Journal of KONBiN 2022
Volume 52, Issue 2
DOI 10.2478/jok-2022-0012

Grzegorz PERUŃ
*Silesian University of Technology (Politechnika Śląska)*

# ASSESSMENT OF THE IMPACT OF FLIGHT OPERATIONS ON NOISE IN THE VICINITY OF AN AIRPORT – PRELIMINARY STUDY

## Ocena wpływu realizacji operacji lotniczych na hałas w otoczeniu lotniska – badania wstępne

***Abstract:*** *The paper presents assumptions and selected results of research aimed at determining the impact of flight operations on noise in the neighborhood of a selected airport. The presented results have a preliminary character, in view of the form of research realization - it took place within the research team established in the Student Research Group "Zębatka" within the program Excellence Initiative - Research University. Researching the nuisance of aircraft noise is an important phenomenon and regulated by law. The study was preceded by an analysis of the literature, especially standards and legal acts, to determine the acceptable levels of noise near airports. Obtained measurements were analyzed using methods of processing acoustic signals to determine whether the activity of the airport does not cause exceeded appropriate standards in the study area.*
**Keywords:** airport, flight operations, noise, environmental impact

***Streszczenie:*** *W pracy zostały zaprezentowane założenia oraz wybrane wyniki badań mających na celu określenie wpływu realizacji operacji lotniczych na hałas w otoczeniu wybranego lotniska. Zaprezentowane wyniki mają charakter wstępny, co wynika z formy realizacji badań – odbywały się one w ramach zespołu badawczego powołanego w Studenckim Kole Naukowym „Zębatka" w ramach programu Inicjatywa Doskonałości – Uczelnia Badawcza. Prowadzenie badań uciążliwości hałasu lotniczego jest zjawiskiem ważnym i uregulowanym prawnie. Badania zostały poprzedzone analizą literatury, przede wszystkim norm i aktów prawnych, pod kątem określenia dopuszczalnych poziomów hałasu w pobliżu lotnisk. Otrzymane wyniki pomiarów analizowano z użyciem metod przetwarzania sygnałów akustycznych celem określenia, czy działalność lotniska nie powoduje na badanym obszarze przekroczenia właściwych norm.*
**Słowa kluczowe:** lotnisko, operacje lotnicze, hałas, wpływ na środowisko

# 1. Introduction

Noise is often defined as the sound of any acoustic nature that is undesirable under given conditions and by a given person. Sound, in turn, is defined as a change in pressure experienced by the human ear. It can cause adverse effects on humans, including permanent effects. A distinction is made between annoying and harmful noise, the difference being whether the effects on the human body is permanent or temporary.

The adverse effects of noise depend on many factors and how noise is perceived by humans, including sound intensity (sound pressure level), exposure time, sound frequency, but also on the personal circumstances of each individual, such as the attitude of the person exposed to the noise and state of health.

Negative effects of noise can already occur at as little as 35 dB and cause a feeling of fatigue. Typically, noise above 70 dB has a harmful effect, and noise above 85 dB can lead to hearing impairment or damage. Permanent damage is caused by noise levels of 130 dB and higher. Table 1 shows examples of noise intensity values generated by different means of transport in comparison with other noise sources [2, 3].

**Table 1**

**Noise intensity of different means of transport compared to other sources**

| Noise source | Sound level [dB] | Noise source | Sound level [dB] |
|---|---|---|---|
| Motorcycle | 75-90 | Aircraft | 80-130 |
| Passenger car | 65-75 | Jet aircraft | 100-140 |
| Lorry | 80-95 | Space rocket | 170-180 |
| Tramway | 60-75 | Quiet street | 60-70 |
| Bus station | 75-85 | Busy street | 70-90 |

Aircraft noise has its specificity; one of such characteristic factors is the area of influence. The enterprise Porty Lotnicze [4] is obliged to take continuous measurements of noise in the environment. This is regulated by the Act of 27 April 2001, the Environmental Protection Law (Prawo ochrony środowiska) [5]. For example, noise monitoring of Chopin Airport in Warsaw is done at 10 different measurement points, and the results of these measurements are presented monthly to the Chief Inspector of Environmental Protection in Warsaw and the Marshal of Mazowieckie Voivodeship. They are also available on the Internet at lotnisko-chopina.pl/pl/monitoring-halasu.html.

