Chapter 11
Peculiarities of Pre-processing of ADS-B Data for Aircraft Noise Modeling and Measurement During Specific Stages of LTO Cycle

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Nomenclature

ADS-B	Automatic Dependent Surveillance-Broadcast
AIP	Aeronautical Information Performance
GPS	Global Positioning System
ICAO	International Civil Aviation Organization
LTO	Landing and Taking-Off
MP	Measurement Point
SEL	Sound Exposure Level

11.1 Introduction

Measuring aircraft noise and noise monitoring in the vicinity of an airport to achieve the main goal – reducing the population affected by noise and improving the quality of life – requires a relevant organization of field acoustic research. According to ISO 20906 for successful processing of monitoring data, in addition to long-term measurements, the selection of the sound event associated with aircraft is necessary, as well as its classification and identification (ISO/CD 20906, 2009).

Under the Directive 49/2002 (Directive 2002/49), the task of noise zoning should be fulfilled based on noise index – Lden. This criterion belongs to the group of the equivalent sound levels that could be applied for zoning purposes; however, there are some countries in the European region where maximum noise level is defined by legislative limits (for example, Ukraine has both types of limits – equivalent (LAeq) and maximum (LAmax) sound levels). In the current circumstances, noise contours LAmax occupy a larger area than noise contours LAeq (Table 11.1), and thus,

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Table 11.1 Ranges of boundaries of noise restricted zones on the basis of criteria: LAmaxN = 70 dBA and LAeqN = 50 dBA

Airport	LAmaxN = 70 dBA km^2	LAeqN = 50 dBA, km^2
Boryspil' (UKBB)	326.1	94.1
Dnipro (UKDD)	59.3	14.8
Antonov-2 (UKKM)	450.4	37.8
Mylolaiv (UKON)	120.1	11.1
Odesa (UKOO)	71.2	15.1
L'viv (UKLL)	63.3	11.9

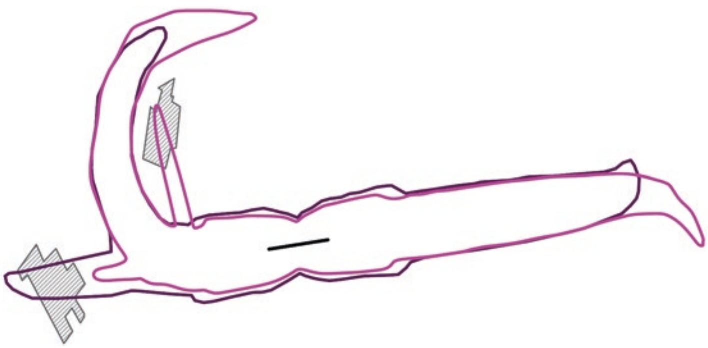

Fig. 11.1 Two approaches to noise zoning on the basis of LAmax: purple – AIP as a sources of track information; magenta – averaged ADS-B tracks and flight data: grey – residential areas

defines boundaries of noise restricted zones. The form and size of noise protection zones (defined on the maximum sound level LAmax) are very sensitive to real track dispersion, flight altitude, and total assessment of the operation scenarios (Fig. 11.1).

To clarify the results of aviation noise modeling at the airport and to explain the possible gaps between measured and modeled results, open track data based on the results of ADS-B surveillance were analyzed (particularly, the results are presented on the FlightRadar24 and OpenSky websites).

According to ADS-B surveillance technology, aircraft determines its position using satellite, inertial, and radio navigation systems, and transmits it (approximately 1 sample per 1 second) periodically with other relevant parameters to ground stations and other equipped aircraft. The signals are transmitted at a frequency of 1090 MHz. The receiver's ADS-B antenna is capable of receiving messages from aircraft up to 400 km away. However, for aircraft at lower altitudes, the range may be significantly limited, especially for aircraft that are on the ground, or in the stages immediately before landing or in the initial stages of takeoff (Schultz et al. 2020).

The possibility of using pre-processed FlightRadar24 data, particularly for the purpose of modeling aviation noise generated at different stages of LTO cycle was analyzed for test case at different airports in Ukraine: ground stage (UKBB, UKKK), departure (UKKM), and arrival (UKKM, UKKK).

