Adaptive control methods

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RISK AND EXPOSURE CONTROL OF AVIATION IMPACT ON ENVIRONMENT

Abstract. Till now the exposure analysis and assessment are put in fundament of the system of environment protection from human activities including the civil aviation. Risk methodology is considered mostly as supplemental tool for this. All the environmental hazards are subject of occupational (or transportation) safety at the same moment. The risks and of their impact on human and ecological (ecosystems) health is more valuable assessment than simply an exposure analysis, for example, a number of people annoyed by noise is more informative value than a number of exposed by noise (over or equal to specific level) people or simply an area of exposed by noise (of specific level) lands in vicinity of the airport under consideration. In comparison with noise annoyance, for which higher exposure provides higher number of annoyed people inside exposed community, for other types of risk agents the severity of health changes is also evident – up to cancer (for example, leukemia may be caused by electro-magnetic field exposure to people) or direct mortality outcomes. So, individual and societal risks are becoming more attractive values for decision making process in a number of practical cases of environment protection, in aviation sector also. To confirm this quite evident now precondition it is important to mention that a vulnerability of the human or/and eco-system under consideration is important to be assessed correctly, in a number of cases the vulnerability is possible to be controlled (not only the exposure of the noise or other factor being controlled!) to reach a final result of protection from a hazard(s). For example, considering noise annoyance, a complementary to Balanced Approach to aircraft noise management the community engagement is recommended (ICAO Cir. 351).For this was launched EU H-2020 project ANIMA (Aviation Noise Impact Management through Novel Approaches) for this to find the better communication solutions between exposed by noise community and authorities responsible for noise management.

Keywords: risk assessment; exposure; aircraft noise; non-acoustic factors; individual risks; environmental impact.

Introduction

Aviation is considered as important contributor to economy, employment and a number of social issues locally and globally. Aviation is a subject of huge concern as one of the important types of human activities impacting the environment – once again locally and globally. Today the list of the impacts, usually considered during Environment Impact Assessment procedures for any new activity or infrastructure implementation in aviation sector, is quite long. It includes human health problems, biodiversity damage, climate change, etc. But even a short list of priority types of the impact needs for tremendous efforts realized to assess and control them in permanent and/or periodic ways. Environmental risk factors include chemical, physical and microbiological hazards, accidents, vectors (vector borne diseases).

Till now the exposure analysis and assessment are put in fundament of the system of environment protection from human activities including the civil aviation, risk methodology is considered mostly as supplemental tool them. Good example for that is a balance approach (BA) to aircraft noise control, where ICAO Guidance to Aircraft Noise Management is emphasizing on noise index (which is a diurnal exposure value for noise) assessment as a main criterion for such a management.

The success of ICAO BA, reached with time globally, regionally and locally in a number of its implementation, may be widening for other hazard assessment and control, mentioned in a short list of priorities. In current practice a number of its specific elements are even realized, for example ICAO Airport Manual (Doc 9184) recommends to implement the Public Safety Zones to control a Third Party Risk around the airports (zoning and land use element of BA), Annex 16 to Chicago Convention “Environment Protection” in vol. II require the standard values for aircraft engine emission (reduction of the emission factor in source), in a very new vol. IY “Carbon Offsetting and Reduction Scheme for International Aviation” (CORSIA) that contains Standards and Recommended Practices (SARPs) for the implementation of global market system on subject of CO2 trading in aviation sector, covering the number of aspects of flight operation and mitigation, new requirements for CO2 emission by aircraft and type of fuel and power usage.

Risk assessment and management for aviation impact control

All the environmental hazards are subject of occupational (or transportation) safety at the same moment. The risks of their impact on human and ecological (ecosystems) health is more valuable assessment than simply an exposure analysis, for example a number of people annoyed by noise is more informative value than a number of exposed by noise (over or equal to specific level) people or simply an area of exposed by noise (over or equal to specific level) lands in vicinity of the airport under consideration. In comparison with noise annoyance, for which higher exposure provides higher number of annoyed people inside exposed community, for other types of risk agents the severity of health changes is also evident – up to cancer (for example leukemia may be caused by electro-magnetic field impact) or direct mortality outcomes. So, individual and societal risks are becoming more attractive values for decision making process in a number of practical cases of environment protection 1].

