throughput environmental; airport traffic modeling; aircraft noise

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ANALYSIS OF AIRPORT TRAFFIC IN THE CONTEXT OF ENVIRONMENTAL THROUGHPUT

Summary. Increased air transport volumes force carriers to make more frequent flights as well as airport operations. Unfortunately, such progress has some negative effects which the main is environment nuisances. Due to its reach, aircraft noise is one of the most important and unpleasant effects of airport operations. The problem of protecting the environment against noise is becoming increasingly more important on the international market. A lot is being done here by the European Union, which urges or obliges Member States to comply with certain rules, laws and standards aimed at preventing too much interference of socio-economic development with nature 19]. Considering how air transport is growing, it is necessary to conduct studies into airport throughput including throughput environment. This throughput is determined by Restricted Use Area and it is defined as acceptable daily number of performed air operations resulting from the noise limit at airport. There are the following noise level limits classification: noise level limits per flight which is measured at monitoring points, with special attention paid to those measures specific to night-time and noise volume limits over a time-period, particularly at night-time.

ANALIZA RUCHU LOTNISKOWEGO W ASPEKCIE PRZEPUSTOWOŚCI ŚRODOWISKOWEJ

Streszczenie. Rozwój transportu lotniczego wiąże się ze zwiększeniem częstotliwości lotów, ich zasięgu, liczby przewoźników oraz floty przewoźników lotniczych. Niestety postęp ten ma także negatywne skutki, m.in. w postaci występowania określonych uciążliwości w środowisku. Hałas lotniczy, przez zasięg oddziaływania, jest jednym z najdotkliwiej odczuwanych efektów działalności lotniska. Ochrona środowiska przed hałasem jest coraz poważniejszym zagadnieniem na rynku międzynarodowym. Jest w tym duży udział Unii Europejskiej, która motywuje bądź zobowiązuje państwa członkowskie do przestrzegania pewnych zasad, praw i norm mających na celu zapobieganie zbyt dużej ingerencji rozwoju społeczno-przemysłowego w przyrodę. Rozwój transportu lotniczego pociąga za sobą prowadzenie badań nad przepustowością portów lotniczych, w tym również przepustowością środowiskową. Przepustowość ta jest określona przez Obszar Ograniczonego Użytkowania i oznacza dopuszczalną dobową liczbę operacji lotniczych wynikającą z limitu hałasu. Klasyfikacja poziomu hałasu wyróżnia: limity poziomu hałasu na poszczególne loty, które są mierzone w punktach pomiaru hałasu, oraz limity hałasu w określonym czasie, ze szczególnym uwzględnieniem godzin nocnych.

1. INTRODUCTION

Care for the environment is one of today's priorities in the pursuit of sustainable development. It is an integral part of projects and programmes to develop new and extend existing industrial and commercial facilities. The concept of sustainable development of transport, which is the result of mankind's search for coexistence with nature, is intended to ensure adequate mobility of goods and people in society while minimising its impact on the environment and is undoubtedly a key issue to be resolved, namely the concept of sustainable development of transport involves providing conditions for stable economic growth 1].

The concept of sustainable development is an issue originating from a 1969 UN report [14]. A concept of sustainable development was born then which is based on the integration of efforts to increase prosperity and improve the condition of the environment. The 1987 Report of the Brundtland Commission, Our Common Future, defined sustainable development as, "meeting the needs of the present generation without compromising the ability of future generations to meet their own needs" [18]. The concept of sustainable development does imply limits. Sustainable development contains two key concepts in definition. One of these is the concept of 'needs', in particular the essential needs of the world's poor, to which overriding priority should be given; and the second is the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs. The concept of sustainable development is rooted in this sort of systems thinking.

Hence, the foundations of the concept of sustainable development include:

- economy – gain for the community, adjusted by social and environmental costs,
- environment – protection of non-renewable natural resources, minimisation of negative impact on the environment,
- society – creation of new jobs and pro-active efforts to improve life quality.

