Scientific Journal of Silesian University of Technology. Series Transport
Zeszyty Naukowe Politechniki Śląskiej. Seria Transport

Volume 122 **2024**

p-ISSN: 0209-3324

e-ISSN: 2450-1549

DOI: https://doi.org/10.20858/sjsutst.2024.122.5

Journal homepage: http://sjsutst.polsl.pl

Article citation information:
Hoika, T., Korecki, Z. Designing of noise pollution measures for a military airfield. *Scientific Journal of Silesian University of Technology. Series Transport*. 2024, **122**, 73-84.
ISSN: 0209-3324. DOI: https://doi.org/10.20858/sjsutst.2024.122.5.

Tomáš HOIKA[1], Zbyšek KORECKI[2]

DESIGNING OF NOISE POLLUTION MEASURES FOR A MILITARY AIRFIELD

Summary. This article discusses the possibilities of reducing noise pollution in the vicinity of a selected airport, with an emphasis on practical measures. The proposed procedures, which are routinely employed at commercial airports, would be ineffective or financially unsustainable under the circumstances of the military airports. The objective at military airports is not to maximise capacity, as at civil airports, where the desire to increase capacity is primarily related to profit. The primary objective for military airports is to perform defined tasks, which may include pilot training, search and rescue exercises and combat training. The main measures proposed to reduce noise pollution in the vicinity of the villages are changes in departure and arrival routes, the splitting of night operations into two parts and the introduction of a new article in the AIP and Airport Regulations prohibiting air operations over and in close proximity to the villages nearby. Finally, it is stressed that a significant reduction in noise will only be possible with the support of changes in legislation or above-standard financial investment by the airport operator.

Keywords: aircraft noise, capacity, noise pollution, sleep disturbance, environment

[1] Faculty of Military Technology, University of Defence, Kounicova 65, 662 10 Brno, Czech Republic. Email: tomas.hoika@unob.cz. ORCID: https://orcid.org/0000-0002-6421-6631
[2] Faculty of Military Technology, University of Defence, Kounicova 65, 662 10 Brno, Czech Republic. Email: zbysek.korecki@unob.cz. ORCID: https://orcid.org/0000-0002-7988-9441

1. INTRODUCTION

The demand for mobility in general and air traffic in particular has been strongly increasing over the past few years. As a minimum interval between two starting or two landing planes is necessary for safety reasons, evasion of air traffic to shoulder hours and even the nighttime has been observed in the past and will even increase in the future [1]. The same applies to military airfields that are used overnight for pilot training in these conditions. Therefore, the strain of residents living in the vicinity of airports is likely to increase due to noise emitted from nocturnal air traffic. Most of the complaints about traffic noise concern the night, i.e., the time of the day when people try to sleep and regenerate mental and physical powers depleted during the day [2] [3]. In the Czech Republic, nighttime means the time between 22:00 and 06:00 LT (local time) [13].

Noise is defined as any unwanted, or mentally or physically harmful sound [4]. As described in its definition, noise involves psychological factors as well as physiological features [5]. As a result, it may unfavorably affect a person's hearing ability or cause various health problems, such as hypertension [6], myocardial infarction [7], psychological disease [8], and sleep disturbance [9].

The consequences of interrupted sleep from transport noise can be classified as immediate reactions, short-term reactions, and long-term consequences [10]:

- Immediate reactions to nocturnal noise: Acute noise exposure impacts the function of multiple organs and systems, including an increase in blood pressure and heart rate. These reactions are most likely induced by the release of stress hormones, such as adrenaline and noradrenaline. Stress reactions such as these occur even when not perceived, such as during sleep. As a result of the physiological changes described, reactions in sleep can ensue, such as changes from a deeper to a lighter sleep stage, awakenings, body movements, resulting in an increase in total wake time, a reduction of the time spent in deep sleep, and more general sleep loss. [11]
- Short-term reactions to night noise: Due to the decrease in overall sleep time, next day effects include sleepiness and a decrease in cognitive performance. There may also be an impact on mood and wellbeing. [11]
- Long-term reactions: Chronic sleep loss and recurring interruptions of sleep are a major risk factor for cardiovascular and metabolic diseases. The relationship between the immediate and long-term effects of noise is not completely clear, yet, as mediators such as noise annoyance seem to play a relevant role in long-term health effects. Nocturnal aircraft noise exposure has also been found to increase the risk of developing hypertension via a direct effect on blood pressure as well as via a mediated effect because of chronic sleep disturbance. [11]

