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Anna KWASIBORSKA[1], Jacek SKORUPSKI[2]

OPERATIONAL RESTRICTIONS FOR REDUCING NOISE AND THE SAFETY OF AIR OPERATIONS

Summary. Many European airports are located in close proximity to residential or protected areas. Aircraft noise emissions caused by the landing and taking off of aircraft are a big problem in these areas. From an operational point of view, the method for reducing noise is to reduce traffic volume or change its organization, especially during the night. Some procedures and tools have been developed to support air traffic management in the implementation of operational constraints necessary to maintain noise at an acceptable level. The objective of this paper is to analyse the effectiveness of these tools. For this purpose, we have analysed existing methods of operational noise reduction, taking into account their influence on the structure, smoothness, punctuality and, especially, the safety of air traffic. As a result, existing risks have been identified, while methods have been proposed to combine two important air traffic service tasks: ensuring safety, while taking into account the environmental constraints, especially in relation to the acoustic climate.
Keywords: aircraft noise, traffic management, safety of air operations

1. INTRODUCTION

Aircraft noise generated by aircraft engines during flight operations (mainly take-offs and landings) depends on many factors [2, 21]. The most important is the volume of air traffic,

[1] Faculty of Transport, Warsaw University of Technology, Koszykowa 75 Street, 00-662 Warsaw, Poland. Email: akw@wt.pw.edu.pl.
[2] Faculty of Transport, Warsaw University of Technology, Koszykowa 75 Street, 00-662 Warsaw, Poland. Email: jsk@wt.pw.edu.pl .

expressed in the number of daily flight operations. Another factor is the type of aircraft. The noise level depends greatly on weather conditions, such as wind direction and force, temperature and humidity (these are the parameters conditioning the propagation of sound waves). An important factor determining the nuisance of aircraft noise is the time of day in which airline operations are performed. Night operations are perceived as much more onerous [3].

In recent years, the dynamic development of air transport has been noteworthy. Airport expansions result in higher throughput, as well as an increase in nuisance for the surrounding environment. Indeed, noise is the main source of negative feelings and reactions among the public towards air transport, which can even impede its development in the future. In accordance with European regulations, aviation noise must be continuously monitored [8]. In cases where the standards are exceeded, measures to mitigate them must be introduced. The most commonly used operating limitations are those that reduce the amount of traffic (as a whole or at certain times of the day) or change its structure, for example, by altering the approach direction or starting procedure.

This paper attempts to analyse how implemented operational limitations, which are associated with noise, affect the safety of flight operations. Depending on the planning horizon of changes in traffic (well in advance or leaving the decision to the air traffic controller until the last moment), the type of planned changes and the nature of restrictions (e.g., a total ban on access or simply a suggestion to change the procedure), the impact of these changes on traffic safety in airport areas may be different.

The remainder of the article has the following organization. Chapter 2 presents a review of the literature and legal regulations limiting noise in airport areas. Chapter 3 presents an analysis of the possible measures for reducing noise in terms of their scope and impact on the structure of air traffic. As a result of this analysis, Chapter 4 proposes the greater use of Quota Counts (QCs), as well as presenting measurements to show how it is possible to obtain benefits, while highlighting their effects on air traffic, including its security. Chapter 5 provides a summary and conclusions.

2. LITERATURE REVIEW

The general framework for combating noise in the EU is set out in Directive 2002/49/EC of the European Parliament and of the Council of 25 June 2002 [5]. This refers to the assessment and management of environmental noise and the standardization of noise measurements. Member countries, in turn, are obliged to draw up action plans aimed at the prevention of noise in the environment and reducing its levels.

Directive 2002/30/EC of the European Parliament and of the Council of 26 March 2002 [4] on the establishment of rules and procedures with regard to restrictions relating to noise levels at Community airports introduces the need for a balanced approach to dealing with noise problems at airports. As part of these activities, analyses should be conducted in order to predict the effects of the reduction in aircraft noise at source, along with carrying out the spatial planning and implementation of operational procedures to reduce noise, which is the subject of this work.

The ICAO document, which contains guidelines for a balanced approach in the management of aircraft noise, is Document 9829 [17], which presents four basic methods for reducing noise:

1) reduction of noise and its source

2) spatial planning
3) operating procedures to minimize noise
4) restrictions on operating activities

The relevant legislative acts indication a range of different methods, the use of which contributes to noise reduction. There is a noticeable emphasis in the normative documents on operational activities that are believed to be the most "profitable" at reducing noise levels. These are outlined in more detail in Chapter 3. That said, these documents do not contain an analysis of the effects of introducing these solutions on safety and liquidity, or the general quality of air traffic.

