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, LAmax, 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.

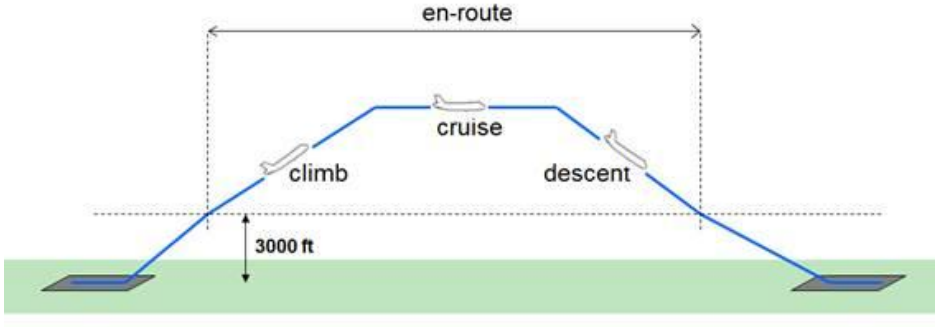

Fig.1 Aircraft operation stages

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 foot print 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 75^0 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 30^0 [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.

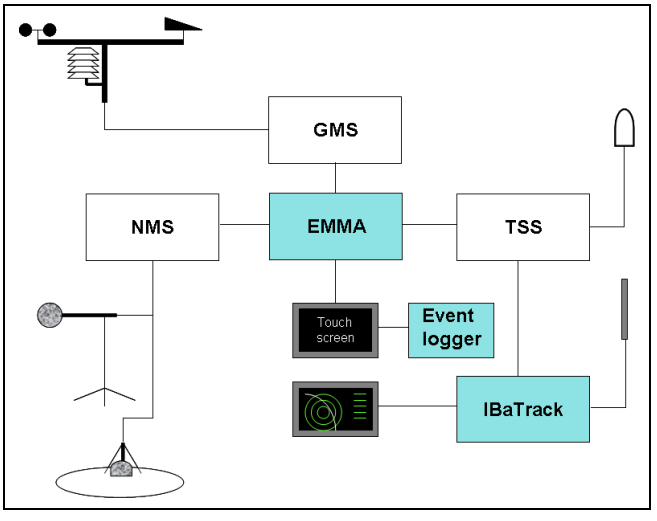

Fig. 2 Schematic overview of the EMMA system

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.

modes	callsign	sign	manufa...	model	phase	cpa_t	cpa_lat	cpa_lon		elev_an
0100E5	MSC4639	SU-BPV	AIRBUS	A-320	CRUISE	53603....	46.04768	24.60328		43.9069
0100E6	MSC4635	SU-BPW	AIRBUS	A-320	CRUISE	38035.933	46.04745...	24.60367		42.2146
06A013	QTR6056	A7-ABY	AIRBUS	A-300B4-...	DESCENT	60645.674	46.148595	24.7525		59.2304
06A019	QTR028	A7-ACB	AIRBUS	A-330-200	CRUISE	54106.301	46.19476	24.802425		44.0903
06A031	QTR018	A7-AEA	AIRBUS	A-330-300	CRUISE	46113.358	46.10847	24.70812		88.2937
06A045	QTR008	A7-AGC	AIRBUS	A-340-600	CRUISE	59905.58	46.187825	24.80665		43.5095
06A047	QTR042	A7-ACI	AIRBUS	A-330-200	CRUISE	54562.757	46.06418	24.66877		61.9445
3C09F4	GMI1195	-	-	-	DESCENT	58225.895	46.04761	24.6045		45.7308
3C5CA5	GMI2308	D-AGEE	BOEING	737-300	DESCENT	63260.033	46.190365	24.808815		41.057
3C5CB1	GMI2894	D-AGEQ	BOEING	737-700	CRUISE	61982.156	46.18685	24.804445		45.5776
3C6DCF	GWI8E	D-AKNO	AIRBUS	A-319	CLIMB	47438.263	46.192615	24.806525		40.8328
40058C	BAW73	G-ZZZC	BOEING	777-200	CRUISE	50814.718	46.204765	24.78261		42.2057
4400F7	AUA608	OE-LVE	FOKKER	100	CRUISE	62481.844	46.08804...	24.70291...		75.6644
440BB8	AUA839R	OE-LAX	BOEING	767-300	CRUISE	64009.581	46.194165	24.802275		41.0796
45AA81	JTG344	OY-JTA	BOEING	737-300	CRUISE	53051.534	46.04807	24.609505		44.9935
45AA82	JTG562	OY-JTB	BOEING	737-300	CRUISE	44536.48	46.03848...	24.58768	...	38.3935
45B645	CIM5408	OY-MRE	BOEING	737-700	CRUISE	49754.594	46.04783	24.60267	...	45.4662
45D964	VKG718	OY-VKD	AIRBUS	A-321	CRUISE	54526.706	46.047715	24.602705	...	42.1304

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).

