Aircraft noise footprint for Bucharest – Sophia flights

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Abstract: Studies of impact noise have traditionally focused on landing and takeoff procedures in the airports vicinity. Beside these studies, en-route noise is considered an issue when we talk about noise in natural reservation or other populated sensitive areas and when it comes to designing a new aircraft engine. In these cases, the studies are focusing on the impact at ground level of the en route noise produced by aircraft at all the flights stages. This paper presents the results of the measurement performed for an A320 aircraft when flying en-route and the impact map for a flight from Bucharest – Sofia – Bucharest (OTP-SOF-OTP).

Key words: noise, en-route, LMax, noise impact

1. INTRODUCTION

First thing, when we talk about en-route noise is to define the term „en-route”, Garbell being the first to do it [1]. Certification requirements for aircraft noise are related to the final approach of aircraft to an airport and the initial climb-out from the airport. Regulations establish precise points for noise measurements during takeoff and landing. The “en route” term covers all the aircraft operations between the operation from the initial climb to the final approach, i.e. manoeuvres above 3000ft.

A more detailed look at noise emitted by aircrafts in en-route flight, brings out three different flight stages, as shown in figure 1, that have to be treated separately:
- Transition from takeoff climb to cruise;
- Cruising flight;
- Transition from cruise to landing.

Fig.1 Aircraft operation stages

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As it was mentioned at the beginning, the paper presents results obtained for all these three stages of the en-route flight of a short- to medium-range, narrow-body, commercial passenger A-320, and the footprint obtained for a flight from OTP-SOF-OTP.

2. MEASUREMENTS

Locations. As part of the ongoing study, a program of noise measurements in several locations under the major airways was undertaken. First the selection of the measurement location took into consideration general criteria for site selection, as:
- sufficiently flat terrain, without obstructions which significantly influence the sound field within 75° from the vertical through the microphone;
- quiet rural area;
- very low level of background noise from man-made sources.

Apart from these general characteristics especially aircraft en-route noise measurements require specific additional attention with respect to the proper selection of the test sites (underneath major airways with sufficient traffic).

An additional criterion for site selection is the elevation angle (i.e. the angle between the horizontal and the line aircraft-microphone at the closest point of approach to the microphone - above 30° [2]).

Equipment. The measurement system used in the study is the Anotec EMMA system, presented in figure 2. This system is modular and comprises of a variety of subsystems, but for the purpose of the study only the noise (NMS), ground meteo (GMS) and time sync (TSS) subsystems were used. In addition, Anotec IBaTrack system was used for flight trajectory tracking. To reduce any noise from the control position, the microphones were located at around 50-100 meters from the van, using low noise cable type RG59.

![Fig. 2 Schematic overview of the EMMA system](image)

Results. The objective of these measurements was to establish a baseline set of data that would feed the impact model and calculate different noise metrics.

After several measurement campaigns, the central database was filled with aircraft data when en-route, figure 3.
Fig. 3 Example of data recorded in the database

3. NOISE METRICS

According to Jones and Cadoux [3], there are three groups of measurement types of the aircraft noise:

- Single event metrics
- Exposure metrics
- Supplementary metrics.

We are going to focus on single event metrics, which are referring to the noise associated with one and only one event. The single event parameters of most interest are: LAmax, SEL, PNL and EPNL. Where the noise consists of a small number of discrete events, the A-weighted maximum level (LAmax) will be a better indicator of the disturbance to sleep and other activities. It can be used to describe a single aircraft noise event and measure the highest root mean square sound level that occurs during a single event in which sound level varies with time. However, in most cases the A-weighted sound exposure level (SEL) will provide a more consistent measure of such single-noise events, because it is based on an integration over the complete noise event, see figure 4. Basically it represents the sound level, in dBA, of a one second of steady noise that contains the same total A-weighted sound energy as the whole event (the dBA value that would be measured if the entire event energy were uniformly compressed into a reference time of one second).
Metrics that are based on LAmax do not take into account the duration of the noise, and so they are less representative of the disturbance due to the noise event. SEL - the Sound Exposure Level accounts for the duration of the sound as well as its intensity.

PNL (Perceived Noise Level) and its variants are metrics used for aircraft noise certification. Its measurement involves analyses of the frequency spectra of noise events as well as the maximum level. The research performed on human perception of aircraft noise concluded that PNL did not adequately reflect the true noisiness of a complete aircraft event unless it takes into account the effects of both tones and duration. Sounds that exhibit distinct whistles and whines and/or have longer durations proved to be more annoying than simple PNL measures indicate. This leads to the use of the Tone corrected PNL or PNLT. The parameter to include also the duration of the event is EPNL and this is used for setting the international noise standards with respect to certification according to ICAO Annex 16.

In the present study we are going to focus on LAmax because it provides some measure of how intrusive the noise event is; and it is one of the few metrics than people can actually experience and measure.

4. MEASUREMENT RESULTS FOR A-320

During the measurement more than 400 aircrafts were recorded, of which more than 50 are of the aircraft model A-320. Hereafter, the results are presented, obtained for three aircrafts, flying in different phases, covering all of the en-route flight stages, see figure 6, 7 and 8.

During data analysis only events within a +/- 60º cone above the microphone (i.e. elevation angles > 30º, see figure 5) were considered valid. For an easy visualization of criterion, in the following figure the cone is presented: acceptable part is given in green, whilst the invalid part is in red.

![Fig. 5 Elevation angle](image)

All the time references for the following graphs are expressed in seconds after midnight (s am).

**Transition from takeoff climb to cruise**

![Fig. 6 A320 in Transition from takeoff climb to cruise](image)
5. NOISE IMPACT FOR A-320 AIRCRAFT

A-320 data for the noise impact map was taken from the database and a simplified noise impact model, developed by Anotec in the EU project NINHA [4], was applied for the two flights considered (see figure 9).

The following two flight profiles (figure 10 and 11) were used in the noise impact model.
It can be seen that during flight, the aircraft do not have a major impact (see figure 12). During Transition from takeoff climb to cruise and Transition from cruise to landing phases, we obtained values of about 50dBA and for cruise phase 40-45dB, values that are not far from in-situ measurements.
6. CONCLUSIONS

The present study shows that it is possible to obtain the noise levels for aircraft when en-route, both by measurement and by modelling. The en-route noise levels obtained are quite low and are usually similar or lower than the background noise existing in most places. Only in very quiet areas en-route noise of current aircraft types will be really audible, although most likely not annoying.

The experience from the measurements tells us that the same aircraft may produce different values in noise, which vary significantly from the average values for a large number of reasons, mainly related to the atmospheric conditions and their effect on the sound propagation: aircraft weight, temperature, wind speed and direction, precipitation, ground conditions, etc. These factors should be taken into consideration to minimise the uncertainties of the model.

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8. REFERENCES