Findings from the World Health Organisation (WHO) estimate that in western European countries at least 1 million healthy life years (Disability Adjusted Life Years, or DALYs) are lost every year due to environmental noise, with most being attributed to sleep disturbance and annoyance. [11] [12]

Even smaller airfields or airfields that fall short of the amount of traffic that is required by law to create noise protection zones and procedures should still consider the surrounding communities and the impact of the traffic on the convenience of people living nearby. This paper should propose options to reduce the noise impact on surrounding communities with minimal traffic and safety and capacity impacts for selected military airfields as an example.

2. MATERIALS AND METHODS

The assessment starts by defining the noise impact on the residents living near Náměšt' airfield. It considers the physiological and psychological effects of noise exposure on human health, including immediate, short-term, and long-term reactions, such as sleep disturbance and associated health problems.

Relevant laws, regulations, and standards governing noise pollution and airport operations in the Czech Republic and the European Union are compiled. This includes Government Decrees, European Union Regulations, and ICAO guidance. The established hygiene limits for noise, as set by the Czech Government in Regulation No. 272/2011 Coll., are considered. Nighttime noise limits (e.g., 50 dB) are identified as a key reference for assessing noise impact. The impact of potential noise reduction measures on noise levels in neighboring communities is evaluated, considering factors like altitude, distance, and noise source characteristics.

The study area encompassed the communities in close proximity to Namest Airport, specifically focusing on the villages of Studenec, Kladeruby nad Oslavou, and Hartvíkovice. The geographical coordinates and maps were employed to delineate the locations of these communities.

A comparative analysis was conducted to assess the impact of various measures, including changes in approach angles and flight paths, on noise levels in the surrounding communities.

It's important to acknowledge that this study did not consider various atmospheric influences on sound propagation in the calculation of noise intensity, which is a limitation of this research.

3. LAW AND NOISE POLLUTION IN CZECH REPUBLIC

Hygiene limits are set for all known and objectively determinable factors that may negatively impact human health. Hygienic limits for noise and vibration in the Czech Republic are laid down in Government Regulation No. 272/2011 Coll., (Collection of Laws) On the Protection of Health against the Adverse Effects of Noise and Vibration, as amended [14]. Here it is stated that the national noise limit for night is 50 dB (decibel). The airport also follows ICAO (International Civil Aviation Organization) Doc 9829, Guidance on the Balanced Approach to Aircraft Noise Management. Furthermore, within the AIP (Aeronautical Information Publication) there is information on slots. In the Czech Republic, only required at LKPR airport [13].

Furthermore, in the Czech Republic, noise measures must be governed by Act 258/2000 Coll., the Act on the Protection of Public Health and on Amendments to Certain Related Acts. Within the European Union, Regulation (EU) No 598/2014 of the European Parliament and of the Council of 16 April 2014 on rules and procedures for the introduction of operating restrictions to reduce noise at Union airports as part of a balanced approach is in force from a noise perspective. From a noise perspective, Directive 2002/49/EC of the European Parliament and of the Council on the assessment and management of environmental noise is also in force [13].