Suppose the subject of the study is the general environment and noise from roads, tramways, or railroads. In that case, the reference document is the Regulation of the Minister of Environment from 16 June 2011 on the requirements for conducting measurements of the levels of substances or energy in the environment by the manager of a road, railroad, tramway, airport or port - Dz. U. 2011, No. 140, item 824, as amended, and more specifically Attachment No. 3 of this regulation. Noise from airports is the subject of Attachments 1 and 2 of this regulation.

According to the above document and its attachments, continuous measurements of energy levels in the environment are conducted to determine the values of noise levels in the environment expressed by the indicators $L_{Aeq\,D}$, $L_{Aeq\,N}$, $L_{DWN}$ i $L_N$ in connection with the operation of:

- airports with more than 50 000 combined take-offs, landings, and transits per calendar year, regardless of the airport location,
- airports with more than 10 000 combined take-offs, landings, and overflights per calendar year, regardless of the airport location, situated in agglomerations or with arrival and departure routes over agglomeration areas [1].

Periodic measurements are conducted at airports with more than 5 thousand take-offs, landings, and flights per calendar year, regardless of the airport location [1].

Attachments of the document [1] precisely define the reference methodology of continuous (Attachment 1) and periodical (Attachment 2) measurements of noise levels introduced into the environment by aircraft take-offs, landings, and overflights as well as the criteria for the selection of measurement points.

Since the idea of the program, within which the research described in this paper took place, was to activate students to scientific research conducted at the Silesian University of Technology, the actual research had to be preceded by a theoretical and practical introduction to the implementation of the research process. A significant difficulty encountered was also the epidemiological restrictions in the period for which the program was planned, making it impossible to extend the study to a larger number of airports, and repeat it in other periods. Time constraints also prevented many project participants from becoming thoroughly familiar with the methods of signal processing and analysis of the acquired data. For these reasons, the results presented in this article should be treated as the results of preliminary research, which should be continued due to their importance, and changing conditions of airport operations. A few months after the end of the program, significant differences in the number of flight operations are visible; the aviation industry is striving to return to its pre-pandemic state. The apparent change in the impact of each airport on its surrounding neighbourhoods is also linked to this, making the study results no longer valid to some extent.

## 2. Purpose and stages of research

The main objective of the project, carried out under the Excellence Initiative - Research University program by the Student Research Group "Zębatka" was to determine the impact of the implementation of air operations at a selected airport on the noise in the vicinity of the airport. As indicated in the introduction, noise is a factor that has a detrimental effect on people's comfort of life and health, all the more so its measurements in the vicinity of places of particular intensity gain importance.

The following stages of project implementation were assumed:

- preparation stage - selection of the airports for the actual study, determination of measurement point locations in the areas adjacent to the airport, selection of research period;
- measurement stage- execution of measurements according to the guidelines of the preparation stage;
- analysis & conclusion stage - archiving of measurement data and their preliminary verification, preparing measurement data sheets, conducting analysis of data acquired from sound level meters, and formulating conclusions.

In addition to the main, master goal of the project, several other smaller goals, usually of a purely educational nature, were set. One of such intermediate goals was to learn how to use the measurement equipment and assess the correctness of the measurements. From the methodological point of view, carrying out the research required acquiring the ability to plan the research process and acquiring knowledge that would allow one to conduct analyses of the recorded data, and to formulate conclusions.

As part of the first stage - the preparatory stage, an analysis of literature was carried out, primarily standards and legislation, to determine permissible noise levels in the vicinity of airports.

In the second stage - proper measurements were conducted at selected airports and their vicinities (depending on availability). Noise level measurements were conducted during operations at measurement points determined in the first stage.

The third stage was after each measurement day to allow for a rough verification of the results obtained and to determine the causes of any errors and how to eliminate them during the following tests. Due to the limited number of tests carried out using measurement microphones connected to the data acquisition card, it was not necessary to use advanced computing environments to analyse the obtained results.

