Environmental Risk Management of Air-Transport and Airport Development

J. Bera*, L. Pokorádi✈

***Middle-Danube-Valley Inspectorate for Environmental Protection, Nature Conservation and Water Management**
Phone: 30/303 9959, fax: 1/478 4520
e-mail: bera@kdvktvf.kvvm.hu
✈University of Debrecen
Phone: 30/919 4929, fax: 52/418 643
e-mail: pokoradi.laszlo@prosysmod.hu

Abstract: The aviation has environmental risk as well as other forms of transportation. The risk factors shown by data and limiting values represent a danger to environment. These ones de-emphasize considerations that are needful for development of aviation and its complete estimation from point of view of environmental protection. Therefore the Authors would like to review the played down questions mentioned above applying their experiences of environmental protection investigations and risk management.

Keywords: aviation; environmental protection; risk; uncertainty

1. Introduction

Nowadays people opine negatively the aviation from environmental protection point of view albeit that air-transport fulfils global requirements.

Firstly an important fact should be cleared: most people are not there, where they want to be, so people are traveling, more and more distance is wanted to bridge the shortest time, which is no possible without the flight.

The aviation has many advantages compared to other transport sectors. Few of them are: extent of land reservation, the environmental impact of airports covered by their neighborhood, soil loads affect only the area of airport.

Many examples show that the problems of environmental protection can be solved by a series of possible compromises. The problem solving requires a compromise position, and later to maintain a series of decisions, which in itself carries any uncertainty and risk. Its essence has been expressed: How to effectively reduce the uncertainty and risk is inherent in environmental impact assessment?

These questions can arise in case of earlier initiated or long time activities. Therefore, the existing air traffic and airport related development also raises the question of

properly environmental impacts management. The over- or underestimated environmental effects can generate several consequences that are taken up as a mistake. Therefore, the uncertainty and risk management are increasingly linked to environmental protection questions related to the airport and aircraft operation and development processes.

This relationship has other importance. The environment protection should become a requirement system that saves the natural and built environment. This can be realized by the proper management of environmental risks, that requires continuous inspection of risk factors.

The main aims of this paper are to summarize their former environmental protection [1]; [2]; [3] and risk management studies [9]; [10] of the Authors, and to determine their future investigation connected to them in the aviation.

The paper will be organized as follows: Section 2 shows environmental judgment of the aviation. Section 3 presents risk factors of airport development and connection between aviation and its environment. Section 4 words methods of uncertainty analysis in the risk management. Conclusions and future work are provided in the last section.

2. Environmental judgment of the aviation

In our days the enforcement of environmental interests can be approached by two ways. Therefore there are two levels: the *human judgment* and the *natural environment based assessment levels*.

The environmental protection based assessment is important as a decisive factor in the environmental judgment of the aviation-related activities. The term of environmental assessment level has more importance because of the environmental impact of human activities in a modern society form a coherent system. The aviation is an important part of transportation and economy. The Authors have investigated this question in reference [4] in case of noise protection.

The environmental impact assessment is dependent on how the neighborhood affected by flight. The expected reaction of the environment can be used to estimate the frequency of the noise depends on different areas. An example is shown by Figure 1. in which a passenger aircraft noise levels can be seen in cases of a noisy city and quiet residential area background.

Approaching from environmental point of view, the human activity can be investigated as: waste, soil, surface and ground water, air, noise and vibration, nature conservation and built environment protection. There are links between the fields mentioned above, but the environmental impacts are classified separately, by different standards of compliance.

To assess the environmental effects of aviation, the following conclusions can be depicted:

- environmental impact of aviation and its assessment can not be independent of the levels of the environmental assessment;

- the environmental impacts should be rated by only consistent comparison requirements of the different areas of expertise;
- for environmental judgment of aviation the levels of evaluation based analysis that discovers the flight activity and environmental relations can bring good results.