3.1. Government Decree No. 272/2011 Coll.

Government Decree No. 272/2011 Coll. on the protection of health against the adverse effects of noise and vibration respects Section 108(3) of Act No. 258/2000 Coll. (on the protection of public health and on amending certain related acts). The regulation elaborates

the relevant European Union regulations and regulates the hygienic limits for noise and vibration in various outdoor and indoor environments. In the section entitled Noise in protected indoor areas of buildings, in protected outdoor areas of buildings and in protected outdoor areas, it is given in § 11 (Hygienic limits for noise in protected indoor areas of buildings), paragraph 1: For noise from traffic on roads and railways and for noise from air traffic, the equivalent sound pressure level A L_{Aeq},T is determined for the whole day (L_{Aeq},16h) and the whole night (A L_{Aeq},8h) [13].

In paragraph 8, § 12: The hygiene limit of the equivalent sound pressure level A from air traffic shall apply to a characteristic flight day and shall be set for the whole daytime equivalent sound pressure level A L_{Aeq},16h equal to 60 dB and for the whole nighttime [13].

3.2. Act 258/2000 Coll.

Airport operators under Title 2 (Care of living and working conditions), Part 6 (Protection against noise, vibration and non-ionizing radiation - Noise and vibration), § 30, paragraph 1 are obliged to ensure by technical, organizational and other measures that noise does not exceed the hygienic limits regulated by the implementing legislation for protected outdoor space, protected indoor spaces of buildings and protected outdoor spaces of buildings. [15]

Pursuant to Section 31, paragraph 3, the airport operator is obliged to propose the issuance of a measure of a general nature pursuant to the Administrative Code for the establishment of a noise protection zone. The airport operator is obliged to introduce such a measure when the hygienic limits of noise from air traffic are exceeded, when it ensures beyond 50 thousand take-offs or landings per year. The measure is issued by the Civil Aviation Authority in agreement with the Regional Hygiene Station. [15]

3.3. ICAO Doc 9829

ICAO tries to limit or reduce the number of people affected by aircraft noise. This is one of their priorities and key environmental objectives [13]. ICAOs Doc 9826 is a detailed guidance on the Balanced Approach to Aircraft Noise Management. The Balanced Approach consists of identifying the noise problem at a particular airport and analyzing the various measures available to reduce noise through an exploration of different measures that can be divided into four main elements [16]:

1) Noise abatement at source,
2) Spatial planning and management,
3) Noise abatement operational measures,
4) Operational restrictions.

The aim is to address noise problems at individual airports and to identify noise-related measures that will achieve the maximum environmental benefit in the most cost-effective manner using objective and measurable criteria [16].

Operational restrictions are a tool that, in accordance with the legislation in force, is used only as a last resort when the expected result cannot be achieved by other measures, in particular operational measures. Operational restrictions are noise abatement measures that restrict access to the airport for certain aircraft or reduce its operational capacity, or partial operational restrictions that apply, for example, for a fixed period of time during the day or only to certain runways [17].

4. AIRPORT CAPACITY AND ENVIRONMENT

There are many definitions of airport capacity regarding various issues: operational, flight safety, economic and environmental. The relative importance of each issue depends on the local, regional and national circumstances of each airport. Environmental capacity is the extent to which the environment can receive, tolerate, assimilate or process the outputs of aviation activity. Local environmental airport capacity can be expressed in terms of the maximum numbers of aircraft, passengers, and freight accommodated during a given period under a particular environmental limitation and consistent with flight safety. For example, the airport noise capacity is the maximum number of aircraft that can be operated during a given period so that total aircraft noise levels do not exceed a prescribed limitation in critical zones around an airport. [18]

Strategies adopted to increase airport capacity affect environmental sustainability: air transport accounts around 10% of all transport energy consumption in the EU and is responsible for approximately 15% of all CO2 emissions [19,20]. Therefore, any modification of airport capacity influences and depends on the environmental policy of airport operators and the social and transport organizations [21,22, 23].

Capacity and ecology, which includes noise, are closely linked and must be balanced for each airport. For military airports, the objective is not to maximize capacity, as it is for civil airports, where the drive to increase capacity is primarily related to profit. The primary objective for military airports is to perform defined tasks, which may include pilot training, search and rescue and combat training. Thus, the capacity of the airfield is sufficient for aircraft to take off to the area around and away from the airfield to perform tasks and return again. Given that it is not necessary to address capacity at such airports, it is at least possible to look at and address possible noise measures at the airport without considering the capacity factor.