11.2 Analysis of Track Data in Terms of Noise Event Reconstruction

The importance of taxiing noise modeling, as indicated in many studies (Page et al. 2009, 2013; Zaporozhets and Levchenko 2021) is not always the same. For some of airports because of the specific aerodrome layout, infrastructure, and much quieter aircraft in operation due to the ICAO Balanced Approach influence on acoustic performances of new aircraft designs taxiing of the aircraft may contribute essentially on noise footprints (Zaporozhets and Levchenko 2021). The usage of aircraft real trajectories along the apron and taxiways before and after takeoff/landing, engine mounting height, and engine operating mode should be considered during noise modeling and measuring for airports such as Kyiv/Juliany Airport (UKKK), Kharkiv Airport (UKHH), and Zaporizhzhia Airport (UKDE) located near residential areas, or in the center of city directly and on closer distances from the apron and taxiways to multi-storey buildings from the runway (UKKK).

Paths tracked by individual receivers or generated by aggregators (FR24) receiving information from many receivers all at the same time, require pre-processing of data to avoid the false data. The study of such erroneous data can be useful in improving the monitoring system or correcting the location of receivers.

11.2.1 Taxiing

Information on the movement of aircraft on the ground is the easiest to process, as it is transmitted in the form of individual messages MSG 2 and they are easy to separate from the general flow of flight data. At the preliminary stage, it is necessary to exclude trajectories from the general stream with (Schultz et al. 2020): messages formed in the absence of GPS data; insufficient number of signals, which leads to missed points and false trajectories, which is most evident in the ground stages due to mismatch with the geometric dimensions of the runway, taxiways, and platforms (Fig. 11.2).

Such changes in tracks based on the ADS-B data are usually connected (Page et al. 2009) with a lack of reception in the signal, for example, breaks in continuously transmission of a signal due radio interruptions. The location of the receivers is the other important factor. Aprons often are not in the zone or the reception. For example, according to the FR24 data for the UKKK aerodrome, there are a number of receivers operated in a stable mode (more than 97% of total working time). However, mutual influence of factors such as location of receiver, relief features, and large distance from the runway to aprons (over 1 km) leads to the low data quality during taxiing (Fig. 11.2).

Three possible locations of receivers were analyzed in the current research (Fig. 11.3). The best efficiency in terms of assessment of environmental factors (noise, air pollution) for ground stages of aircraft movement was defined at the

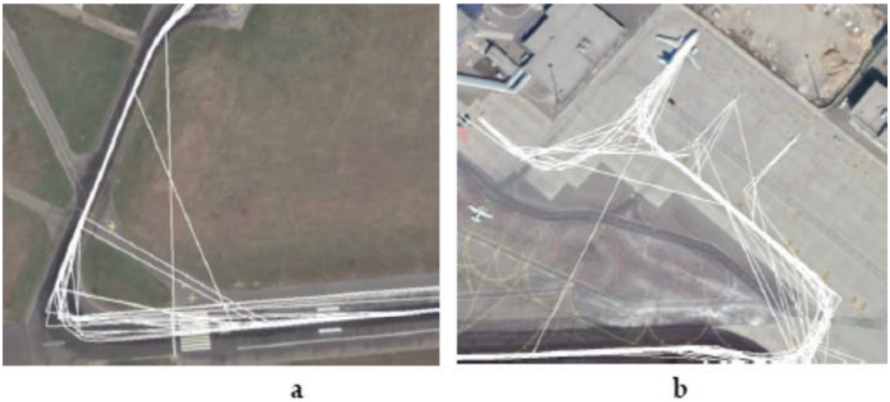

Fig. 11.2 Examples of distortion of the aircraft trajectory during ground operation: aircraft taxiing from the runway (**a**); movement on the apron (**b**); UKKK, October–November 2021

Fig. 11.3 Location of additional receivers A1-A3 (**a**) and track (yellow) correspondence to runway and taxiways geometry (A2) (**b**)

airfield or very close to the outer perimeter of the aerodrome (Fig. 11.3a) – for example, point A2. The main recommendation for selection of final location of the receiver for tracking of ground operation is providing line of sight with moving aircraft from the moment of start of runway operation to final location at apron.

11.2.2 Arrival Tracks

Measured arrival altitudes tend to be close to the modeled altitudes at the shorter track distances, higher than the modeled altitudes at the middle distances, and lower than modeled at the furthest track distances (Page et al. 2009). For the descent and approach stages, the track dispersion is significantly lower: the deviation does not exceed 200 m at a distance of 6 km (Fig. 11.4) for the same flight (October–November 2021).