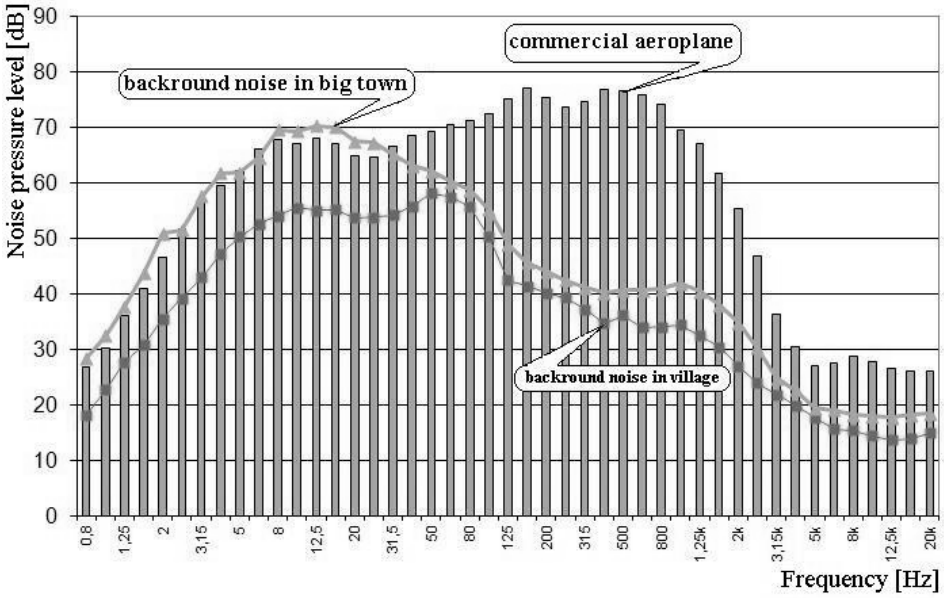

Figure 1. Comparison of aircraft noise and different background values

The key aspect of the environmental assessment should be to collect the important data sets and their application with sufficient accuracy. It is a fundamental base to estimate which will be the real situation?

It is very easy to say that human activities, as the aviation, have significant environmental impact. The environmental impact is a complex and time-varying definitions, which have many factors and these ones should be considered individually and collectively necessary.

If the importance of different environmental effects is examined, the following result can be got:

- in aviation, waste management, soil conservation, surface and ground water protection issues can be treated mean, here we meet with the least conflict;
- protection of nature and the built environment forms a complex problem area because of the uncertainties of the system, the system boundaries and the current neighborhood.

Delineation of the environmental aspects as described above will influence the estimation of effects and the possible outcomes of various events. From point of view mentioned above It is should be investigated, that system excitations and excitations

from neighborhood how generate the environmental loads. Features arise from excitation process, and can affect environmental risk levels are shown by Figure 2.

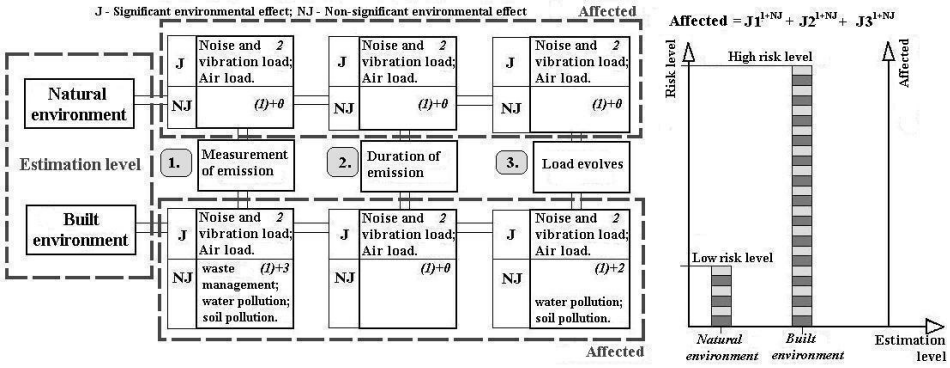

Figure 2. Estimation of risk level depend on affects

3. Risk factors of airport development

The air transport should be renewed from social and economical demands. This regeneration means the development of air traffic and airports. This change is not always the increases of air traffic and the environment load. The modernization can mean upgrading traffic conditions, renewed fleet and technologies.

To understand the environmental impacts – to determine influences from airport development exactly –, various model and mathematical modeling procedures should be applied. For this modeling, measured data, empirical information and exact conclusions should be used.

The mathematical model is the mathematical equation or system of equations which describes the internal principles of the process occurring on the system from the point of view of the given investigation [11]. On the one hand the real systems are precise, but complex. Additionally the large-scale systems consist of large number of inter-related subsystems. On the other hand, the mathematical model should be simple therefore may be imprecise. Mathematical modeling and simulation of complex technical systems, such as the aviation, must include the nondeterministic features of the modeled system and its environment or human interaction with the system [8]. These nondeterministic features mean that the response of the system cannot be predicted precisely because of the existence of uncertainty in the system or the environment [7].