5. MILITARY AIRFIELD AND NOISE PROTECTION ZONE

The noise protection zone is not defined at the airport in Náměšt' nad Oslavou. According to Act No. 258/2000 Coll., the airport operator is not even obliged to establish the zone, as the number of movements at the airport per year does not exceed 50 thousand. At the same time, however, Government Regulation No. 272/2011 Coll., (Collection of Acts) on the Protection of Health against the Adverse Effects of Noise and Vibration, as amended, should be taken into account. [14] Here it is stated that the national noise limit for night is 50 dB (decibel). In the established noise protection zone, it is expected that the hygienic limits for noise from aviation traffic in the outdoor protected area and outdoor protected area of buildings will be exceeded for a longer period of time [15]. At least inside the buildings, the airport operator is obliged to ensure that the hygienic limits are complied with (the hygienic limit for aviation noise in the interior of buildings at night is 30 dB). There are several villages in the direct vicinity of Náměšt' airport (see Figure 1). Of these, Studenec and Kladeruby nad Oslavou are located directly below the level of the arrival and departure lines from the airport and Hartvíkovice and Popůvky are in the direct vicinity of the airport itself.

It can be expected that the noise limits set for the surrounding villages will be exceeded at night. Therefore, at least basic noise abatement procedures should be defined for the surrounding villages.

Fig. 1 Map of the surroundings of Namest Airport

6. SOUND INTENSITY LEVEL

There are various charges at airports such as passenger airport use charges, PRM charges, landing charges, parking charges and so on. However, noise charges are particularly important for this work. States and airports are flexible in setting these noise charges for both day and night, depending on local conditions. Noise charges should be applied according to the following principles:

1) They should only be levied at airports that have noise problems, and should also be designed to cover only the costs incurred to prevent or mitigate noise [24].
2) They should be linked to the landing fee, possibly as a surcharge, and the provisions for certification of aircraft noise levels in Annex 16 should also be considered [24].
3) They should be non-discriminatory between users and should not be set at levels that are prohibitively high for the operation of certain aircraft [24].

No noise charges are levied at Namest airport. Nevertheless, consideration should be given to nearby communities and the level of noise intensity they are exposed to at night. Various atmospheric influences on sound propagation are not taken into account in the calculation. If we want to calculate the sound intensity level L in dB we use the following formula:

$$L = 10\log(I/I_0)^2 \quad (1)$$

Where:
I – sound intensity [W.m^{-2}]
I_0 – hearing threshold intensity [W.m^{-2}] [25]

The sound intensity level L in dB or sound pressure level L in dB can also be expressed by the following relation, where the sound pressure of the sound and the sound pressure corresponding to the audibility threshold are substituted for the sound intensity [26]:

$$L = 10log(p/p_0)^2 = 20log(p/p_0) \quad (2)$$

Where:
p – the sound pressure of a given sound [Pa]
p_0 – sound pressure corresponding to the hearing threshold [Pa] [27]

Equation three is the calculation of the aircraft altitude over the village Studenec, located on the axis of runway 12, where x is the altitude over the village Studenec in meters, α is the angle of descent, 4 300 is the approximate distance of the village Studenec from the RWY threshold in meters, 26 is the difference in altitude between Studenec and Náměšť' airport in meters.

$$x = (\tan \alpha * 4\,300) + 29 \text{ [m]} \quad (3)$$

The approximate altitude of the aircraft over Studenec is 253 meters.