Methods that have been implemented in the context of operating activities are the QCS and the "green" Continuous Descent Approach (CDA). Analysis of the methods for reducing operational noise levels can be found, for example, in [3], whose authors pointed out that the QCS method is straightforward but effective, because it assumes the noise level based on the structure of the aircraft. Other authors have attributed the success of noise reduction in large part to the quantitative QCS, which allows for a certain permissible limit on noise at any given time, with each aircraft assigned a number of QC noise points, separately for take-off and for landing [10]. Each further operation reduces the available limit by the appropriate number of points. The first implementation of such a system took place in 1990 at several airports in the UK [11]. Analysis of the literature reveals the benefits of the system's implementation for night operations. This is confirmed by the extensive use of the system at European airports, which indicates the correctness and relevance of implementation. Although noise at night is the most troublesome for the environment, the problem concerning the generation of noise by air traffic also occurs in the daytime. In our work, we propose a greater use of the QCS during daytime flight operations. For this purpose, we propose the introduction of quantitative restrictions for QCS operations performed during the day between 06:00 and 22:00. In the following part is an analysis of the effects of such a solution in respect of the benefits to the surroundings of an airport and the risks due to possible (necessary) traffic diversion.

3. METHODS OF OPERATIONAL NOISE REDUCTION

The overarching objective of operational noise reduction is to facilitate a change in the characteristics of aircraft flow such that the noise level is consistent with the prescribed standards, or, more generally, that flight operations do not cause a nuisance to the environment. These standards are defined in [4] and presented in brief in Table 1.

Operational activities related to noise abatement can be divided into two main groups: soft and hard. The former involves the use of economic incentives or various kinds of guidance that will encourage aircraft operators to put operations planning into place that lead to reducing noise-related nuisance. The latter involves the introduction of obligatory action involving the redirection of traffic or its physical limitation.

According to the Act of 3 July 2002 on Aviation Law [8], the airport operator may determine a noise-related airport surcharge or a distinct a noise fee. In practice, this is a very effective means of reducing noise, which can be classified as a soft measure.

Table 1. Acceptable environmental noise levels caused by aircraft take-offs, landings and flights expressed using the indicators $L_{Aeq\ D}$ and $L_{Aeq\ N}$

Type of land	L_{AeqD}: 16 h	L_{AeqN}: 8 h
a) Protection zone A (health resorts) b) Hospitals, care homes c) Residential areas permanently or temporarily inhabited by children and young people	55	45
a) Single and multifamily residential areas, homesteads and housing estates b) Recreational and leisure areas c) Residential and service areas d) Central areas of cities with populations over	60	50

Source: [4]

The layout and orientation of runways and taxiways at the airport are factors in the creation of noise nuisance from flight operations. However, decisions in this area are taken at the design phase, whereas, in the operating phase of the airport, you can, to some extent, control the use of these infrastructure elements, for example, by choosing which runway to use. In addition to purely motion-related criteria, you can take into account the environmental aspect and minimize the number of aircraft operations over critical areas or at a critical time (for example, at night). There are, of course, further-reaching reduction measures available, including the complete closure of the airport at night. These are hard measures, as aircraft operators are essentially forced to apply them (except in special situations, such as emergencies).

In addition to these activities, noise reduction can be achieved by applying appropriate piloting techniques combined with appropriate operating procedures, such as implementing the CDA to landing operations [5]. CDA involves the steady reduction of altitude, while maintaining the aircraft engines in idle mode (Fig. 1). As a result, the engines produce a noise of low intensity. At the same time, throughout much of the approach procedure, the aircraft is at a greater height above the ground, which also reduces noise nuisance on the ground. It is estimated that, compared to the traditional approach, this method allows for the reduction of noise by 2-5 dB, depending of course on the type of airplane, the distance from the airport and weather conditions [13].

In addition, compared to the traditional “stepped” approach, the aircraft performing the CDA consumes less fuel, which means the emission of harmful substances is lower.

The above-mentioned anti-noise operations cannot, however, impair the safe operation of airports. It is therefore necessary to support ATM services in the form of consulting systems or experts, which can facilitate traffic planning in both the long and the short terms. An example of such a support system is the QCS, which facilitates the coordination of night flights. The main aim of operational activities using this system is to identify a certain point limit (related to noise), which cannot be exceeded within a specified time (e.g., within an hour, night, day etc.). These points (known as QCs) are determined (allocated) for each flight operation, depending on the acoustic parameters, on the basis of the certificates of airworthiness of the aircraft in terms of noise [20]. According to the applied noise scale, the level of points ranges from 0.25 to 16, which translates into individual operations and types of aircrafts (see Table 2).