Fig. 1. Key elements of sustainable development
Rys. 1. Kluczowe elementy zrównoważonego rozwoju

The overlapping-circles model of sustainability acknowledges the intersection of economic, environmental, and social factors (fig. 1) 21]. Depending on our mindset, we re-size the circles to show that one factor is more dominant than the other two [19].

The concept of sustainable development is reflected in Poland's supreme law, namely in the Constitution of the Republic of Poland, where in article 5 it is stated that *'the Republic of Poland (....) ensures environmental protection while respecting the principle of sustainable development'*. At the same time, in the Environment Act of 27 April 2001, Poland has enacted the statutory enforcement of

the Rio Declarations in the form of Agenda 21 for the 21st Century, where the notion of sustainable development is defined as a socio-economic development in which political, economic and social efforts are integrated while maintaining natural balance and the sustainability of fundamental natural processes in order to balance the chances of access to the environment for individual communities and citizens, both now and for future generations1].

The problem of protecting the environment against noise is becoming increasingly more important on the international market. A lot is being done here by the European Union, which urges or obliges Member States to comply with certain rules, laws and standards aimed at preventing too much interference of socio-economic development with nature. One of the major legislative measures is European Union Directive 2002/49/EC of 25 June 2002. It relates to the assessment and control of environmental noise levels [8]. Some of its regulations have been incorporated into the Polish Environment Act. Among other things, these two statutes impose the obligation to create noise contour maps on a periodic basis and subsequently translate them into programmes designed to protect the environment against noise. This regulation applies to the authorities of towns with populations over 100,000, and to road, railway and airport operators. Both the Directive and the Environment Act specify what such noise contour maps should contain, how they should be made and to whom they should be delivered.

The importance and popularity of transport today sets high requirements for both aviation and environmental engineers. Doing without this convenience is something that contemporary people could not imagine. On the other hand, the needs of society are getting into conflict with inconveniences due to transport. Noise, vibrations and hazardous emissions are an undoubted drawback of transportation, which are hard to avoid, however. Thus, the goal is to conflate the two sides of the conflict, where the notion of sustainable development seems to be helpful.

According to the Environment Act [17], sustainable development is understood as such a socio-economic development in which political, economic and social efforts are integrated while maintaining natural balance and the sustainability of fundamental natural processes in order to balance the chances of access to the environment for individual communities and citizens, both now and for future generations.

2. PROBLEM IDENTIFICATION

2.1. The main description of noise

An airport can be a nuisance to a metropolitan area in a number of aspects. One of them is the need to remove from the urban development plans relatively large areas allocated for airport operational use. Such areas occupy 250 to 400 hectares. Another aspect is the creation of restricted use areas (varying in size from 40 to 150m^2) and the reduction of building heights around the airport. The security aspect is also taken into account by analysing the risk of danger from potential aircraft failure when using the airport.

When analysing the impact and significance of noise in daily life, one should first define this notion. According to Engel, *'Noise is every undesirable, unpleasant, troublesome or harmful mechanical vibration that makes an elastic medium act through air on hearing, other senses and the human body's parts'* [10].

Noise is the opposite of all the sounds regarded by humans as needed and useful. From the physiological point of view, noise is a sound that has a negative effect on health, prevents rest or the reception of the auditory input sensed by human beings as more useful. Noise often makes it impossible to perform basic activities, disrupts concentration or has an irritating effect.

It is worth noting that the way in which noise is perceived by humans often depends not on its intensity but on the time of exposure to it. The acoustic background level often exceeds that of the noise emitted from a moving aircraft, but due to the pulsing of the incoming sound human beings experience the latter more.

Noise is created by aircraft approaching or taking off from airports and by taxiing aircraft and engine testing within the airport perimeter. This results from air passing over the aircraft's body (fuselage) and wings. This causes friction and turbulence, which makes noise. The amount of noise created varies according to the way the plane is flown, even for identical aircraft. Aircraft land with their flaps extended – this creates more friction (and produces more noise) than a plane with its flaps up. On the fig. 2 is shown how airflow over a wing differs with the flaps up and down. During position flaps down there are more air-flow and so more noise than flaps up.