Environmental causes of disease may be categorized in many ways, e.g. by referring to media which may carry hazards, as individual risk factors (agents), or according to the nature of the hazard. Outdoor air individual risk factors include: chemical substances; physical factors; microbiological hazards; accidents' outcomes; vectors (vector borne diseases), Fig. 1. All of them are really if environmental and occupational importance. For example, physical factors - noise, vibrations (of the houses due to low frequency noise impact on them), ionizing, UV and electromagnetic radiation are the subjects for installing the environmental and occupational limits to control their impact at daily life and at workplace, their outcomes are quite wide – up to mortality, in dependence with the factor strength and exposure, Fig. 2.

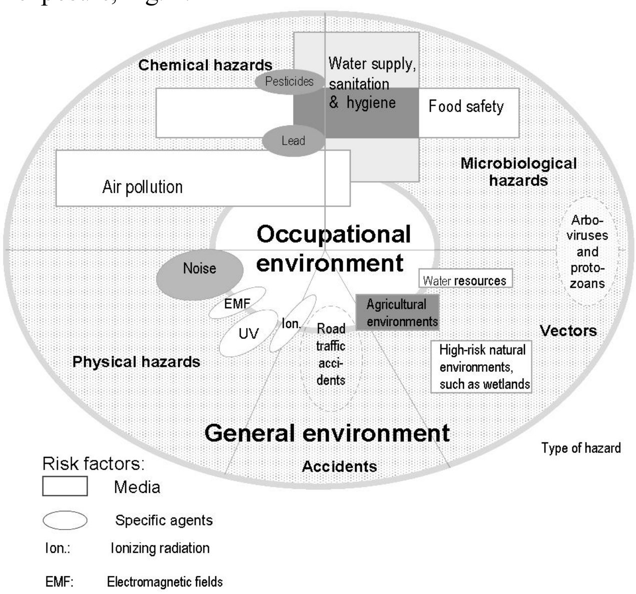

Fig. 1. Environmental hazards and risk factors

Also important issue – what is a way of impact of the risk agent on a human – direct or indirect, providing three levels of physiological outcomes, which are of interest in epidemiological research, for example for noise on cardiovascular effects. These are for aircraft noise: stress indicators (e.g. stress hormones), risk factors (e. g. blood pressure, blood lipids, haemostatic factors), and manifest diseases (e. g. hypertension, ischaemic heart disease), Fig. 3 [2].

Till now the exposure analysis and assessment are put in fundament of the system of environmental protection from human activities, including the civil aviation, risk methodology is considered mostly as supplemental tool to them. Good example for that is a balanced approach (BA) to aircraft noise control, where ICAO Guidanceto Aircraft Noise Management is emphasizing on noise index (which is a diurnal exposure value for noise) assessment as a main criterion for such a management efficiency.