Equation 4 defines the calculation of the noise intensity level L, where 120 is the height in meters at the reference measurement point on approach. The noise limit of the aircraft is from the data given in the Type Certificate Data Sheets from the European Aviation Safety Agency [28]. The equation is derived from the formula in source number [25]:

$$L = \text{aircraft noise limit} + 20 \log (120/ \text{the height of the aircraft above the ground}) \text{ [dB]} \quad (4)$$

If the helicopter flies over the village of Studenec, the sound intensity level will be 80.90 dB for an aircraft noise limit of 87.4 dB [28]. Military aircraft do not have a specified noise limit, so the EC135 was taken as the reference helicopter.

If we calculate in the same way only for the village of Kladeruby nad Oslavou, which is 3 190 m away from the airport and is in the axis of RWY 30, the resulting sound intensity level is 80.48 dB. The village of Hartvíkovice is not located under any arrival or departure line from the airport. However, the village is close enough to the airport (1430 m) that local traffic visual circuits fly over the village. In the case of helicopters, for example, at an altitude of 150 m above the ground. The sound intensity level over the village is then 85.46 dB.

It was found that each arrival under IFR flight rules and the execution of VFR circuits by local traffic exceeds the established noise limits, but according to the law the operator is not obliged to establish a noise protection zone anyway, since the number of movements at the airport does not exceed the established limit. At the same time, the levying of charges would also be pointless as the operator of the airport is the ACR (Army of the Czech Republic) and the primary operator at the airport, which accounts for more than 90% of the traffic, is also the ACR.

7. INCREASING THE ANGLE OF DESCENT

Currently, the standard angle of descent at Náměšť' airport is 3° for all approaches in both directions. A possible option to reduce noise at least in the villages below the runway is to increase the angle of descent for the approach procedure at night to, for example, 3.5°. In this

case, however, the types of aircraft that land at night and their possible change in configuration during the descent for a higher angle approach need to be considered. The increase in angle should only be such that pilots are not forced to use a higher degree/angle of flaps to avoid an unstabilized approach, and not increase the difficulty of this manoeuvre for pilots. Thus, higher angles are no longer an option from a safety and traffic flow perspective. [29]

For such a solution, it is not only necessary to publish additional approach angles in the aeronautical mammoths, but additional measures need to be put in place. For example, an ILS change and PAPI realignment would be needed, which would require a large financial cost, but the change would at least be effective for daytime traffic, as the ILS change and PAPI realignment would be functional during the day. At the same time, when substituted into equations 3 and 4, for the Studenec municipality, increasing the approach angle to 3.5° would mean that the aircraft would fly 291.6 m above the ground, approximately only 40 m higher, and the noise intensity would be reduced by 79.68 dB, which is not a significant difference in perception. Table 1 expresses the dependence of the noise intensity on the height and distance of the ground location from the noise source, according to equation [30]:

$$dB_1 = dB_0 \; x \; 6 \log_2(\frac{D_0}{D_1}) \tag{5}$$

Where:
D_0 – the initial distance of the noise source from the observer
D_1 – the current distance of the noise source from the observer
dB_1 – initial noise intensity
dB_2 – current noise intensity

As shown in Table 1, if the noise source is at 3000ft above the village instead of 1000ft above the village, the sound intensity level will be reduced by 4.5 dB. Conversely, if the arrival runway is moved, for example, 1.5 NM from the village, there is an additional 3 dB reduction in noise intensity. This suggests that the more effective measure is to change the arrival route and generally the paths of aircraft movements, rather than the angle of approach and the heights of aircraft movements in the circuit.

Tab. 1
Noise intensity dependent on height and distance from source [30]

Height (ft)	Distance						
	0 NM	0,25 NM	0,5 NM	0,75 NM	1 NM	1,25 NM	1,5 NM
1000	85,5	82,3	81,9	81,3	80,5	79,7	78,8
1200	82,3	82,2	81,8	81,2	80,4	79,6	78,8
1400	82,2	82,1	81,7	81,1	80,3	79,6	78,7
1600	82	81,9	81,5	80,9	80,2	79,5	78,6
1800	81,9	81,8	81,4	80,8	80,1	79,4	78,6
2000	81,7	81,6	81,3	80,8	80	79,3	78,5
2200	81,6	81,5	81,1	80,6	79,9	79,2	78,4
2400	81,4	81,3	81	80,5	79,8	80,1	78,3
2600	81,3	81,2	80,9	80,4	79,7	79	78,2
2800	81,1	81	80,7	80,2	79,6	78,9	78,1
3000	81	80,9	80,6	80,1	79,5	78,8	78