The air traffic and airport create a complex system which can be determined with relative accuracy. The uncertainty arises when the system boundaries are changing due to environmental effects. What does the uncertainty resulting from the system boundary mean? The answers to these lists are given in a summary way:

- Appropriate and sufficient accurate data should be used to determine the boundaries of the system. Their absence results distorted system boundaries.
- It has to be determined what aspects are used to depict environmental requirements.

- The prescribed threshold values where and what times must be met? Without them depiction of system boundary is impossible.
- Local or larger effects are investigated?
- How much and what kind of change are in environmental conditions?

For example, evaluation and estimation process of flying noise shows the uncertainty arising from the system and environment relationship. This is a time-varying environmental load, which increases the number of risk factors. The value of noise load depends on the flight parameters such as system characteristics, and also excitation from the environment. The aircraft noise load can be determined by the equation:

$$L_{AM,re} = 10 \cdot \lg \frac{\tau_{ref}}{T_M} \cdot M \cdot 10^{0,1 \cdot L'_{AX}} \left[dB\right] \quad (1)$$

where: $L_{AM,re}$ – equivalent A-weighted sound pressure from flying [dB]; T_M – reference time; τ_{ref} – 1 s; M – number of flying operations; L_{AX} – average sound pressure[4].

From equation (1) numerous important statements can be formulated. For example, the reference time T_M is 16 hours in the day-time, and 8 hours at night-time.

4. Investigation of uncertainty

One of the most widely recognized distinctions in uncertainty types is between aleatory and epistemic ones [6].

Uncertainties are characterized as epistemic or model, if the modeler sees a possibility to reduce the model by gathering more data or by refining models. Epistemic uncertainty derives from some level of ignorance of the physical process, the system or the environment. Experts use the term epistemic uncertainty to describe any lack of knowledge or information in any phase of the modeling and model application. During modeling of a large-scale or a system of systems, the complexity can be a significant problem. Complexity involves the number of degrees of freedom in a system and how the parameters that express the degrees of freedom interact. When systems become too complex to deal with all parameters directly, simplification of one or more parameters is necessary. The result is a simplified model, a simply abstraction of the studied system, which has epistemic uncertainty.

The epistemic uncertainty may be comprised of substantial amounts of both objectivity and subjectivity. Some of types of epistemic uncertainty sources that can occur in technical systems simulation include:

- false knowledge of system or its environment;
- incorrect application of scientific laws;
- selecting the appropriate model formulation;
- model generalization;
- model reduction;
- linearization.

Aleatory or parameter uncertainty pertains to random chance and may only be quantified statistically. Also referred to as irreducible uncertainty, this type cannot be

reduced by the addition of more knowledge. The natural variability of the physical properties of the system or its environment typifies sources of aleatory uncertainty. In engineering, this type of uncertainty is usually represented by a random variable or a probability distribution.

Aleatory uncertainty is primarily associated with objectivity. Its possible „engineering“ sources:

- incorrect measuring;
- measuring noises;
- discretization;
- strong statistical information;
- sparse statistical information;

From practical engineering point of view, probabilistic uncertainty investigation set two problems. Firstly, the parameters of probability distributions of independent variables can be determined by any statistical method, therefore they have so-called second-order uncertainties. Secondly, from mathematical point of view, the domain of variability of probability distributions is basically infinity.

In the Fig. 3. there are two possible paths are shown as right and left downward arrows.

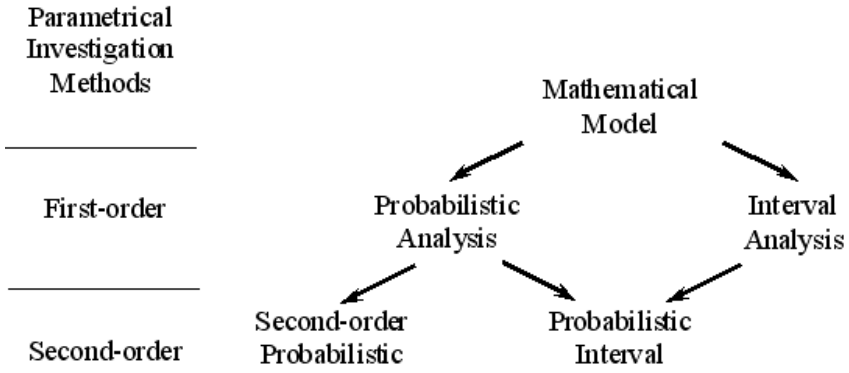

Figure 3. Relationships among Different Uncertainty Investigation Methods

To answer the first question mentioned above, the left one shows a probabilistic uncertainty analysis of a probabilistic calculation. The resulting analysis would be a second-order probabilistic assessment.