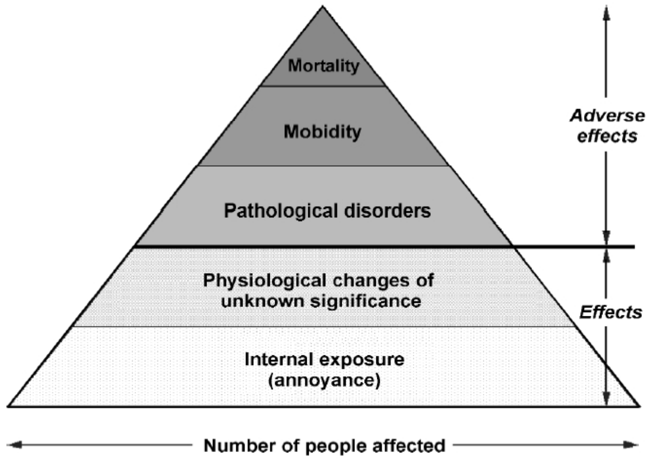

Fig. 2. Severity of the environmental or/and occupational effect on humans

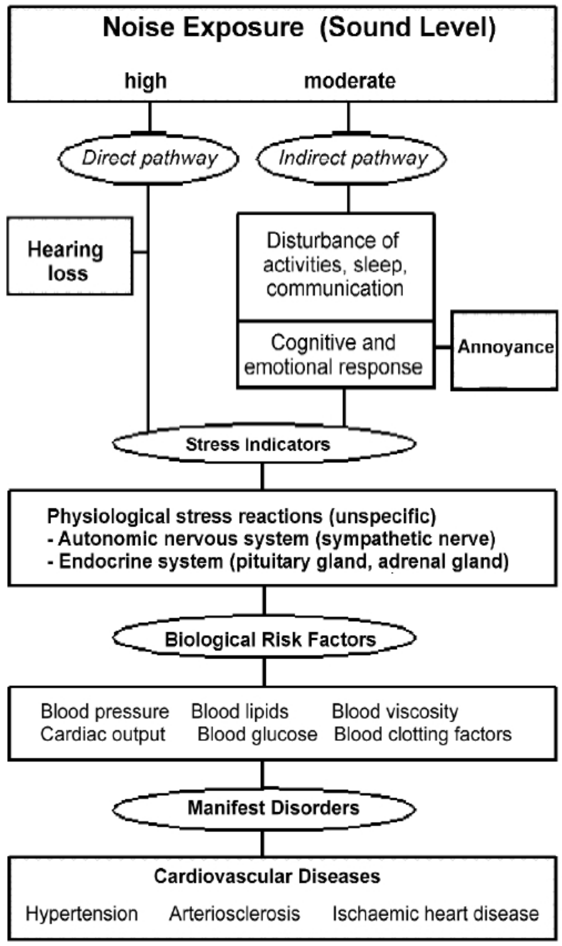

Fig. 3. Noise effects reaction schema [2]

The general algorithm for assessing the risk to public health when exposed to risk agents includes the following steps:

- hazard identification;
- assessment of dependencies "exposure-response" ("dose-effect");
- exposure assessment;
- risk characterization;
- uncertainty of the assessment;
- preparation of data for risk communication, including for decision makers.

Electro-magnetic fields

When identifying hazards, one should take into account all types of effects that, in accordance with modern scientific data, can form among the population under the influence of electro-magnetic fields (EMF) of different frequencies. Summarized data on the types of effects are given in Appendix 2 of the guidelines [3]. The known changes in the human body under the impact of EMF are summarized in Table 1 and 2.

Table 1 – **Known changes in the human body under the action of electromagnetic fields (frequency 0 - 30 kHz) of varying intensity [3]**

Current density, μA/см^2	Observed changes
0,1	Lack of reactions of the nervous system at the cellular level
1,0-10	The phenomenon of electro- and magneto-phosphenes. Membrane potential products
10-50	Thresholds of stimulation of sensory receptors and nerve and muscle cells
>100	The probability of ventricular fibrillation of the heart. The possibility of cardiac arrest, respiratory tetanus

Table 2 – **Known changes in the human body under the action of electromagnetic fields of varying intensity [3]**

Energy flux density, μWt/см^2	Observed changes
600	Pain during exposure
200	Inhibition of redox processes
100	Increased blood pressure with its subsequent decrease. In cases of chronic exposure, persistent hypotension. Bilateral cataractogenic effect in the frequency range of 1.5-10 GHz
40	Feeling warm. When irradiated for 0.5-1 hours - an increase in pressure of 20-30 mm Hg.st
20	Stimulation of redox tissue
10	Neuroasthenic syndrome. Asthenization after 15 minutes of irradiation, changes in the bioelectrical activity of the brain
8	Indefinite shifts on the part of the blood with a total irradiation time of 150 hours, a change in blood clotting
6	Electro-cardiographic changes, changes in the receptor apparatus
4 … 5	Changes in blood pressure during repeated exposures, short leukopenia, erythropenia
3 … 4	Vasotonic reaction with symptoms of bradycardia, slowing of the electrical conductivity of the heart
2 … 3	The pronounced nature of lowering blood pressure, increased heart rate, fluctuations in blood volume of the heart
1	Reduced blood pressure, a tendency to increased heart rate, slight fluctuations in the volume of blood in the heart. Decrease in intraocular pressure with daily exposure for 3.5 months. Reduced perception threshold, increased psycho-physiological test execution time
0,5	Increase the threshold of perception of the stimulus
0,4	Auditory effect when exposed to pulsed EMF
0,3	Some changes in the nervous system during chronic exposure for 5-10 years
0,1	Electrocardiographic changes. No change in psycho-physiological indicators
≤ 0,05	The tendency to lower pressure during chronic exposure