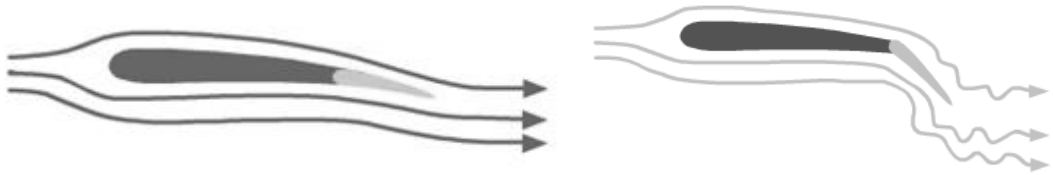

Fig. 2. Position flaps of wing aircraft: up and down
Rys. 2. Pozycje klap skrzydła samolotu: do góry i na dół

When you analyse the aircraft as an object that emits sound waves, you can distinguish in it two main sources of emission to the surrounding medium. The first one is the mechanical vibrations of the aircraft structure, which are caused by the rotating engine turbines. Engine noise is created by the sound of the moving parts of the engine and by the sound of the air being expelled at high speed once it has passed through the engine. Most of the engine noise comes from the exhaust or jet behind the engine as it mixes with the air around it, although fan noise from the front of the engine can also be audible on the ground.

The other vibrations are the result of the flowing combustion gases and the sucked-in air jets as well as the propeller's rotations. This source is classified as turbulence, and sound waves produced in this way are called acoustic.

When discussing aircraft noise, factors that make it a nuisance should be considered. They include:

1. Location of an airport in relation to metropolitan urban areas and the wind rose.
2. Density of any noise-protected development near an airport and the situation of such a development in relation to that of the airport's runways.
3. Road and rail transport routes giving access to an airport and their situation to urban development areas near the airport.
4. Noise levels of aircraft using an airport.
5. Air traffic intensity during day and at night.
6. Noise levels of an airport's ground facilities (engine testing stands, repair workshops, transport, etc.).
7. Weather conditions (wind, fog, snow, vegetation, etc.).
8. Various types of noise protections, such as soundproof casings, screens, soundproof external walls (and windows) of buildings exposed to aircraft noise, including ventilation systems.
9. Special protections of aircraft engine testing stands (acoustic silencers, casings, screens).

When discussing the notion of aircraft noise, some additional definitions associated with the measurement of sound levels should be considered. These definitions are included, for example, in laws regulating acceptable noise levels, depending on the type of noise, time of the day and the use of the land affected by noise emission.

A-weighted equivalent sound level (L_{Aeq}) is the acoustic pressure level of a continuous, steady sound adjusted to match the frequency response A, which in a given reference time interval equals the mean square of the acoustic pressure of a tested time-variable sound; the equivalent sound level A is expressed in decibels (dB). A-weighted equivalent sound level expressed by the formula (1):

$$L_{Aeq,T} = 10 \cdot log\left[\frac{1}{t_2 - t_1} \cdot \int_{t_1}^{t_2} \frac{p_A^2}{p_0^2} dt\right][dB] \quad (1)$$

where: $L_{Aeq,T}$ - A-weighted equivalent sound level [dB], defined for time interval T, from t_1 to t_2, p_0 - reference sound pressure (20μPa), p_A - instantaneous the acoustic pressure value A, measured the acoustic signal.

The sound exposure level A (L_{AE}) is a measure of the total "noisiness" of an event, that takes duration into account, which is expressed in decibels (dB) (2).

$$L_{AE} = 10 \cdot log\left[\frac{1}{t_0} \cdot \int_{t_1}^{t_2} \frac{p_A^2(t)}{p_0^2} dt\right][dB] \quad (2)$$

where: $p_A(t)$ - instantaneous the acoustic pressure value A, t_2 - t_1 - determined time interval to take into account all the parameters, p_0 - reference sound pressure (20μPa), t_0 - reference time (1s).