Other smaller airports in the Czech Republic are also not obliged to create noise protection zones, yet they have implemented policies in their procedures to reduce noise pollution in the surrounding agglomerations. For example, Kunovice Airport has stated in its AIP that due to noise abatement, it is desirable not to fly over the built-up parts of the villages of Ostrožská Nová Ves, Uherský Ostroh, Nedakonice and Kostelany during VFR flights along the traffic circuit, and to minimize overflights of the built-up parts of Kunovice and Uherské Hradiště towns, unless otherwise specified by ATC (e.g., to provide separation). The same applies, for example, to Karlovy Vary Airport with Article 2.21.4: Omnidirectional departures from RWY 29 of the aircraft category C and D are not allowed to turn right north of RWY centerline sooner than after passing 4.0 NM DME KVY. [31]

8. RESULTS

The thesis found that some of the above measures, which are usually implemented at civil airports, would be ineffective or unnecessary at Námt' airport. Some of the proposed measures do not require additional financial costs, unless the costs of the staff that would have to implement and put into practice the new measures are considered. Nevertheless, for those that do require additional financial costs, calculations have been carried out, and it has been found that there is no greater benefit in terms of reducing the noise burden on residents than the financial cost of these proposals. For example, increasing the angle of descent to 3.5 degrees was classified as an ineffective and costly measure. The costs associated with reconfiguring the approach means, together with the lack of reduction in noise pollution to the adjacent communities, therefore dismissed this measure option.

The introduction of night charges is also classified in the paper as ineffective and unnecessary. The airport operator would be primarily self-commissioning with the introduction of charges and the training tasks assigned for the night would have to be performed anyway, so there would be no reduction in the number of flights during night hours.

The proposed measures to reduce noise pollution in the surrounding villages are as follows:

1. departure and arrival changes,
2. nighttime distribution,
3. introduction of an article in the AIP and the Airport Regulations with the obligation not to fly over and in close proximity to adjacent communities.

Point one refers to the change in the trajectory of departure and arrival routes. It has been shown that changing the trajectory has a greater effect on reducing noise intensity and is therefore a more effective measure. This measure would also require significant financial costs associated with updating the AIP and aeronautical charts and retraining pilots, but has already been assessed as beneficial.

The nighttime splitting measure refers to the measure of splitting the night flying block into two blocks. That is, a block from 22:00 to 24:00 inclusive, and a block from 24:00 to 6:00. The airport operator should try to target night flights to the first block. The measure is not so much intended to reduce noise pollution as to shift the noise pollution to at least one part of the night and to ensure undisturbed sleep for residents of the surrounding communities in the other part of the night.

The third possible solution by introducing this article of the AIP and the Aerodrome Regulations brings a new obligation, namely prohibiting the conduct of aeronautical operations over and in close proximity to surrounding communities. This represents a significant measure

to improve the noise pollution of the surrounding communities and to minimize the potential risks associated with aviation operations in the vicinity of the communities. The introduction of this article in the AIP and Airport Regulations means that pilots will have to respect this new regularity and ensure that their operations do not cross the designated boundaries over the villages. Overall, the introduction of this article is intended to achieve better harmony between air traffic and the residents of the adjacent villages, thereby increasing the comfort of all parties involved.

9. CONCLUSIONS

In conclusion, the potential to reduce noise at source is limited and land-use measures are difficult to implement in densely populated zones. Operational procedures which depend on pilot behavior may lead to a reduction in the level of flight safety. The growth of air traffic is faster than developments in new technologies and methods of noise reduction [18]. Therefore, the chances of reducing the noise burden on the surrounding communities are limited and a significant reduction will only be possible with a change in legislation or the allocation of extra financial resources to address this problem by the airport operator.