The data in Tables 1&2 are interpreted as “dose-effect” dependence for EMF impact assessment. Each stage of risk assessment is completed with intermediate results that are of independent value and can be used to solve various problems and make management decisions. It is optimal to apply all EMF sources to an electronic map of a settlement (around the airport, for example) for the development of an electromagnetic map (similar to noise map) of the radio frequency range with the ability to analyze and simulate various situations and scenarios for changing EMFs. The electronic map of the territory should allow estimating the population under the influence of a certain level – to define the number of people impacted for specific health changes.

Aircraft noise

From a number of epidemiological studies that provide dose-response relationships between risk factor and diseases it was estimated that the risk of disease and/or severity of disease increases for a value of strength or exposure of the risk factor.

For example, aircraft noise level 65 dB(A) may be viewed as a NOAEL (No Observed Adverse Effect Level) in this context, and 70 dB(A) as a LOAEL (Lowest Observed Adverse Effect Level) for the present (Fig. 4). At the lower end of the "nuisance-health scale", 55 dB(A) during daytime and evening (45 dB(A) during night-time, 30 dB(A) indoors during night-time) is the threshold and recommended value for ambient noise levels outdoors, to avoid serious annoyance [4].

The simple conceptual dependence between risk and hazard [1] does not consider the contribution of vulnerability of the elements-at-risk to the hazard under consideration –"the conditions determined by physical, social, economic and environmental factors or processes, which increase the *susceptibility* of a community to the impact of hazards".

In general case the vulnerability "describes such *characteristics* and *circumstances* of a community, system or asset under consideration that make them susceptible to the damaging effects of a hazard" [14] (UNISDR). Relating to a number of inter-related conditions (they can be generally classified as shown in Table 3), vulnerability may increase the susceptibility of a community to the impact of any hazards under consideration [5].

Table 3 – **General classification of vulnerability [6]**

	Human – social	Physical	Economic	Cultural Environ-mental
Direct losses	• Fatalities • Injuries • Loss of Income or employment • Homelessness	• Structural damage or collapse to buildings • Non-structural damage and damage to contents • Structural damage infrastructure	• Interruption of business due to damage to buildings and Infrastructure • Loss of productive workforce through fatalities, injuries and relief efforts • Capital costs of response and relief	• Sedimentation • Pollution • Endangered species • Destruction of ecological zones • Destruction of cultural heritage
Indirect losses	• Diseases • Permanent disability • Psychological impact • Annoyance • Loss of social cohesion due to disruption of community • Political unrest	Progressive deterioration of damaged buildings and infrastructure which are not repaired	• Economic losses due to short term disruption of activities • Long term economic losses • Insurance losses weakening the insurance market • Less investments • Capital costs of repair • Reduction in tourism	• Loss of biodiversity • Loss of cultural diversity

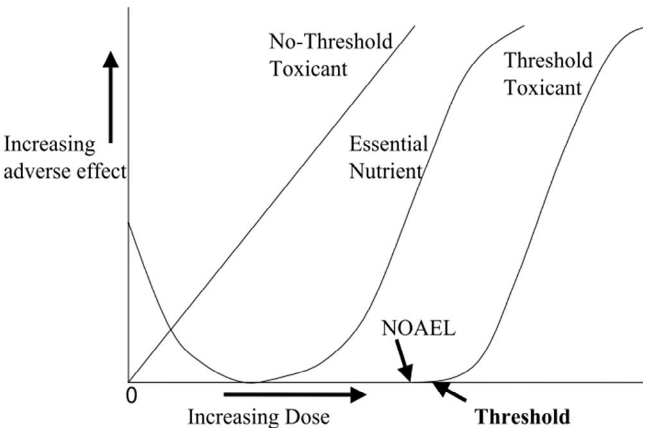

Fig. 4. Dose-Effect curves for various types of response to hazard: NOAEL

For *individual* risk this basic condition may be expressed by the formula [7]:

$$R = P_f \cdot P_{d/f} = p_{Sc} p_{Ex} \cdot k\, v_k, \quad (1)$$

where P_f – the probability of harmful event (eg, aircraft accident); $P_{d/f}$ – the likelihood of the consequences (effect or damage), particularly the fatal consequences caused to individuals in the absence of protection from (or resistance to) a danger; p_{Sc}– the probability of scenario, leading to such event; p_{Ex}– the probability of hazard exposure due to this scenario; k– type of damage (eg, fatality, injury, physical damage, environmental losses, loss of income, etc. depending what are the elements-at-risk, Table 1); v_k– vulnerability of the element-at risk to hazard.

For aircraft noise any flight event is leading to scenario of noise impact, p_{Sc} = 1, the same is valid for aircraft engine emission/air pollution, but the probability of hazard exposure p_{Ex} due to any scenario is dependent of specific location of point of control relatively the flight path – people are impelled to complain when some burden factor in the environment gives rise to any effect and when this stressor reaches a lower limit value (Table 2). Aircraft noise exposure can lead to more than one effect and the community impacts (usually health effects, which can be chronic) depending on multiple effects (also shown in Table 2) [8]: the primary recognized health consequences of community noise exposureare the sleep disturbance during night time and annoyance during composite day time, and anywhere due to vulnerability aspects the cardiovascular disease and cognitive impairment in children also contribute [4].

Efforts to reduce exposure should primarily reduce annoyance and sleep disturbance, improve learning conditions for children, and lower the prevalence of cardiovascular risk factors and cardiovascular disease [8] – they usually different coping capacities for all these types of health consequences.

Evidence is increasing to support preventive measures separately to them, such as noise insulation, policy, guidelines, and limit values. If *k* is correspondent to noise annoyance effect the likelihood $P_{d/f}$ may be represented as a dependence of *HA%* from noise exposure *E*, currently L_{DN} (or its analogue L_{DEN}) is used as its metric because it is mostly correlated with noise annoyance of the population living under the noise impact around the airports, Fig. 5.

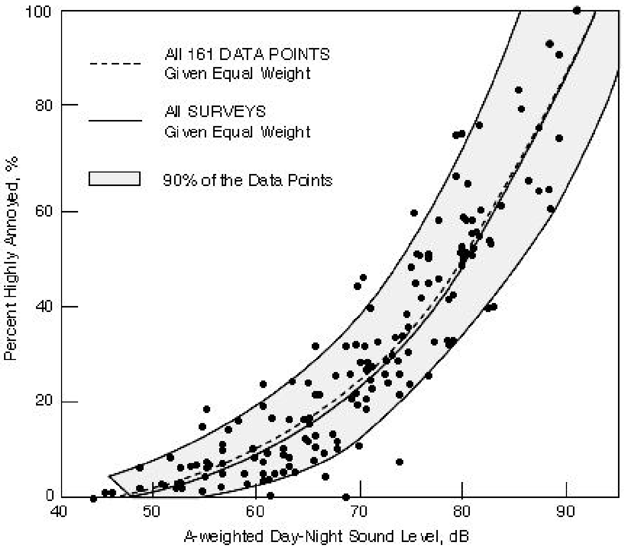

Fig. 5. Dose-effect curve for environmental noise – a portion of highly annoyed people in exposed by noise group correlated with day-night average sound level L_{DN} (the EPA dose-response relationship, developed by Schultz [9]

Exposure covers a number of acoustic factors, which are first of all the maximum sound exposure levels, number of flights during the period of observation, usually during the day.

We may assume that risk for population living around the airport to be highly annoyed by aircraft noise is defined by the day-night average noise exposure level, *DNL*, or a similar indicator (*DENL, WECPNL, etc*). Results show also that if road and aviation noise are impacting jointly (the combined effects of transportation noise) the perception of the total noise annoyance was strongly determined by the sound source which was examined as more annoying (in this case aircraft noise).