# 3. Selection of measurement point locations

Due to the ongoing pandemic, traffic was restricted both at ATZ (Aerodrome Traffic Zone) and CTR (Control Zone) but at different times and in a different degree. At the initial stage of research planning, measurements were taken at: airport of Rybnik Coal District Aeroclub (Rybnik-Gotartowice), Gliwice aeroclub airport (Gliwice-Trynek), Katowice-Muchowiec airport, International Airport Katowice-Pyrzowice – fig. 1, International Airport Kraków-Balice. The availability of flight plan data was also considered when planning the study. However, this information was relatively readily available for each of the airports listed above. The flight plan information made it possible to determine the time scope of the measurements.

Trial tests, aimed both at practical learning of measurements and verification of theoretical assumptions, were carried out at Gliwice airport, on the area of Gliwice aeroclub. Measuring points were selected to be in the vicinity of the runway. The main object of research was International Airport Katowice-Pyrzowice and the presented results that come from measurements at this airport.


**Fig. 1.** International Airport Katowice-Pyrzowice, two main points of measurement are marked on the map [source of the map: OpenStreetMap]

The Katowice-Pyrzowice International Airport is located 24 km north of the capital of Silesian Voivodship. Operations at the airport are conducted around-the-clock; however, their number at night is smaller. Surveys were carried out at International Airport Katowice-Pyrzowice in the locality of spotters - places close to the runway threshold in the 09 direction from Ożarowice and 27 from Mierzęcice or Siewierz. These points are marked in fig. 1.

As a consequence of this decision, due to the lack of access to infrastructure that would allow for powering the measurement set, the possibility of carrying out measurements using acquisition cards connected to measurement microphones was limited.

Measurements, the results of which were used for further analyses, were carried out on selected days of the week in several locations near the airport. The number of flight operations during many hours of observation enabled us to obtain numerous results for this airport, and for different aircraft types. Various aircraft types were operated at this airport during the study, ranging from Boeing 738 and Airbus A320 to more lightweight structures, resulting in significantly different environmental impacts.

The criteria for locating accurate measurement points are defined in the regulation [1] and should take into account the purpose of the measurement, the characteristics and location of the noise sources, absorbing and reflecting properties of the terrain, and the land use. Due to the fact that not all requirements could be met at the research stage conducted so far, it is considered that the results obtained are indicative.

The height of measuring points is also strictly determined by the appropriate regulation [1]. It is determined, among others, depending on whether the measurement is carried out in a developed or undeveloped area. In an undeveloped area, measurement points should be located at the height of 4 m ± 0.2 m, which can be considered fulfilled during the research.

# 4. Research method

Noise measurements can be made using relatively simple devices such as sonometers and measurement microphones connected to data acquisition cards and measurement computers. The second solution provides a wider range of analyses based on the recorded measurements.

During the described studies, mainly Sonopan and Brüel/Kjær sound level meters were used. On selected dates and locations of the research, the measurement microphone connected to the data acquisition card and measurement computer was also used. Using a data acquisition card required access to the mains power supply, which significantly limited the number of measurements performed in this configuration, especially those carried out in the vicinity of International Airport Katowice-Pyrzowice. Therefore, this paper presents only the results of measurements carried out using the sound level meters, mainly Sonopan DSA-50 class 1 accuracy meters (meeting the requirement [1]), which were used each time, in all locations and at all times of measurements.

According to Annexes 1 and 2 to the Regulation [1], measurements of energy levels in the environment shall be carried out to determine the values of noise levels in the environment, expressed by the following indices $L_{Aeq\,D}$, $L_{Aeq\,N}$, $L_{DWN}$ and $L_N$.

$L_{Aeq}$ t is the A-weighted equivalent sound level expressed in dB for the daytime, respectively ($L_{Aeq\,D}$) – 06:00 - 22:00 hours as well as night ($L_{Aeq\,N}$) – 22:00 – 06:00 hours. $L_{DWN}$ and $L_N$ are determined with continuous measurements. By $L_{DWN}$ shall mean the A-weighted long-term average sound level expressed in dB, determined over all the days of the year, including the daytime (06:00 - 18:00), the evening (18:00 - 22:00) and the night-time (22:00 - 06:00). $L_N$ is, in turn, the long-term average sound level A, expressed in dB, determined during all the night periods of the year (22:00 - 06:00).