The *prolonged mean sound level A* (L_{DWN}) is the mean, over a prolonged time interval, of equivalent sound levels A occurring in the consecutive reference time intervals of a prolonged time interval; the prolonged mean sound level A is expressed in decibels (dB) (3).

$$L_{DWN} = 10 \cdot log\left[\frac{12}{24} 10^{0,1L_D} + \frac{4}{24} 10^{0,1(L_W+5)} + \frac{8}{24} 10^{0,1(L_N+10)}\right][dB] \quad (3)$$

where: L_{DWN} – a long-term, average sound level A determined in the subsequent time intervals, taking into account the time of day and night, which is expressed in decibels (dB),
L_D – a long-term, average sound level A determined in the subsequent time intervals between 6:00 am and 6:00 pm, expressed in decibels (dB),
L_W – a long-term, average sound level A determined in the subsequent time intervals between 6:00 pm and 10:00 pm, expressed in decibels (dB),
L_N - a long-term, average sound level A determined in the subsequent time intervals between 10:00 pm and 6:00 am, expressed in decibels (dB).

The maximum sound level (L_{Amax}) is the maximum value of the effective sound level A. This parameter is used to assess the short-and impulse noise with high levels.

2.2. Legal Framework

In Poland the most important document addressing the issue of noise in terms of environmental protection is the Regulation of the Minister of Environment of 14 June 2007 regarding acceptable environmental noise levels. Promulgated in 2007 Journal of Laws No. 120, item 826, it has been enacted under article 113 clause 1 of the Environment Act of 27 April 2001 (Journal of Laws No. 62, item 627, as amended).

Tab. 1 shows details of the acceptable noise levels in decibels 17]. The indicators $L_{Aeq\ D}$ and $L_{Aeq\ N}$ are used to establish and control the requirements for daily environment usage.

Table 1

Acceptable environmental noise levels caused by aircraft takeoffs, landings and flights expressed using the indicators $L_{Aeq\ D}$ and $L_{Aeq\ N}$

Item	Type of Land	Acceptable Noise Level in dB			
		Aircraft Takeoffs, Landings and Flights			
		$\mathbf{L_{Aeq\ D}}$ reference time interval of 16 hours	$\mathbf{L_{Aeq\ N}}$ reference time interval of 8 hours	$\mathbf{L_{DWN}}$ reference time interval of all days in a year	$\mathbf{L_N}$ reference time interval of all nights
1	a) Protection zone A (health resorts) b) Hospitals, care homes c) Residential areas permanently or temporarily inhabited by children and youth[1)]	55	45	55	45
2	a) Single- and multi-family residential areas, homesteads and housing estates b) Recreational and leisure areas[1)] c) Residential and service areas d) Central areas of cities with populations over 100,000[2)]	60	50	60	50

Legend:
1) If such areas are not used at night in accordance with their intended purpose, they are not subject to the acceptable noise level at night.
2) The central area of cities with populations over 100,000 means dense residential development with a concentration of administrative, commercial and service facilities. For cities with metropolitan boroughs of more than 100,000 inhabitants, a central area can be established in such boroughs if it is densely developed with residential buildings and a concentration of administrative, commercial and service facilities.

The official document that regulates the reduction of aircraft noise in Poland is Directive 2002/30/EC of the European Parliament and the Council of 26 March 2002 on the establishment of rules and procedures with regard to the introduction of noise related operating restrictions at Community airports. The following purposes of the Directive have been specified:

- airport-level harmonisation of efforts to limit or reduce the number of people affected by harmful effects of noise,
- compliance of the Directive with a Member State's legislation,
- no negative effect of airport throughput on the environment,
- taking of measures to attenuate noise levels at every airport,
- achievement of appropriate satisfaction levels with low impact on the environment.

The Directive also makes it clear that excessively noisy aircraft (that do not meet applicable technical requirements) should be removed from service. A crucial element of the Directive is the concept of 'sustainable approach', which is composed of the four main requirements:

- conscientious assessment of practicable noise reduction solutions (noise reduction at source),
- concept of spatial planning,
- implementation of suitable management measures and noise reduction procedures,
- operational restrictions that do not interfere with Member States' regulations.

Another important element relating to environmental protection in terms of aircraft noise and the protection of areas around airports is article 179 Area Noise contour map of The Environment Act of 27 April 2001. The article requires that every five years airports prepare noise contour maps of areas particularly susceptible to exceeding acceptable noise levels. The airport should do acoustic map for

the first time within one year from the date on which the airport has been assigned to objects that have a negative effect on large areas.