Another derived method applies bounding arguments to the probabilistic calculation and arrive at interval versions of probability distributions. The second problem mentioned above can be answered by this method. Therefore the infinity of variability of probability distributions is impossible in engineering practice. Ferson and Tucker call such calculations PBA [5]. This approach represents the uncertainty about a probability distribution by the set of cumulative distribution functions. PBA is an uncertainty analysis of a probabilistic calculation because it defines neighbourhoods of probability distributions.

One of the most well-known probabilistic uncertainty investigation methods is the Monte Carlo simulation. The "classical" Monte Carlo simulation is used as an uncertainty analysis of a deterministic calculation because it yields a distribution describing the probability of alternative possible values about the nominal (designed) point.

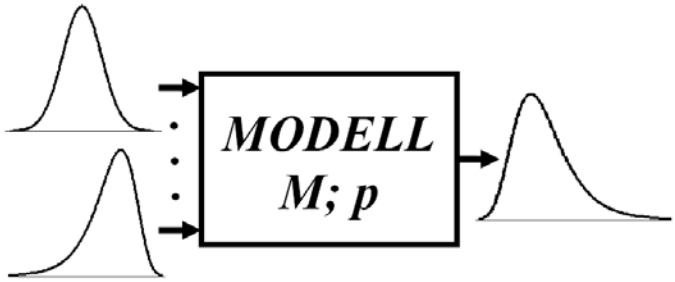

Figure 4. Monte-Carlo Simulation

5. Conclusions, future works

The environmental impacts of air traffic are many sources of conflicts. The flight parameters uncertainties create uncertainties of environmental impact assessment automatically. This is a risk factor during the investigation of airport operations and development. Risk factors of airport development closely associated with the system and system-environment relationship that is risk and uncertainty too. Therefore, the airport development process can be controlled by tools of risk assessment methodology

Authors plan the future scientific investigation based on their earlier work and results of other related scientific activities. Their aims are to develop risk and uncertainty analysis methods and procedures, which greatly assist environmental experts and decision makers. For example accomplishment a Monte-Carlo Simulation-based method to estimate impacts of changing the flight parameters and neighborhood characteristics to noise loads of a heliport.

References

[1] Bera J.: *Repülési zaj értékelése*, Műszaki Tudomány az Észak Alföldi Régióban (2007), pp. 5-14. http://store1.digitalcity.eu.com/store/clients/release/musz_fuz_jo_04.pdf

[2] Bera J.: *Repülőtér létesítés és környezeti zajvédelem*, Repüléstudományi Közlemények Különszám, , Szolnok, (2009). http://www.szrfk.hu/rtk/kulonszamok/2009_cikkek/Bera_Jozsef.pdf

[3] Bera J.: *Ipari helikopteres repülés környezeti hatása*, Műszaki Tudomány az Észak Alföldi Régióban, (2010), pp. 89-94., www.mfk.unideb.hu/mszb/muszfuz.

[4] Bera J., Pokorádi L: *Helikopterzaj elmélete és gyakorlata*, Campus Kiadó, (2010).

[5] Ferson S., Tucker W. T.: *Sensitivity analysis using probability bounding*, Reliability Engineering and System Safety 91 (2006) pp. 1435-1442.

[6] Möller B., Beer M.: *Engineering Computation under Uncertainty – Capabilities of Non-traditional Models*, Computers & Structures. Vol. 86, Issue 10, (2008), pp. 1024-1041.
[7] Oberkampf W.: *Error and Uncertainty in Modeling and Simulation*. Reliability Engineering & System Safety Vol. 75. (2002) pp. 333-357.
[8] Perincherry V.: *Uncertainties in the Analysis of Large-Scale Systems, Uncertainty Modeling and Analysis*, Proceedings Second International Symposium (1993), pp. 216-222.
[9] Pokorádi L., Madarász L.: *Kockázati tényezők és kockázatkezelési példák a katonai repülésben*, Új Honvédségi Szemle, Budapest, 1999/12, pp. 7-16.
[10] Pokorádi L.: *A repülőterek körüli madárveszély vizsgálata*, Haditechnika, Budapest, 2005/4, pp. 16-20.
[11] Pokorádi L.: *Rendszerek és folyamatok modellezése*, Campus Kiadó, Debrecen, (2008).