According to [1], the used sound analyzers Sonopan DSA-50, which can function as a sound level meter and octave or 1/3 octave analyzer, are perfectly suitable for performing periodic measurements. During the measurements, the configuration of the sound level meter with the registration of a set of parameters and the noise monitoring mode was used, i.e. history recording with the smallest available step – a period of 1 second of six selected parameters. According to [1], the registration in the meter's memory of the time series of sound level changes should take place with the sampling step not greater than 1 [s], which was fulfilled. In the history recording mode, the measurement time was from several to several dozen seconds, depending on the duration of airport operations, and included one such operation each time.

All measurements were preceded by the calibration of instruments with the use of a KA-50 calibrator. This meets another requirement of the document [1]. All of the instruments that were used had valid calibration certificate, which results from the fact that calibration must be done every 2 years [1].

The measurement range of 55 ÷ 135 dB and A/C correction characteristics was assumed. Archiving of the results and their further processing was done after copying the data from the instruments to the measuring computer.

Due to the existing possibilities, not only the values of measurements with time constant of fast meter - the requirement [1], but also the values obtained with slow time constant and impulse - for measurements in sound level meter configuration were recorded. In the history recording mode, only the regulation-compliant fast time constant was used. Regardless of the configuration, measurements were always made with the correction characteristic A and, as mentioned above, also with the correction characteristic C. In accordance with the requirements, wind shields attached to measuring microphones were used (again, except for one of the meters, whose indications were treated as auxiliary, and measurements made with it had an educational character).

Meteorological conditions during the measurements met the requirements of the regulation [1]. The exceptions are selected measurements performed on 16 September 2021, due to changeable weather conditions in the morning hours and precipitation accompanied by stronger wind. These were carried out (again for educational purposes), but appropriately marked in the measurement sheets as unreliable.

Permissible noise levels during take-offs, landings and flights of aircraft are defined in the Regulation of the Minister of Environment of 14 June 2007 on permissible noise levels in the environment (Dz. U. 2007 No. 120, item 826):

- for the protective zone "A" of the health resort, areas of hospitals, nursing homes, and areas of housing connected with a permanent or temporary stay of children and youth: $L_{Aeq\,D}$ = 55 dB, $L_{Aeq\,N}$ = 45 dB;
- for single- and multi-family residential areas, as well as farmsteads and collective housing, recreation and leisure areas, residential and service areas, and areas in the inner zone of cities with a population over 100,000: $L_{Aeq\,D}$ = 60 dB, $L_{Aeq\,N}$ = 50 dB.

# 5. Research results

The sample results presented below are from measurements taken on 14 and 16 September 2021, between approximately 07:00 a.m. and 3:00 p.m. Among several measurement points, results are presented from locations near spotters (as signalled in section 3 and shown in figs. 1 and 2), near the threshold of the belt toward direction 09 and 27.

Table 2 presents a list of major departures on the presented measurement days (according to data from the official website of International Airport Katowice-Pyrzowice and Flightradar service). These data represent the planned operation times.

Table 3 presents a list of major arrivals on the presented measurement days. As before, these data represent the planned operation times.

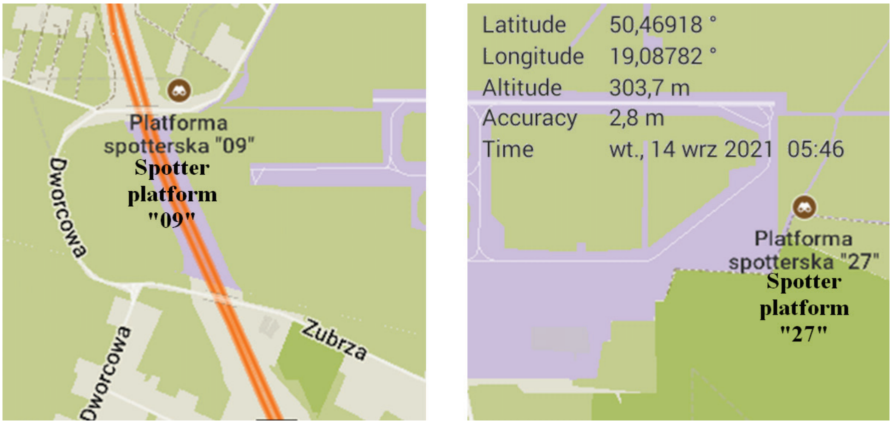


**Fig. 2.** International Airport Katowice-Pyrzowice, two main measurement points are marked on the map [source of the map: OpenStreetMap]