Chopin Airport in Warsaw is Poland's largest public transport airport and handles almost half of the passenger traffic in the country. It continues to be a junction airport, holding a dominant position in the Polish air transport market. With the growth of regional airports, however, the percentage of operations carried out at Chopin Airport in Warsaw is shrinking. Chopin Airport is the best example where such a map is prepared. The noise measurement system is made up of nine stations (Piaseczno, Zamienie, Mysiadło, Onkologia, Meral, 17 stycznia, Kossutha, Ursus, Załuski) along aircraft flight paths on the outskirts of Warsaw (fig. 3) [22].

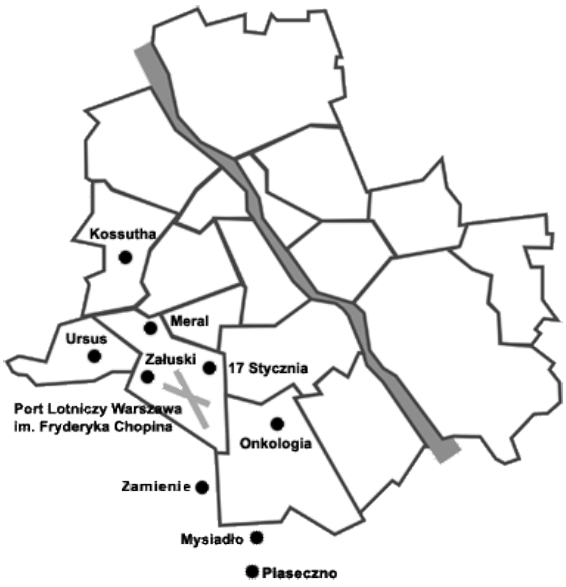

Fig. 3. The aircraft noise measurement near Chopin Airport
Rys. 3. Punkty pomiaru hałasu lotniczego w pobliżu Lotniska Chopina

A restricted use area has had to be established under applicable laws because Chopin Airport's acoustic impact extends beyond the boundaries of the area to which the airport's operator has a legal title, and at the same time this impact cannot be contained within the airport's area. To define the outer boundaries of the restricted use area, the short-term noise indicators have been taken which are used to establish and control the requirements for daily environment usage:

- L_{AeqD} – equivalent sound level A during the day (understood as a time interval from 6.00am to 10.00pm),
- L_{AeqN} – equivalent sound level A at night (understood as a time interval from 10.00pm to 6.00am).

These indicators are used to prepared maps of the acoustic climate in the environment of Warsaw Chopin Airport during the day and night (600 operations per day, with the predicted structure of the aircraft fleet). Then the envelope of the isolines equivalent sound level L_{AeqN} = 45 dB, and isolines L_{AeqD} = 55 dB was found external border area of limited use. Internal frontier area of limited use determines the limit of the airport area.

Two spaces most exposed to noise have been identified within the restricted use area to create the two zones:

1) zone Z1, with its outer boundary defined by the 55dB isoline of the A-weighted equivalent sound pressure level at night and the inner one by the airport's boundary;
2) zone Z2, with its outer boundary defined by the 50dB isoline of the A-weighted equivalent sound pressure level at night and the inner one by the boundary of zone Z1.

Zone Z2occupies an area of 9.11 km^2 and includes land in Warsaw (Areas Włochy, Ursynów and Ursus) and in communities Michałowice, Lesznowola and Raszyn. Zone Z1 occupies an area of 3.23 km^2 covers the most exposed to noise in areas on Ursynów, Włochy and Michałowice.

For zones Z1 and Z2 introduced restrictions on zoning and how to use the land:

1) in zone Z1 - forbidden to allocate land for residential single and multi-family, residential services, homestead, collective residence associated with a permanent or temporary stay of children and youth, hospitals and nursing homes,
2) in zone Z2 - forbidden to allocate land for hospitals and nursing homes, and the buildings associated with permanent or temporary stay of children and youth, the construction of buildings with the function of hospitals, nursing homes and social the functions associated with the permanent or temporary stay of children and youth.

