 7 locations the values of SEL's were calculated using the INM procedure with the NPD curves evaluated with SAE-AIR. Fig. 5 shows the difference between measured and INM predicted SEL values using both detailed and SAE-AIR 1845 NPD curves at the receiver point P41, that is located at a great distance from the runway (thrust C).

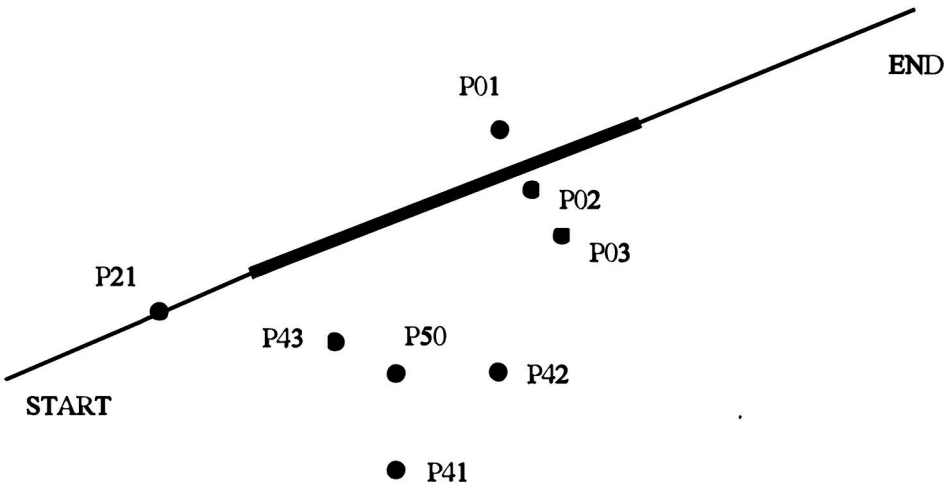

Figure 2: Measurement locations around the airport.

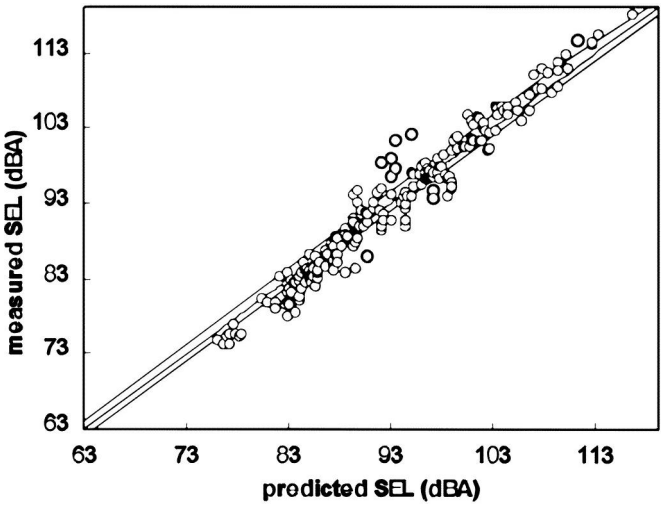

Figure 3: Comparison between predicted and measured noise levels.

An overall comparison between measured SEL's and calculated ones with NPD SAE-extrapolated curves, like that reported in Fig. 3, showed that the absolute difference is within 2 dB only for the 40% of data.

5 - CONCLUSION

First results suggest that better prediction with INM are obtained using measured detailed NPD curves. Further research data will shed more light over the observed discrepancies.

REFERENCES

1. **FAA**, *INM Technical Manual 5.1*, 1997

2. **SAE-AIR 1845**, *Procedure for the calculation of Airplane Noise in the Vicinity of Airports*, 1986

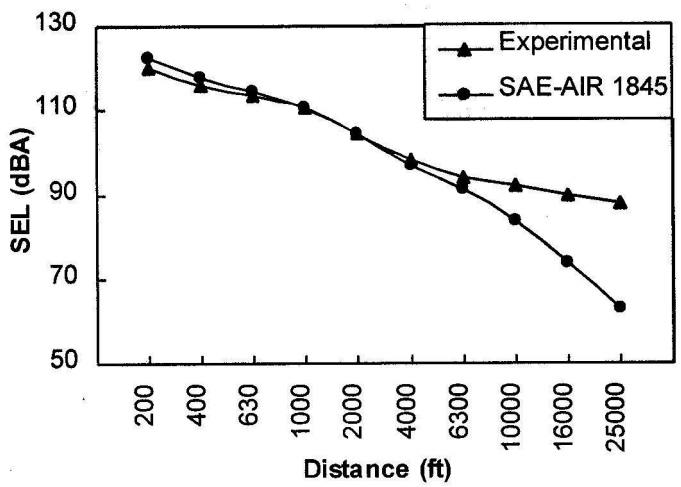

Figure 4: Comparison between experimental and calculated according to SAE-AIR 1845 NPD curve for thrust B.

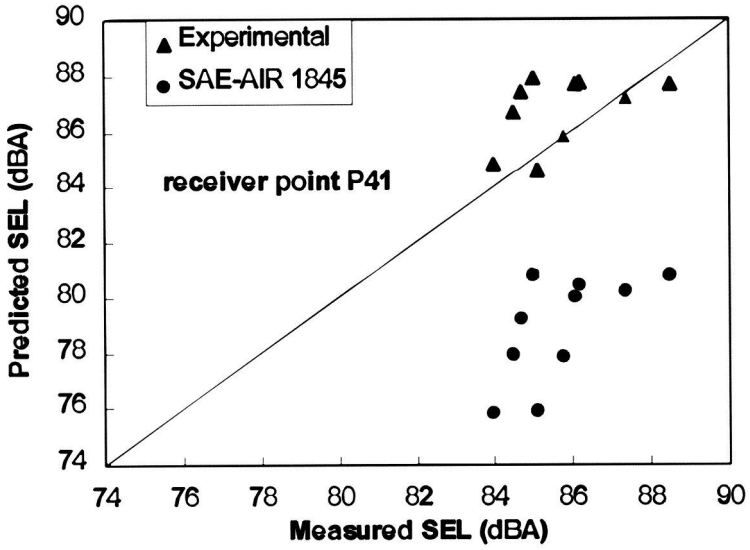

Figure 5: Comparison between measured and INM predicted SEL values at the farthest receiver using detailed and SAE-AIR 1845 NPD curves.