References

1. Basner Mathias, Barbara Griefahn, Martinvan den Berg. 2010. „Aircraft noise effects on sleep: Mechanisms, mitigation and research needs". *Noise and Health* 12(47). ISSN: 1463-1741. DOI: 10.4103/1463-1741.63210.
2. Guski Roman. 1991. „The right to peace and quiet at home (Zum Anspruch auf Ruhe beim Wohnen)". *Journal for noise abatement (Zeitschrift fór Lδrmbekδmpfung)* 38: 61-5.
3. Hume Ken, Thomas Callum. 1993. „Sleep disturbance due to aircraft noise at a rapidly expanding airport (Manchester Airport)". In: *Proceedings of the 6th International Congress Noise as a Public Health Problem*: 563-6. Nice, Italy, 5-9 July 1993.
4. Kim KS. 2007. „Occupational Disease". 2007. Hearing Loss. Seoul, Gyechuk Munwhasa.
5. Kwak, Kyeong Min, Young-Su Ju, Young-Jun Kwon, Yun Kyung Chung, Bong Kyu Kim, Hyunjoo Kim, Kanwoo Youn. 2016. „The effect of aircraft noise on sleep disturbance among the residents near a civilian airport: a cross-sectional study". *Annals of Occupational and Environmental Medicine* 28(1). ISSN: 2052-4374. DOI: 10.1186/s40557-016-0123-2.
6. Haralabidis Alexandros, Konstantina Dimakopoulou, Federca Vigna-Taglianti, Matteo Giampaolo, Alessandro Borgini, Marie-Louise Dudley, et al. 2008. „Acute effects of night-time noise exposure on blood pressure in populations living near airports". *Eur Heart J.* 29: 658-64. DOI: 10.1093/eurheartj/ehn013.
7. Willich Stefan, Karl Wegscheider, Martina Stallmann, Thomas Keil. 2006. „Noise burden and the risk of myocardial infarction". *Eur Heart J.* 27: 276-82. DOI: 10.1093/eurheartj/ehi658.
8. Hardoy Maria Carolina, Mauro Carta, Anna Rita Marci, Fiora Carbone, Mariangela Cadeddu, Viviane Kovess, et al. 2005. „Exposure to aircraft noise and risk of psychiatric disorders: the Elmas survey". *Soc Psychiatry Psychiatr Epidemiol* 40: 24-6. DOI: 10.1007/s00127-005-0837-x.