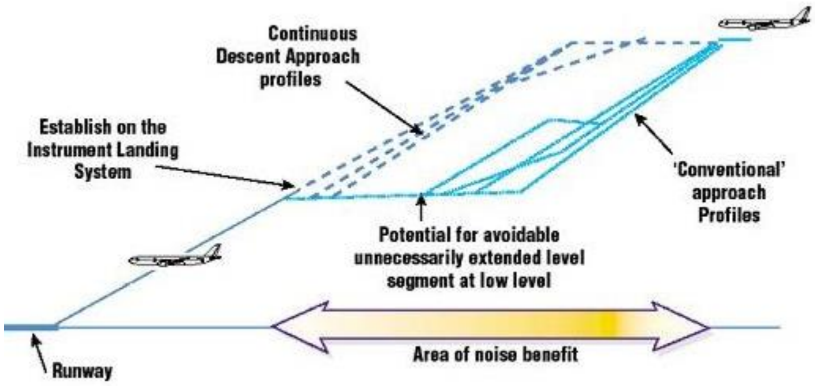

Fig. 1. Scheme of landing approach CDA
Source: [1]

Table 2. Rule of determining QC points

Noise level in EPNdB	*Value of QC points*
Poniżej 87 EPNdB	0.25
87-98.9 EPNdB	0.5
90-92.9 EPNdB	1
93-95.9 EPNdB	2
96-98.9 EPNdB	4
99-101.9 EPNdB	8
101.9 EPNdB	16

Source: [20]

Limits on QC points are determined mostly for night-time air operations, according to the respective scheduling season, while values can be changed depending on the results of the monitoring of noise disturbance [19]. For example, at Warsaw Chopin Airport during summer 2014, 32 QC points were adopted, while operational tactics involving the planning of operations to the level of 29 points QC was used at the same time. The remaining 10% limit was regarded as a provision for special operations, excluded from the coordination process. The benefits of such an approach, as well as its potential threat to air traffic safety, will be presented in Chapter 4.

Table 3. Number of QC points depending on the aircraft type and type of operation

Type of aircraft	*Landing*	*Take-off*
Airbus A310	1	2
Airbus A318	0.25	0.25
Airbus A330	0.5	2
Boeing 737-100	20	20
Boeing 737-600	0.25	0.25
Boeing 747	8	16
Antonov An-30	20	20
ATR 42/72	0.5	0.25

Source: own elaboration based on [9]

4. NOISE LIMITATIONS AND SECURITY OPERATIONS

This chapter presents the noise measurements for the area around Warsaw Chopin Airport, which has 10 measuring points located near the runways. The noise monitoring system is called ANOMS and consists of a computerized network, workstations and measuring points (Fig. 2).

Fig. 2. Measurement points at Warsaw Chopin Airport

The measurements at these points are presented in Table 4, showing parameters related to average acoustic value based on the data acquired in January 2016.

Table 4. Average acoustic value – January 2016

Measurement points	Average value of the sound level exposition: [dB]	Standard deviation σ: [dB]	Confidence interval Δ	Long-term average sound level for the time of night [dB]
1. “Załuski”	93.34	6.19	0.65	56.5
2. “Piaseczno”	78.2	3.24	0.67	43.2
3. “Mysiadło”	82.31	2.49	0.1	56.1
4. “Onkologia”	86.37	3.08	0.73	45.8
5. “Meral”	84.59	5.33	0.64	56.8
6. “17 Stycznia”	85.11	3.79	0.32	51.3
7. “Kossutha”	79.55	3.0	0.55	48.9
8. “Ursus”	83.18	3.01	0.1	56.8
9. “Zamienie”	80.45	5.48	0.7	46.8
10. “Piastów”	78.25	3.09	0.14	48.4

Source: own elaboration based on [21]

As shown, the best result and, at the same time, the lowest value in dB were recorded for Measuring Point 2 ($L_{Aeq,\,LT}$ = 43.2 dB), while the highest value was recorded for Measuring Point 5 and Measuring Point 8 , both with the same value ($L_{Aeq,\,LT}$ = 56.8 dB). At all points, the noise limit was observed, so the standard was maintained.

Based on the identification of aircraft at individual measurement points, the allocation of QC points was made for flight operations performed during the night (22:00-06:00) and during the day (06:00-22:00). The presented QC system is currently deployed at night; but, to illustrate the level of the noise nuisance, points for aircraft conducting take-off and landing were designated between 6 and 22 (Table 5).