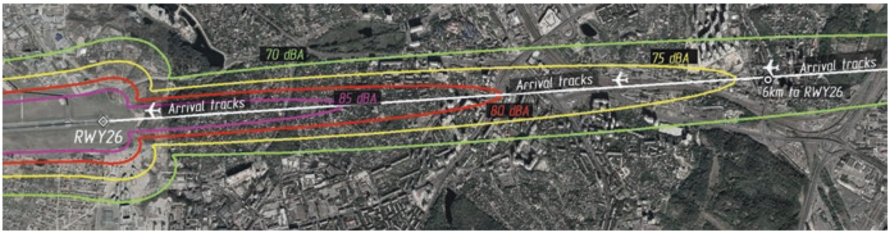

Fig. 11.4 Track dispersion (white lines) during descent and arrival procedures, typical for city airport; 70–85 dBA are LAmax noise levels

Very different picture can be observed for manufacturing airport UKMM: test flight data compared with AIP recommendation are significantly different. Such differences, considering the very rare flight events, lead to the significant gap in modeled and measured results only because of dispersion of ground track trajectories.

Additionally, the altitude dispersion should be included into noise calculations.

11.2.3 Departure Tracks

The horizontal dispersion of takeoff tracks for the same flight performed on A320 aircraft during October 2021 for the runway end 26 is shown in Fig. 11.5. As shown, such a dispersion of tracks can affect the acoustic situation in the vicinity of aerodrome, changing the shape of the contours of equal noise, determining the boundaries of the noise restricted zones for the residential development.

Thus, an important task for the takeoff phase is to consider the actual flight trajectories when modeling noise contours and substantiating the boundaries of residential restriction zones, as well as comparing the LAmax sound levels obtained as a result of modeling and measurements.

11.3 Results and Discussion

The complex measurements of aircraft noise in addition to ADS-B data recording were performed in the vicinity of airports (UKMM, UKKK). The results have shown that calculated altitude of flight is higher than standard altitude at noise models (INM, AEDT) because of shifted moment of runway touching in comparison with AIP data about displaced thresholds. This causes the changes in NDP-dependencies. The results of the altitude and thrust correction are presented in Table 11.2.

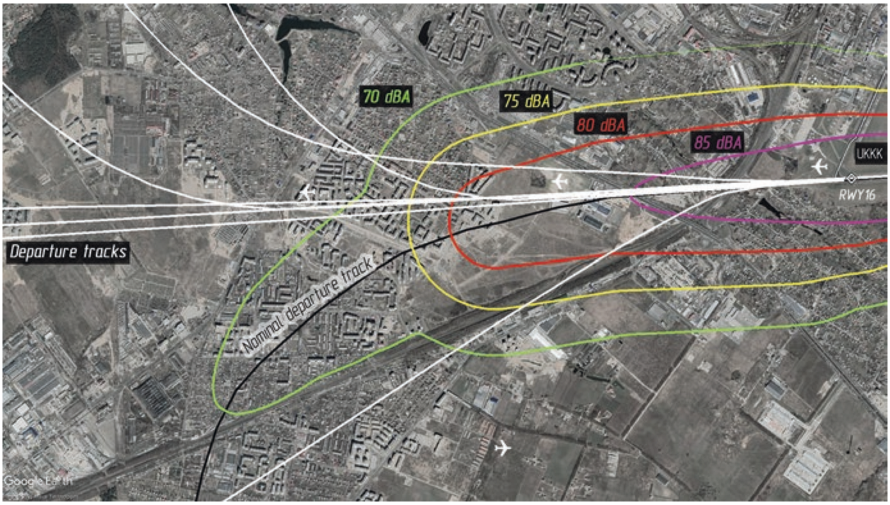

Fig. 11.5 Dispersion of takeoff tracks for the same flight and its impact on the form of noise contours LAmax = 70…85 dBA; A320, October 2021

Table 11.2 Comparison of measured and modeled data on example of A321

Point	Model led data	Measured data	Difference	Correction	Difference (corr)
LAmax, dBA					
MP2	89.4	95.2	−5.8	91.8	−3.4
MP3	84.2	88.01	−3.81	85.6	−2.41
SEL, dBA					
MP2	94.4	96.7	−2.3	95.1	−1.6
MP3	91.1	90.91	0.19	90.9	−0.01

11.4 Conclusion

Noise contours simulating along nominal routes and standard takeoff/landing profiles embedded in modern noise modeling systems (AEDT, INM, IsoBella), in comparison with noise contours along the trajectories of aircraft traffic, obtained from the results of ADS-B observations can significantly differ in area and shape: both close to the aerodrome (for levels LAmax = 85 dBA), and for large distances from the ends of the runway (for levels LAmax = 60–65 dBA).

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