Concluding the general model of noise annoyance [10, 11], one may recognize the noise annoyance as a form of psychological stress, that is determined by the extent to which a person perceives a threat [11], i.e. perceived disturbance and the possibilities or resources that a person has with which to face this threat.This conclusion is possible to be considered as fundamental for risk assessment and management methodology and it is proposed to be used for noise (or particularly aircraft noise) impact assessment and management.

The methodology provides necessary tools to include in consideration *vulnerability*&*capacity* values, both very important for management of the impact first of all.

Looking in Eq. (1) and considering the noise annoyance effect it was proposed to represent the likelihood $P_{d/f}$ as a dependence of *HA%* from noise metric L_{DN} (or its analogue L_{DEN}), currently it should be noted that normalized dependence is considered. A vulnerability shift in relation to noise source (ΔL_s) is proposed to be included in a form of adjustment used in [12] – Eq. (2).

Today it is highest for noise from wind turbines (wind farms), because expectation rate among the population in quiet suburban or rural community, where wind farms are usually installed, is highest. Such expectation rate is introduced [1] to assess the expected vulnerability effect on a value of response of the population on noise via the factor of expectation (Fig. 6):

$$\Delta L_{s\,i} = \Delta L_{s\,i\,max} F_{ex}, \quad (2)$$

where *i* is a type of vulnerability considered, $\Delta L_{s\,i\,max}$ is a maximum possible value of vulnerability shift.

Further step is a “normalization” procedure for noise level used in noise impact assessment:

$$L_{DN\,norm} = L_{DNcal/meas} + \Delta L_{s\,\Sigma}, \quad (3)$$

where calculated or measured value $L_{DNcal/meas}$ is correspondent with case of noise event under consideration, and vulnerability shift $\Delta L_{s\Sigma}$ may include additively a number of factors influencing on vulnerability of this case.

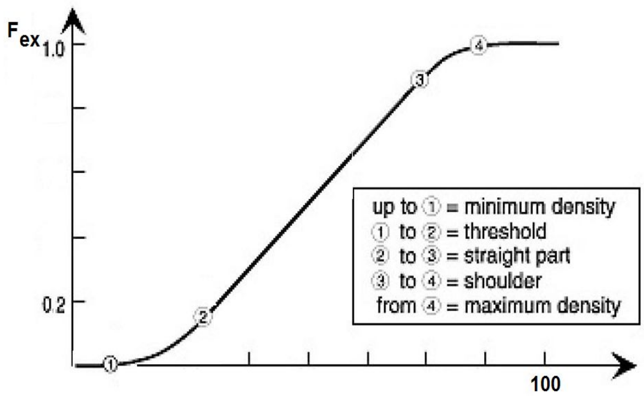

Fig. 6. Factor of expectation (expectation factor F_{ex} = [0,1]) in dependence with rate of expectation R_{ex} = [0,100]: Any deviation from the expected level in the direction of growth causes the growth F_{ex}

Concept of vulnerability is proposed to be widening to include the coping capacity of the system under consideration, as it is considered by [5], Fig. 6, and it takes into account the multifunctional dependence between hazard, vulnerability and capacity due to concept-formula Eq. (1) in [1].

In an attempt to reduce the scatter to the community response data (Fig. 4), the EPA [9] suggested the use of “normalized” L_{DN}, which is the measured or predicted L_{DN} with a number of *adjustments* added to account for specific characteristics of the sound (Table 4) shows the EPA-suggested adjustment factors and their magnitudes [13].

All of them in proposed above risk terminology are *vulnerability factors* for the risk to be annoyed by noise assessment also.

For new situations, especially when the community is not familiar with the sound source in question, greater community annoyance than predicted by application of the equation can be expected, the difference may be as much as +5 dB. One more classical example of noise impact vulnerability is an additional guideline values, which are suggested for specific environments [4], all data are in L_{Aeq}, Table 5.

The measurements of aircraft noise and the analysis of the results are necessary in order to protect correctly the local community living in the airport surrounding areas.