Globalisation makes every year a place increasingly more airports on the world's map. Until recently airports were located only in the largest cities of a country, handling low volumes of traffic. Nowadays, due to cheap flights, time saving, comfort and safety, travellers are using planes more intensely. An example can be Poland, where still a few years ago the main hubs were Warsaw and Cracow, that is, airports within the country's largest metropolitan areas. At present a substantial proportion of passengers have been taken over by smaller airports (Bydgoszcz, Rzeszów, Gdańsk, Wrocław, Poznań), which have become prospering businesses too. This has made the airports and aircraft have a clearly negative impact on the surroundings and residential communities.

It is becoming commonplace that the health of people living along flight routes is worse than that of those who do not come into contact with excessive noise and fumes. Hearing and the nervous system are only few of the human body's parts that can be injured by the sounds of aircraft and their infrastructure. Aircraft noise can affect concentration, impair communication and consequently make it impossible to work. People living near airports are found to be more prone to coronary heart disease, cerebral stroke and raised blood pressure.

Aircraft noise is a negative phenomenon that contributes to the degradation of the environment and human health. These days every effort is being made to reduce aircraft noise. This is aided by applicable directives, laws and regulations, which, when not complied with, impose applicable sanctions. Aircraft makers have an increasingly higher environmental awareness, which can be seen in the improved performance of engines designed to emit the lowest possible amounts of fumes and thus not adversely affect human health. Airports should be planned in such locations as not to have an excessive impact on human mind and not to destroy natural environment.

Another negative feature of airports and aircraft is the emission of exhaust fumes. Harmful pollutants from diesel combustion (carbon oxide, hydrocarbons, solid particles, soot) can lead to diseases such as cancer, asthma, pneumonia, depression and myeloid leukaemia.

2.3. Airport Operations

Most European airports' operations cause acceptable noise levels to be exceeded in critical locations around the airport. In such situations applicable laws and implementation regulations require restricted use areas to be created.

Compared with other noise sources, the uniqueness of aircraft noise is that:

- noise affects relatively large tracts of land,
- aircraft produce high noise emissions,
- top-down propagation of sound wave makes it impossible to provide efficient protection of the environment against noise.

An airport's noise nuisance can be eliminated through:

- noise optimisation of takeoff and landing procedures,
- restrictive reduction of night flights,

- continuous monitoring of the extent of aircraft noise zones using valid measuring methodologies,
- analysis of the results of continuous aircraft noise monitoring and issuance of takeoff and landing approvals only for aircraft with noise type certificates acceptable to aviation safety authorities (as defined in chapters 3, 5 and 10 of ICAO Annex 16).

Standard airport departure and arrival procedures have been consistently implemented since 1998. The works have been carried out taking into account applicable regulations, conditions arising from the reorganisation of the airspace over Warsaw following the introduction of a uniform civil and military airspace management system, aviation safety factors and the need to reduce the environmental impact of aircraft noise.

One of the aspects of environmental protection is using a pilotage technique called 'green approach'. In 2009, as part of implementing the so-called P-RNAV Procedures, or precision area navigation, Continuous Descent Approach (CDA) procedures and new departure routes were introduced at Chopin Airport.

Aircraft land in a stepped approach: decreased thrust to descend and increased thrust to level, and this cycle is repeated until touchdown. This approach is completely managed by air traffic controllers from the top of the « staircase » right through to the final alignment and landing (fig. 4) [23].