**Table 2**

**Planned aircraft departure times at International Airport Katowice-Pyrzowice on 14 and 16.09.2021 [International Airport Katowice-Pyrzowice / Flightradar service]**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Departures 14.09.2021** Aircraft type | **07:05** | **07:20** | **07:25** | **07:25** | **07:45** | **07:50** | **08:10** | |
| | A320 | B738 | B738 | B734 | B738 | B738 | B738 | |
| | **08:35** | **09:05** | **10:00** | **10:10** | **10:30** | **10:40** | **10:45** | |
| | B738 | B738 | B738 | B738 | B38M | B738 | A21N | |
| | **11:45** | **12:35** | **12:40** | **13:05** | **13:40** | **14:55** | **15:10** | |
| | B738 | B738 | 321 | 32Q | 73H | | 73H | |
| **Departures 16.09.2021** Aircraft type | **07:00** | **07:15** | **07:20** | **07:30** | **10:05** | **10:20** | **10:30** | **10:55** |
| | | | | | | | B738 | |
| | **11:50** | **12:00** | **12:00** | **12:00** | **12:20** | **12:45** | **13:10** | **13:35** |
| | 73H | 73H | 320 | | 73H | 321 | | |

**Table 3**

**Planned aircraft arrival times at International Airport Katowice-Pyrzowice on 14 and 16.09.2021 [International Airport Katowice-Pyrzowice / Flightradar service]**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Arrivals 14.09.2021** Aircraft type | **07:00** | **07:19** | **08:33** | **08:40** | **09:18** | **09:19** | **09:30** |
| | B738 | B738 | B738 | CL35 | B738 | B738 | B738 |
| | **09:55** | **10:10** | **10:40** | **11:35** | **11:40** | **11:47** | **11:49** |
| | A320 | A21N | B738 | B738 | A21N | | B738 |
| | **12:21** | **12:25** | **12:29** | **12:50** | **14:00** | | |
| | B738 | 321 | B738 | B738 | CRJ9 | | |
| **Arrivals 16.09.2021** Aircraft type | **09:00** | **09:15** | **10:15** | **11:00** | **11:25** | **11:25** | **11:40** |
| | | | | B738 | B738 | A320 | A21N |
| | **12:15** | **12:20** | **12:50** | **13:18** | **14:00** | **14:10** | **14:15** |
| | A21N | 321 | B38M | B738 | CRJ9 | 320 | 320 |
| | **14:20** | **15:20** | **15:40** | **15:55** | **16:00** | | |
| | 73H | 321 | 73H | 320 | 7M8 | | |

Measurements have been carried out for flight operations listed in the tables above at several measurement points; however, the results presented in this paper have been obtained at the points indicated earlier in fig. 1. They are presented in a division by measurement days and location of points, without a division by type of performed flight operation and aircraft type. Result tables contain values of all parameters selected for registration (not only those required by regulations) and their standard deviations.

**Table 4**

**Values of measured parameters at the measuring point located near the threshold of the belt toward direction 09 - 14.09.2021**