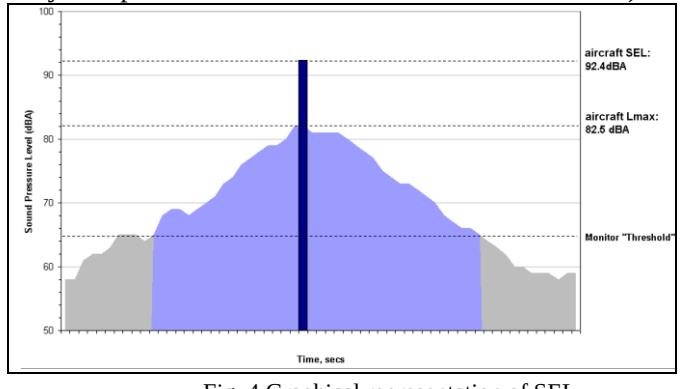

Fig. 4 Graphical representation of SEL

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.

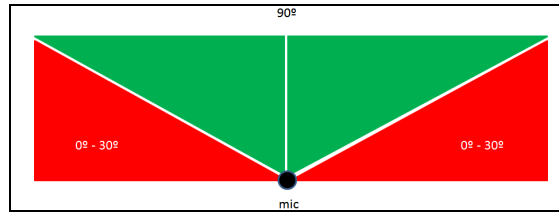

Fig. 5 Elevation angle

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

Transition from takeoff climb to cruise

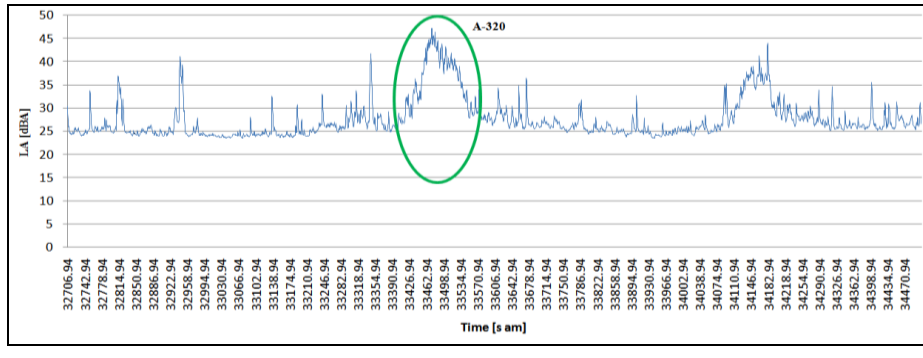

Fig. 6 A320 in Transition from takeoff climb to cruise

Cruising Flight

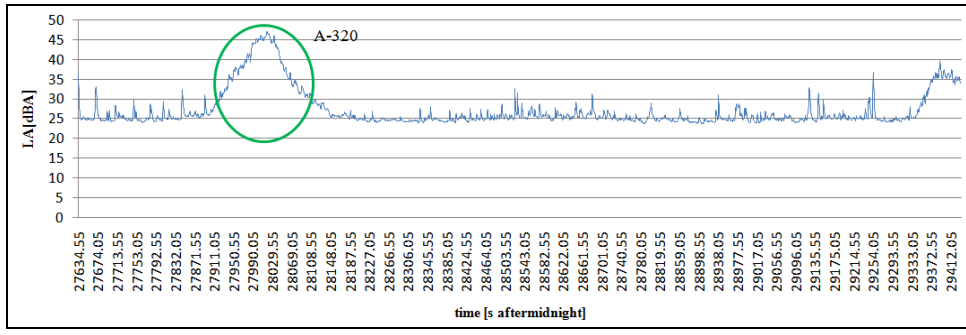

Fig. 7 A320 in Cruising Flight

Transition from Cruise to Landing

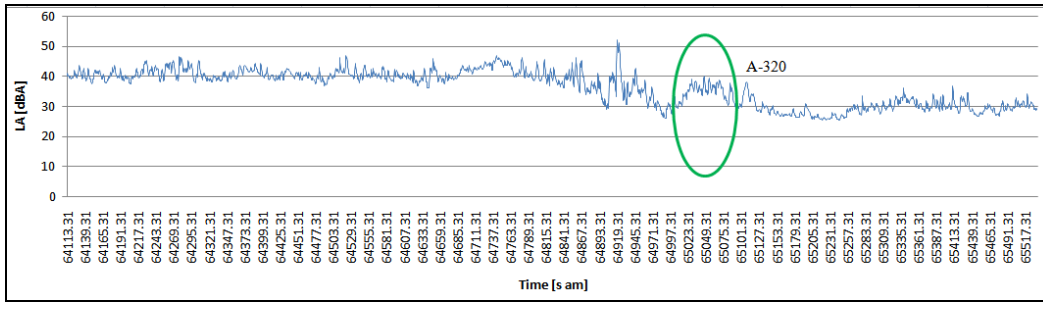

Fig. 8 Impact model for OTP-SOF-OTP flights

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).