Table 4 – **EPA-recommended adjustments [9] to be added to the measured or predicted L_{DN} of an intruding noise at a residential location [13]**

Type of adjustment	**Description of condition**	**Adjustment to be added to measured L_{DN}, dBA**
Seasonal considerations	Summer (or year-round operation)	0
	Winter only (or windows always closed)	−5
Adjustment for ***outdoor background noise*** measured in the absence of intruding noise (***change in noise environment***)	Quiet suburban or rural community (remote from large cities and from industrial activity and trucking)	+10
	Normal suburban community (not located near an industrial activity)	+5
	Urban residential community (not immediately adjacent to heavily travelled roads or industrial areas)	0
	Noisy urban residential community (near relatively busy roads or industrial areas)	−5
	Very noisy urban residential community	−10
Adjustment for previous exposure (***change in noise environment***) and ***community attitudes***	The community has no prior experience with the intruding noise.	+5
	Community has had some previous exposure to the intruding noise, but little effort is being made to control the noise. This adjustment may also be applied in a situation where the community has not been exposed to the noise previously, but the people are aware that bona-fide efforts are being made to control the noise.	0
	Community has had considerable previous exposure to the intruding noise and the noisemaker's relations with the community are good.	−5
	Community is aware that the operation causing the noise is very necessary and will not continue indefinitely. This adjustment can be applied for an operation of limited duration and under emergency circumstances.	−10
Pure tone or impulsive sound	No pure tone or impulsive character	0
	Pure tone or impulsive character present	+5

Table 5 – **WHO noise guidelines, 1996 [4]**

Day time		**Night time**		**Type of residence**
Inside	**Outside**	**Inside**	**Outside**	
50 dBA	55 dBA			Dwellings
		30 dBA	45 dBA 45dBAmax	Bedrooms
35 dBA	55 dBA			Schools
35 dBA		35 dBA 45dBAmax		Hospitals General
30 dBA		30 dBA 40dBAmax		ward rooms

Permanent or/and temporary noise monitoring to be undertaken usually in their local community on the assumption that aircraft noise will exceed what is considered 'acceptable' or legally permissible, and in this connection it is necessary to refer to the legislative controls on aircraft noise.

The results show that for airports with low intensity of flights the long term equivalent sound level is heavily changing in relation with the long term maximum sound level, but for high intensity flight traffic this interrelation is quite stable. In the vicinity of airports with low flight intensity the maximum sound level as a noise impact metric is more sensitive than the equivalent level. In general case the purposes of monitoring are described elsewhere as:

1) to assess the current status of the resource to be managed or to help determine the priorities for management,

2) to determine if the desired management strategies were followed and produced the desired consequences,

3) to provide a greater understanding of the system being managed,

4) to show that population involvement in noise management helps to reach the goals of the noise management program, etc.

Although today in most cases the main concern is the negative impact of aircraft noise, the highest goal is to show that measuring and monitoring the aircraft noise can be used for positive purposes. For example to show in routine mode what an aircraft exceeded the permissible level at a point of noise control, to show even why it was exceeded (flight procedure mistake happened or an aircraft type is quite noisy to be operated in particular conditions), any flight safety issues may be raised with monitoring system usage and at the same moment providing confidence to aviation as a whole. A very new challenge should be expected: how to deliver respite from aircraft noise at the airport that is valued by the community, which is consistent with efficient operations?

Conclusions

To confirm this quite evident now precondition it is important to mention that also a vulnerability of the human or/and eco-system under consideration is important to be assessed correctly, in a number of cases the vulnerability is possible to be controlled (not only the exposure being controlled!) to reach a final result of protection from a hazard.

For example, considering noise annoyance, a complementary to BA the community engagement is recommended (ICAO Cir. 351) and EU H-2020 project ANIMA was launched to find the better communication solutions between exposed by noise community and authorities responsible for noise management.

The reviewed and proposed models provide a good model fit and support to the toolboxes of noise annoyance management, currently under the design.

It can be concluded that the concern about the negative health effects of noise and pollution, other environmental issues, are still the subjects of scientific and societal attention, their newish deliverables may improve the approach to build the fifth element of ICAO balanced approach to aircraft noise control around the airports, which cover the measures to reach the final goal of aircraft noise management – to reduce the number of people living in vicinity of the airports and affected by noise.