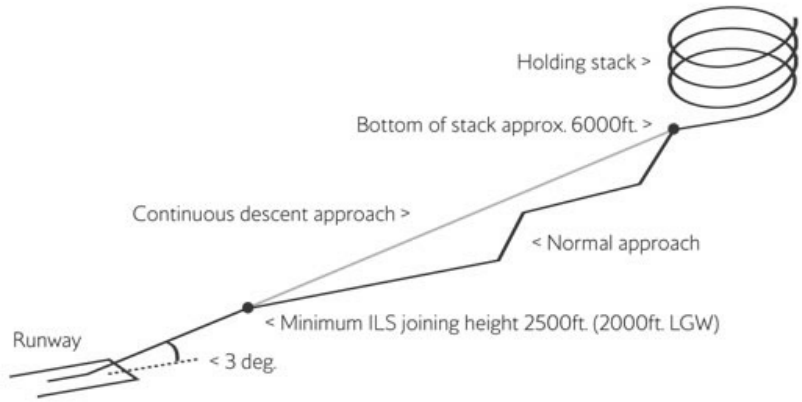

Fig. 4. Continuous Descent Approach
Rys. 4. Płynne podejście do lądowania

In opposition, CDA allows the aircraft to descend with some engines idling approximately 40 miles or 65 km before landing. An increase in thrust is only needed 5 minutes before landing. From the cruise altitude right through to the final segment of the approach, the aircraft FMS (Flight Management System) enables all of the approach to be done automatically. The benefits are immediate both for the company and airports' neighbourhood. Indeed, fuel consumption is reduced, but the noise is also diminished because the engines are idling. We should also note that fuel consumption reduction is also increased thanks to the resulting time savings.

This enables to reduce noise emissions significantly, as well as makes engines work more cost-effectively. It is a pilotage technique that the aircraft crew uses in cooperation with air traffic controllers during landing approach. It involves descending at a steady rate while keeping the engine at idle and extending the flaps and undercarriage at the right time before landing. Using this method brings several advantages. For one thing, it minimises the noise that reaches the ground by two to five decibels. Obviously, the numbers depend on the type of aircraft, weather conditions and the distance to the airport. The CDA technique also reduces fuel consumption by 50 to 150kg per flight, as well as harmful emissions, mainly of carbon dioxide, to the atmosphere 5]. The average monthly emission reduction is 31.5 to 94.5 tonnes of CO_2.

3. ENVIRONMENTAL THROUGHPUT

Increased air transport volumes force carriers to make more frequent flights as well as airport operations. At the same time, an inherent part of it is planning airport operations aimed at increasing the environmental throughput of airspace and airports, which is a key measure for the airport's operational efficiency.

Forecasts and studies show that the capacity of Polish airports' existing technical and organisational infrastructure will not be able to meet demand and is going to become a factor to impede the growth of air transport the most. The basic throughput is defined as the maximum number of a conventional aircraft's air operations carried out under specified air traffic conditions unit while maintaining smooth handling of passengers, cargo and post during a time [Manual on Airport Planning (ICAO Doc 9184 – 2002)]. The practical throughput is defined as the number of a conventional aircraft's air operations during a time unit carried out under specified conditions of air traffic and continuous handling of passengers, cargo and post, for which the mean waiting time equals the acceptable mean time; it can be determined for the two intervals: hourly and annual [Manual on Airport Planning (ICAO Doc 9184 – 2002)]. With a calculated throughput considering all its value-creating factors, it is possible to determine the existing airport's throughput redundancy and work out projects for upgrading the airport's structure and air traffic operations in order to increase this value. An extremely important aspect is also environmental throughput. Unlike e.g. the terminal's throughput or ground traffic area, the environmental throughput is defined as the maximum number of operations that are allowed to be carried out during one day, with a breakdown into day (6.00am to 10.00pm) and night (10.00pm to 6.00am) hours.

For the analysis of the acoustic environment was selected measurement point "Mysiadło". On the fig. 5 is presented the calculated values of noise indicators in 2011.