| Parameter | Value | Std. dev. | Parameter | Value | Std. dev. |
|---|---|---|---|---|---|
| **$L_{A\ FAST}$** | **62,0** | **10,6** | $L_{C\ FAST}$ | 77,5 | 22,8 |
| **$L_{A\ FAST\ min}$** | **54,4** | **7,9** | $L_{C\ FAST\ min}$ | 64,3 | 30,1 |
| **$L_{A\ FAST\ max}$** | **82,1** | **16,3** | $L_{C\ FAST\ max}$ | 90,1 | 20,1 |
| $L_{A\ SLOW}$ | 64,5 | 12,2 | $L_{C\ SLOW}$ | 78,0 | 23,1 |
| $L_{A\ SLOW\ min}$ | 58,9 | 10,3 | $L_{C\ SLOW\ min}$ | 70,4 | 30,7 |
| $L_{A\ SLOW\ max}$ | 80,5 | 16,4 | $L_{C\ SLOW\ max}$ | 88,2 | 23,9 |
| $L_{A\ IMP}$ | 67,6 | 13,8 | $L_{C\ IMP}$ | 81,1 | 21,5 |
| $L_{A\ IMP\ min}$ | 56,3 | 9,0 | $L_{C\ IMP\ min}$ | 68,3 | 25,5 |
| $L_{A\ IMP\ max}$ | 83,2 | 15,8 | $L_{C\ IMP\ max}$ | 91,7 | 30,9 |
| **$L_{Aeq}$** | **73,7** | **14,6** | $L_{Ceq}$ | 81,8 | 23,1 |
| $L_{APk}$ | 72,2 | 11,8 | $L_{CPk}$ | 86,6 | 9,8 |

**Table 5**

**Values of measured parameters at the measuring point located near the threshold of the belt toward direction 27 - 14.09.2021**

| Parameter | Value | Std. dev. | Parameter | Value | Std. dev. |
|---|---|---|---|---|---|
| **$L_{A\ FAST}$** | **53,5** | **7,1** | $L_{C\ FAST}$ | 68,2 | 12,4 |
| **$L_{A\ FAST\ min}$** | **48,2** | **5,4** | $L_{C\ FAST\ min}$ | 60,5 | 24,5 |
| **$L_{A\ FAST\ max}$** | **69,0** | **7,8** | $L_{C\ FAST\ max}$ | 79,1 | 9,0 |
| $L_{A\ SLOW}$ | 52,9 | 6,6 | $L_{C\ SLOW}$ | 67,1 | 12,2 |
| $L_{A\ SLOW\ min}$ | 49,1 | 5,5 | $L_{C\ SLOW\ min}$ | 62,8 | 24,6 |
| $L_{A\ SLOW\ max}$ | 66,2 | 8,1 | $L_{C\ SLOW\ max}$ | 76,7 | 15,0 |
| $L_{A\ IMP}$ | 56,0 | 7,8 | $L_{C\ IMP}$ | 71,0 | 12,8 |
| $L_{A\ IMP\ min}$ | 49,6 | 5,6 | $L_{C\ IMP\ min}$ | 64,2 | 15,8 |
| $L_{A\ IMP\ max}$ | 70,8 | 7,8 | $L_{C\ IMP\ max}$ | 81,3 | 25,4 |
| **$L_{Aeq}$** | **58,9** | **7,0** | $L_{Ceq}$ | 71,2 | 12,2 |
| $L_{APk}$ | 66,6 | 7,2 | $L_{CPk}$ | 78,4 | 4,1 |

**Table 6**

**Values of measured parameters at the measuring point located near the threshold of the belt toward direction 09 - 16.09.2021**

| Parameter | Value | Std. dev. | Parameter | Value | Std. dev. |
|---|---|---|---|---|---|
| **$L_{A\ FAST}$** | **60,3** | **13,1** | $L_{C\ FAST}$ | 73,3 | 14,3 |
| **$L_{A\ FAST\ min}$** | **47,4** | **4,6** | $L_{C\ FAST\ min}$ | 62,2 | 25,1 |
| **$L_{A\ FAST\ max}$** | **77,8** | **9,9** | $L_{C\ FAST\ max}$ | 87,5 | 16,8 |
| $L_{A\ SLOW}$ | 58,3 | 11,5 | $L_{C\ SLOW}$ | 71,6 | 14,5 |
| $L_{A\ SLOW\ min}$ | 48,6 | 5,7 | $L_{C\ SLOW\ min}$ | 64,7 | 25,3 |
| $L_{A\ SLOW\ max}$ | 74,6 | 9,1 | $L_{C\ SLOW\ max}$ | 84,8 | 13,8 |
| $L_{A\ IMP}$ | 63,2 | 13,3 | $L_{C\ IMP}$ | 76,3 | 16,4 |
| $L_{A\ IMP\ min}$ | 53,3 | 9,4 | $L_{C\ IMP\ min}$ | 68,5 | 25,0 |
| $L_{A\ IMP\ max}$ | 80,1 | 10,3 | $L_{C\ IMP\ max}$ | 89,7 | 30,7 |
| **$L_{Aeq}$** | **66,1** | **6,7** | $L_{Ceq}$ | 77,7 | 8,3 |
| $L_{APk}$ | 74,3 | 13,3 | $L_{CPk}$ | 84,0 | 2,3 |