Fig. 9 Google Earth visualization of the flights of interest

The following two flight profiles (figure 10 and 11) were used in the noise impact model.

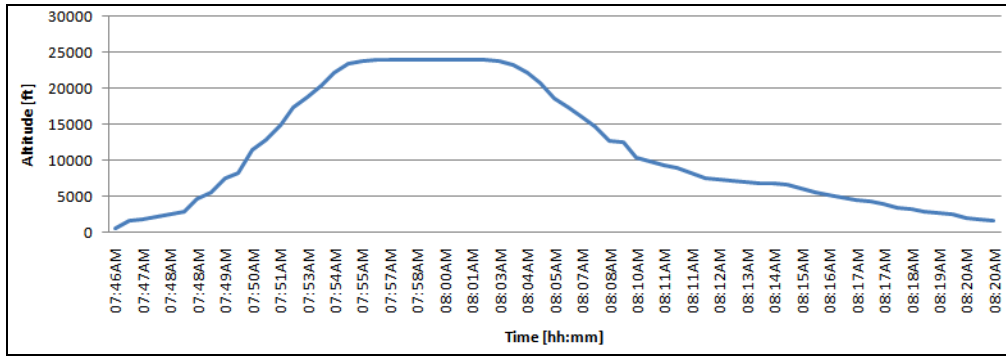

Fig. 10 QTR943 flight profile for OTP-SOF route

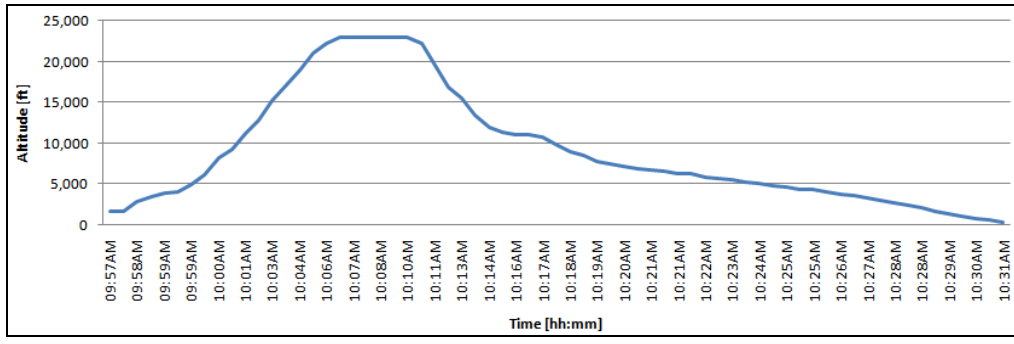

Fig. 11 QTR944 flight profile for SOF-OTP route

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.

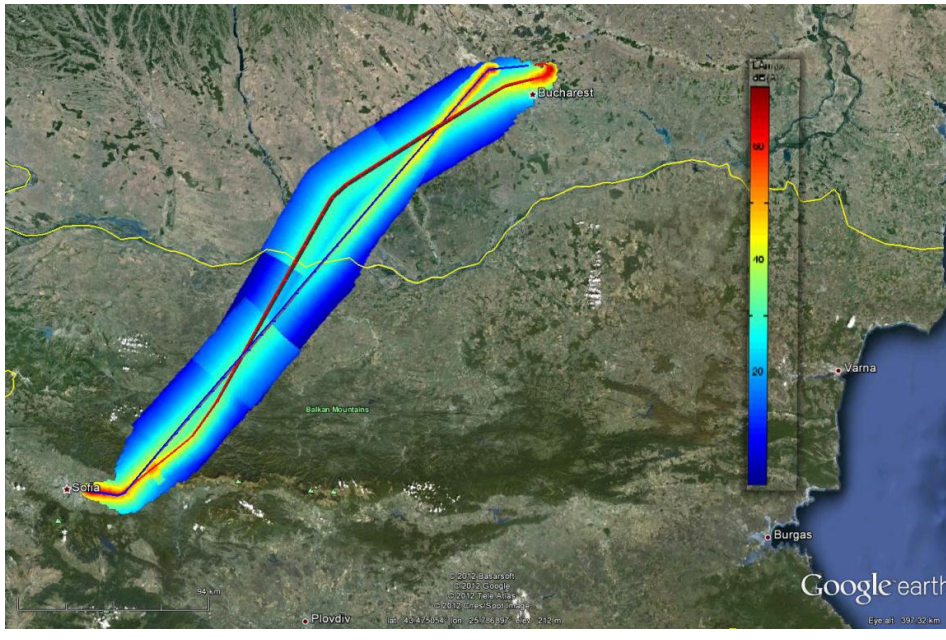

Fig. 12 Noise impact model for a A320 aircraft flight on Bucharest – Sofia-Bucharest route

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.

7. AKNOWLEDGEMENT

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8. REFERENCES

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