Table 5. Assigned QC points for operations performed on 4 January 2016

Measurement points	Aircraft operations (A: landing, D: take off)	Night 22:00-06:00	Day 06:00-22:00
1. “Załuski”	A	11	124.75
2. “Piaseczno”	D	2	9.75
3. “Mysiadło”	D	7.5	5
5. “Meral”	A/D	1	4.25
6. “17 stycznia”	A/D	2	5.25
8. “Ursus”	A	11	111.25
9. “Zamienie”	D	1.5	6.75
10. “Piastów”	A	9.25	70.25

Table 4 does not include information on Measuring Points 4 and 7 because they did not register any noise measurement on the reporting day of 4 January 2016. As indicated in Table 4, the QC point limit was not exceeded on that reporting day at night. Regarding operations performed during the day, the largest number of QC points was recorded for Measuring Points 1 and 8.

By introducing a QC limit for operations performed in the 06:00-22:00 time period to 90 points, or three times that limit at night, it should be noted that, at Measuring Points 1 and 8, these limits were exceeded.

If treating the noise limit appears challenging, then try and think about what kinds of changes in traffic organization should be made instead. It is noteworthy that the two Measuring Points that exceed of the proposed QC limit was observed in relation to the RWY11 runway of Warsaw Chopin Airport. Choosing the direction of the runway used for landing is dependent on a number of elements, of which the main one is wind direction. With this in mind, consideration could be given to temporarily changing the runway used to RWY15 for a certain number of aircraft. From a noise nuisance point of view, such a change is quite possible, given that, at Measurement Point 5, there was only a very slight noise level, while there was nothing recorded at all at Measurement Point 7. Both of these points are located on the approach path for landing on RWY 15.

However, let us consider the effects of such changes on the organization of air traffic in the vicinity of airports from the safety point of view. Even a cursory analysis indicates that this is disadvantageous. Firstly, in the RWY15 direction, there is much worse navigation equipment. There are only SALS and PAPI lights. In the RWY11 direction, as well as ALPA-ATA Category II and PAPI lights, there is available Category II ILS/DME. Therefore, regarding an alternative direction, landing can only be made by means of the VOR/DME lights and the approach light.

It seems that an even greater operational issue, which is closely linked to security, could occur in respect of the aerodrome traffic. Given that the direction of RWY15 is not normally used for landing, it is not equipped with an exit expressway. This is a problem that is mainly related to capacity. However, it should be noted that the need to decelerate to a very low speed, in order to exit at the T, H and B taxiways, is a potential threat for a tightly packed queue of aircraft wishing to land, which is common during peak hours. In such a situation, any disruption to the process of landing may result in the need to perform a missed approach procedure, which can be regarded as an adverse (dangerous) event as it causes a disturbance in planned traffic.

Another safety problem concerning the use of RWY15 for landing procedures is associated with taxiing, which most likely involves the taxiway exit marked H2. In this case, the A7, A6, A5 and A4 taxiways could be used, or the A7, L, E3, E2 and E1 roads. In each of these cases, it is necessary to intersect the other runway, on which you can expect to find start operations, since, at Warsaw Chopin Airport, it is a standard rule to use one runway for landings and another for take-offs. Intersecting a runway that is in use by taxiing aircraft is one of the main factors contributing to the incidents of runway incursion, which can have disastrous consequences. The described relationship is connected to the shape of the network of taxiways and runways, as well as the location of the passenger terminal.

The above analysis of the need to reorganize the structure of air traffic, in cases where the limit on noise nuisance (treated in hard way) is exceeded, shows that this can have a negative impact on the overall level of aviation safety. Therefore, how do we reconcile the two most important criteria: maximizing safety and minimizing the negative environmental impacts? Undoubtedly, the simplest and probably the cheapest solution is to plan ahead. Assuming that the restriction imposed by the QCS remains active, the landing approach procedure should be reorganized so that it takes place in the second direction on RWY 33 (provided that weather conditions, specifically wind, allow it). In this case, all the above disadvantages disappear. However, it requires the earlier application of other procedures of “standard terminal arrival route” diversion. Performing such an action “at the last minute” is impossible, however.

5. SUMMARY

In summary, the issue of aircraft noise and the policy of mitigating its impact remain important issues in traffic and safety modelling. Care for the environment is one of the priorities in terms of sustainable transport. One of the elements of airport operations is the reduction of noise disturbance through the use and implementation of systems and procedures for changing the organization of traffic.

This article has presented the concept of introducing a QCS during the day, as well as shown that hard compliance with imposed limitations, without suitably advanced methods for predicting QC points, will have a negative impact on traffic safety. Thus, the need has been demonstrated for a more comprehensive approach to the issue, in which the process of change in the organization of air traffic, as a result of imposing noise limitations, must be coordinated. Possible computer systems must include the appropriate module forecasting of noise load, correlated with a module for supporting air traffic controllers, while accepting the need to act in relation to a much longer time horizon.

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