**Table 7**

**Values of measured parameters at the measuring point located near the threshold of the belt toward direction 27 - 16.09.2021**

| Parameter | Value | Std. dev. | Parameter | Value | Std. dev. |
|---|---|---|---|---|---|
| **$L_{A\ FAST}$** | **72,1** | **9,3** | $L_{C\ FAST}$ | 83,0 | 8,9 |
| **$L_{A\ FAST\ min}$** | **55,7** | **7,3** | $L_{C\ FAST\ min}$ | 65,0 | 20,1 |
| **$L_{A\ FAST\ max}$** | **86,1** | **6,3** | $L_{C\ FAST\ max}$ | 90,9 | 13,9 |
| $L_{A\ SLOW}$ | 72,8 | 7,0 | $L_{C\ SLOW}$ | 82,5 | 9,3 |
| $L_{A\ SLOW\ min}$ | 63,6 | 5,9 | $L_{C\ SLOW\ min}$ | 73,0 | 17,5 |
| $L_{A\ SLOW\ max}$ | 83,6 | 6,9 | $L_{C\ SLOW\ max}$ | 88,3 | 11,3 |
| $L_{A\ IMP}$ | 77,3 | 8,3 | $L_{C\ IMP}$ | 86,0 | 10,5 |
| $L_{A\ IMP\ min}$ | 62,5 | 9,0 | $L_{C\ IMP\ min}$ | 70,7 | 21,8 |
| $L_{A\ IMP\ max}$ | 87,5 | 6,2 | $L_{C\ IMP\ max}$ | 92,5 | 17,7 |
| **$L_{Aeq}$** | **78,0** | **5,4** | $L_{Ceq}$ | 83,5 | 10,8 |
| $L_{APk}$ | 83,4 | 9,5 | $L_{CPk}$ | 92,8 | 4,4 |

The time series of recorded parameters measured during aircraft takeoff/landing for two aircraft are shown in figs. 3 and 4.

Thanks to the presented results, it can be noted that landing aircraft exerts less negative impact of noise on the environment. Peak values exceed acceptable levels. However, it should be taken into account whether to locate measuring points in the direct vicinity of the airport area. The selection of presented measurement results was random from over 150 sets and concerned the measurement points most affected with noise. As it has been mentioned before, measurements made with correction characteristic C are only educational in nature.