9. Muzet Alain. 2007. „Environmental noise, sleep and health". *Sleep Med Rev.* 11: 135-42. DOI: 10.1016/j.smrv.2006.09.001.
10. Benz Sarah Kuhlmann, Julia Jeram, Sonja Bartels, Susanne Ohlenforst, Barbara Schreckenberg. 2022. „Impact of Aircraft Noise on Health". *Aviation Noise Impact Management.* DOI: 10.1007/978-3-030-91194-2_7.
11. CAA. „Aircraft Noise and Sleep Disturbance: An update (2014-2022)". Available at: https://publicapps.caa.co.uk/docs/33/CAP2370.pdf.
12. Basner Mathias, Wolfgang Babisch, Adrian Davis, Mark Brink et al. 2014. „Auditory and non-auditory effects of noise on health". *Lancet* 383: 1325-32. DOI: 10.1016/S0140-6736(13)61613-X.
13. Kuželová Karolína. 2021. „Design of night noise measures for LKPR". *Diploma thesis*. Prag, Czech Republic: Czech Technical University in Prague. Available at: https://dspace.cvut.cz/bitstream/handle/10467/107297/F6-DP-2022-Kuzelova-Karolina-Nocni_hluk_LKPR.pdf?sequence=-1&isAllowed=y.
14. Czech Republic. *„Government Regulation No. 272/2011 Coll.: Government Regulation on the protection of health against the adverse effects of noise and vibration".* 2011, 24. July 2011. Available at: https://www.zakonyprolidi.cz/cs/2011-272.
15. Czech Republic*. „Act No. 258/2000 Coll.: Act on the Protection of Public Health and on Amendments to Certain Related Acts".* Available at: https://www.zakonyprolidi.cz/cs/2000-258#f5047140.
16. ICAO. „*Aircraft Noise: Balanced Approach to Aircraft Noise Management*". Montréal: International Civil Aviation Organizaation. Available at: https://www.icao.int/environmental-protection/Pages/noise.aspx.
17. Prg.aero. „*Air traffic noise and airport traffic noise*". Prag: Airport Prag. Available at: https://www.prg.aero/hluk.
18. Zaporozhetz Oleksandr, Vadim Tokarev, Keith Attenborough. 2011. „Aircraft Noise: Assessment, Prediction and Control". CRC Press. ISBN: 0415240662. Available at: https://books.google.cz/books?hl=cs&lr=&id=wSMXnVVgOSQC&oi=fnd&pg=PP1&dq=Aircraft+Noise+&ots=CH9l2JiT4_&sig=Vge2UDQ-ko0RqqlmsK5Dg_p_jNs&redir_esc=y#v=onepage&q&f=false.
19. Stanners David, Philippe Bourdeau. 1995. „Europe's Environment: The Dobris Assessment". Office for Official Publications of the European Communities: Luxembourg. European Environment Agency. Copenhagen, Denmark.
20. Ivkovi´c Ivan, Olja Cokorilo, Snežana Kaplanovi´c. 2018. „The estimation of GHG emission costs in road and air transport sector: Case study of Serbia". *Transport* 33: 260-267. DOI: 10.3846/16484142.2016.1169557.
21. Button Kenneth, Peter Nijkamp. 1997. „Social change and sustainable transport*". J. Transp. Geogr.* 5: 215-218.
22. Cokorilo Olja, Gianluca Dell'Acqua. 2013. „Aviation Hazards Identification Using Safety Management System (SMS) ˇ Techniques". In: *Proceedings of the 16th International Conference on Transport Science ICTS 2013*: 66-73. Portorož, Slovenia.
23. Mascio Paola, Gregorio Rappoli, Laura Moretti. 2020. „Analytical Method for Calculating Sustainable Airport Capacity". *Sustainability* 12: 9239. DOI: 10.3390/su12219239
24. International Civil Aviation Organization. *„*ICAO's policies on charges for airports and air navigation services: Doc 9082/7*".* 2004. Available at: https://www.icao.int/publications/Documents/9082_7ed_en.pdf.

25. MEF. „Basic definition”. 2006. Available at: http://fyzika.jreichl.com/main.article/view/208-zakladnidefinice?fbclid=IwAR0pFJmqFug4ejlxCepRiynPei17We1V653hOmAgyyA4gygrPtySgnyiPT4.
26. MEF. „Basic definition”. 2006. Available at: http://fyzika.jreichl.com/main.article/view/208-zakladni-definice4.
27. MEF. „Basic definition”. 2006. Available at: http://fyzika.jreichl.com/main.article/view/208-zakladni-definice.
28. EASA. *„*Type-certificate data sheet for noise*”*. 2022.
29. Kotvaldová Tereza. 2018. „The voice pollution problem of arrival routes*”*. *Diploma thesis*. Prag, Czech Republic: Czech Technical University in Prague.
30. Turner Wes. 2021. „How to calculate the reduction in airplane noise as a function of increased distance?*”*. Available at: https://www.physicsforums.com/threads/how-to-calculate-airplane-noise-as-a-function-of-distance.1006504/.
31. Air Navigation Services of the Czech Republic. 2022. „Aeronautical Information Publication”. Available at: https://aim.rlp.cz/ais_data/aip/control/aip_obsah_cz.htm.

Received 07.12.2023; accepted in revised form 30.01.2024