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Управління ризиками та експозицією впливу авіації на оточуюче середовище

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Анотація. До теперішнього часу аналіз і оцінка експозиції є основою системи захисту навколишнього середовища від діяльності людини, включаючи цивільну авіацію. Всі небезпеки для навколишнього середовища є предметом охорони праці (або транспортування) одночасно. Ризики та їх вплив на здоров'я людини і навколишнє середовище (екосистем) є більш цінною оцінкою, ніж просто аналіз експозиції, наприклад, кількість людей, роздратованих шумом, має більш інформативну цінність, ніж число людей, що піддаються впливу шуму (вище або рівного певному рівню), або просто область, піддана впливу шуму (певного рівня), в безпосередній близькості від аеропорту, що розглядається. У порівнянні з роздратуванням шуму, для якого більш висока експозиція забезпечує більшу кількість роздратованих людей в суспільстві, що піддається впливу, для інших типів чинників ризику також очевидною є серйозність змін здоров'я - аж до раку (наприклад, лейкемія може бути викликана електромагнітним полем). Таким чином, індивідуальні та громадські ризики стають все більш привабливими для процесу прийняття рішень в ряді практичних випадків захисту навколишнього середовища, в тому числі в авіаційному секторі. Щоб підтвердити це, цілком очевидно в даний час є передумова про те, що вразливість людини або / та екосистеми важливо правильно оцінити, в ряді випадків вразливість може бути керованою (не тільки експозицією шуму або іншого контрольованого фактора!). Для досягнення остаточного результату захисту від небезпеки. Наприклад, з огляду на роздратування шумом, на додаток до збалансованого підходу до управління авіаційним шумом рекомендується участь спільноти (ICAO Cir. 351). Для цього був запущений проект ЄС H-2020 ANIMA (Управління впливом авіаційного шуму за допомогою нових підходів), щоб знайти найкраще рішення по комунікації між спільнотою, куди поступає шум, і органами влади, відповідальними за управління шумом.

Ключові слова: оцінка ризику; експозиція; авіаційний шум; неакустичні чинники; індивідуальні ризики; вплив на навколишнє середовище.

Управление рисками и экспозицией воздействия авиации на окружающую среду

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Аннотация. До настоящего времени анализ и оценка экспозиции являются основой системы защиты окружающей среды от деятельности человека, включая гражданскую авиацию. Все опасности для окружающей среды являются предметом охраны труда (или транспортировки) одновременно. Риски и их влияние на здоровье человека и окружающей среды (экосистем) являются более ценной оценкой, чем просто анализ экспозиции, например, количество людей, раздраженных шумом, имеет более информативную ценность, чем число людей, подверженных воздействию шума (выше или равного определенному уровню), или просто область, подверженная воздействию шума (определенного уровня), в непосредственной близости от рассматриваемого аэропорта. По сравнению с раздражением шума, для которого более высокая экспозиция обеспечивает большее количество раздраженных людей в сообществе, подвергающемся воздействию, для других типов факторов риска также очевидна серьезность изменений здоровья - вплоть до рака (например, лейкемия может быть вызвана электромагнитным полем). Таким образом, индивидуальные и общественные риски становятся все более привлекательными для процесса принятия решений в ряде практических случаев защиты окружающей среды, в том числе в авиационном секторе. Чтобы подтвердить это вполне очевидным в настоящее время является предпосылка о том, что уязвимость человека или / и экосистемы важно правильно оценить, в ряде случаев уязвимость может быть управляемой (не только экспозицией шума или другого контролируемого фактора!) для достижения окончательного результата защиты от опасности. Например, учитывая раздражение шумом, в дополнение к сбалансированному подходу к управлению авиационным шумом рекомендуется участие сообщества (ICAO Cir. 351). Для этого был запущен проект ЕС H-2020 ANIMA (Управление воздействием авиационного шума с помощью новых подходов), чтобы найти лучшее решение по коммуникации между сообществом, которое подвергается воздействию шума, и органами власти, ответственными за управление шумом.

Ключевые слова: оценка риска; экспозиция; авиационный шум; неакустические факторы; индивидуальные риски; воздействие на окружающую среду.