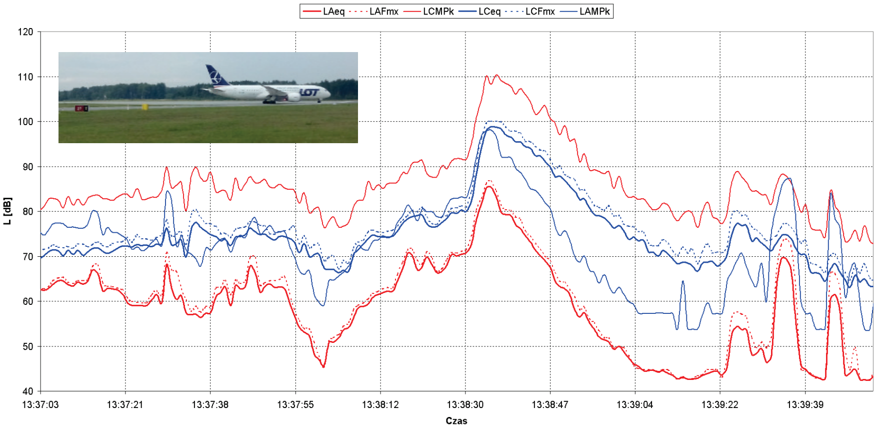


**Fig. 3.** The time series of recorded parameters measured during aircraft takeoff – direction 09

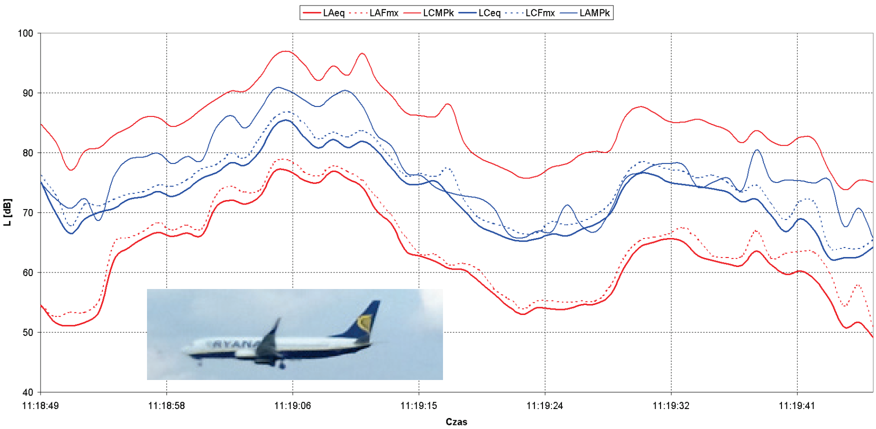


**Fig. 4.** The time series of recorded parameters measured during aircraft landing – direction 09

# 6. Conclusion

The research results presented in this paper should be treated as preliminary and, due to the period in which they were carried out, they do not give a full picture of the nuisance of air operations on the airport environment. However, the secondary aim of the project, which was to activate students - members of the Student Research Group “Zębatka”, to conduct scientific research as part of the Excellence Initiative - Research University program, was achieved. The research topic was consistent with one of the main areas of activity of the SRG, which is vibroacoustic diagnostics and GIS, and therefore met with great interest and involvement of the project participants.

The conducted research allowed members of the SRG to develop skills in vibro-acoustic testing. They were able to familiarize themselves with the current regulations and with the operation of professional, specialized measurement equipment.

Current standards and regulations on the operation of airports in terms of their nuisance to the environment were also covered. The compliance of selected airports with the regulations was verified through measurements carried out at designated sites in their vicinity. Another effect of the project was input data acquisition for GIS software, which is planned to be used in the course of the second level of studies in the Spatial Information Systems.

Comparison of the measured values, presented in the article in Tables 4-7 by days and measurement points, allows us to observe a significant scattering of the measured parameters. This results from different conditions of measurements - starting from the type of flight operations, aircraft type, meteorological conditions, etc.

By analyzing the time courses of measured parameters, it can be concluded that the inconvenience of airport activity from the point of view of a single flight operation is relatively short-lived. Therefore, the overall impact of airport activity on the environment depends on the number of operations performed per day to a greater extent and to a lesser extent on the type of aircraft involved in them.

The location of the measurement point itself is indispensable in determining the nuisance of airport operations. As presented, the measurements for this work took place near the airport; hence in some measurements, high values of the measured parameters were obtained. However, due to the takeoff and landing procedures, it should be taken into consideration that the negative impact on the environment is not created only in the immediate vicinity of the airport, and appropriate measurements should also be carried out at various distances from the airport, especially along the approach paths.

# 7. References

1. Rozporządzenie Ministra Środowiska z dnia 16 czerwca 2011 r. w sprawie wymagań w zakresie prowadzenia pomiarów poziomów substancji lub energii w środowisku przez zarządzającego drogą, linią kolejową, linią tramwajową lotniskiem lub portem - Dz. U. 2011 nr 140, poz. 824 z późn. zm.
2. Rozporządzenie Ministra Środowiska z dnia 14 czerwca 2007 r. w sprawie dopuszczalnych poziomów hałasu w środowisku - Dz. U. 2007 No. 120, item 826
3. Rozporządzenie Ministra Środowiska z dnia 18 czerwca 2007 r. w sprawie sposobu udostępniania informacji o środowisku - Dz. U. 2007 nr 120, poz. 828 z późn. zm.
4. Ustawa z dnia 15 września 2017 r. o przedsiębiorstwie państwowym „Porty Lotnicze".
5. Ustawa z dnia 27 kwietnia 2001 r. - Prawo ochrony środowiska - Dz. U. z 2020 r. poz. 1219, z późn. zm.