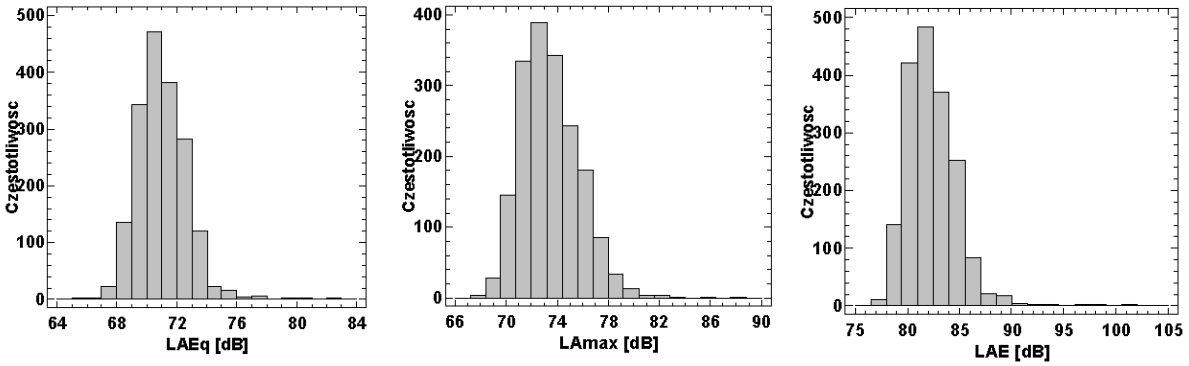

Fig. 5. Histograms present indicators in measurement point "Mysiadło" in 2011
Rys. 5. Histogramy wartości wskaźników pomiaru hałasu w punkcie "Mysiadło" w 2011 roku

Histograms on fig. 6 shows the equivalent maximum levels and exhibition sound for individual acoustic events over the month, at the point measuring "Mysiadło" in the time of day, or hours 6.00-22.00. Data include only the landing operations.

The highest equivalent sound level for the time of day (2011) was identified and it was $L_{Aeq\,D}$ = 58.87 [dB]. The highest exposure sound L_{AE} = 86,02 [dB].

The acceptable number of operations carried out during the day and at night depends on the types of aircraft operating during such hours, and it would be possible to increase traffic if carriers used quieter aircraft.

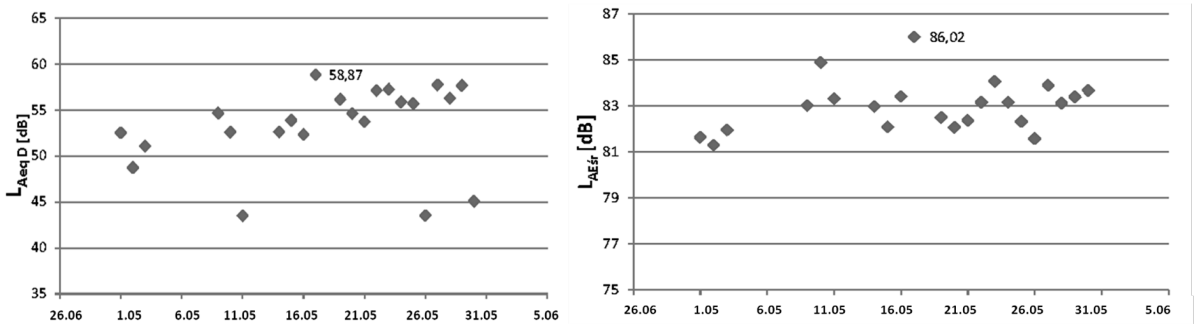

Fig. 6. Value of indicators L_{AeqD} i $L_{AEśr}$ in 2011 (measurement point "Mysiadło")
Rys. 6. Wartości wskaźników L_{AeqD} i $L_{AEśr}$ w 2011 roku (punkt pomiaru "Mysiadło")

4. SUMMARY

Growth of each industry has its advantages and disadvantages. More frequent and distant flights, more carriers or larger fleets bring tangible benefits to each stakeholder. This means profits for manufacturers, carriers and airports, more fast and efficient travel opportunities for passengers and prestige or advertising for the country. Unfortunately, such progress has some negative effects. Growth of air transport and related use of airports produce certain environment nuisances. Due to its reach, aircraft noise is one of the most important and unpleasant effects of airport operations. To some extent, it also predetermines the creation or growth of airports that already exist. Constantly growing demand for this mode of transport make airport managers face a dilemma how to split between the disputable issue of growth and proper airport management and that of protecting the environment, mainly against noise. It is quite a challenge because responsibility for every air operation involves responsibility for all the people living in the areas adjacent to airport infrastructure.

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Received 23.11.2012; accepted in revised form 22.01.2014