PROCEEDINGS

of the

13th MINI CONFERENCE ON VEHICLE SYSTEM DYNAMICS, IDENTIFICATION AND ANOMALIES

Held at the

Faculty of Transportation Engineering
Budapest University of Technology and Economics, Hungary
BUDAPEST, 5-7 November, 2012

Edited by Prof. I. Zobory

VSDIA 2012

BUDAPEST UNIVERSITY OF TECHNOLOGY AND ECONOMICS

THE CONFERENCE ORGANISING COMMITTEE GRATEFULLY ACKNOWLEDGES THE GENEROSITY OF THE FOLLOWING ***MAJOR SPONSORS*** AND SPONSORS:

BME Faculty of Transportation Engineering and Vehicle Engineering,
BME Department of Railway Vehicles and Vehicle System Analysis,
Knorr-Bremse Railway Vehicle Systems Hungária Ltd.,
Knorr-Bremse R&D Institute, Budapest,
Knorr Bremse Kecskemét Ltd.,
BKV Budapest Mass Transport Ltd.,
Grampet Debrecen Wagon Factory Ltd.,
AVL Autoku Ltd.,
Bombardier MÁV Ltd.,
MÁV Wagon Ltd.

The Organising Committee thanks the authors for their efforts in providing the electronic version of the full paper manuscripts. Issued by the ***Department of Railway Vehicles and Vehicle System Analysis at the BME***, Budapest, 2012. **ISBN 978-963-313-102-2**

ASSESSMENT OF HELIPORT NOISE EMISSION

László POKORÁDI[+] and József BERA[*]

[+]University of Debrecen, H-4228 Debrecen, Ótemető u. 2-4. Hungary
[*]Middle-Danube-Valley Inspectorate for Environmental Protection, Nature Conservation and Water Management, H-1447 Budapest PBox 541

Received: November 7, 2012

ABSTRACT

Nowadays, number of helicopter flights increases over living spaces. It calls for more and more heliports, for example in hospitals. During planning and localization of heliports noise protection questions have to be observed. It is possible that number of takes off and landings should be limited, or flight paths have to be determined strictly. Therefore preliminary assessment of flying noise emission of heliports has to be done in the planning phases. During preliminary modeling the estimators meet model uncertainties. Their reasons can be data inaccuracy from various numbers of operations, different helicopters, and different meteorological and other environmental effects. The paper will show a new noise emission assessment method that takes account of the uncertainties mentioned above.

Keywords: Environmental protection; Noise emission; Helicopter; Monte-Carlo Simulation

1. INTRODUCTION

Nowadays, number of helicopter flights increases over living spaces. It calls for more and more heliports, for example in hospitals. During planning and localization of heliports noise protection questions have to be observed. It is possible that number of takes off and landings (flying operations) should be limited strictly. The noise load is developed around heliports and its investigation methods are determined by background noise and landing procedure. The noise protection questions can be very important ones of heliport noise increases by leaps during a hort-time cultural, political or sport event. In this situation the organizers should estimate the possible noise emission and they have to manage the ecpected problems during planning and organization of event. This paper proposes a new simulation method to solve the question mentioned above.

The Authors have been investigating noise protectional questions of helicopters and aeriel and other tipes of transportation [1], [2], [3], [4], [5], [6] and [7]. Newman and Barkema show the Monte-Carlo Simulation and its possibilities of use to investigate several scientific problems. Pokorádi has summarized theoretical background of mathematical modelling of technical systems and processes [9].

The outline of the paper is as follows: Section 2 shows the environmental aspects of heliport noise emission. Section 3 depicts the Monte-Carlo Simulation. Section 4 demeonstrate as assessment method of heliport noise emission used Monte-Carlo Simulation. Section 5. summaries the paper, outlines the prospective scientific work of the Authors.

2. ENVIRONMENTAL RESPECTS OF HELIPORT NOISE EMISSION

The environmental effects of heliport are identified basically as noise load. The other effects (e.g. air- and soil pollution) are not investigated in case of normal operation. The noise load of aviation is a very important question which can be determined by following equation [7]:

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

where:

$L_{AM,re}$ – authoritative acoustical pressure level occurred from aviation[dB];
$\tau_{ref.}$ – 1 s;
T_M – estimating time [s];
M – number of flying operations;
L'_{AX} – average noise load [dB].

The application of equation (1) is prevail in Hungary end European Union. This equation will be used during this investigation to estimate heliport's noise load of a planed event. This method has respect to number of flying operations and (8 or 16 hours long) estimating time, not only the average noise loads. This average value differs from short time noise loads occurred from flying. These differences are shown by Figure 1.

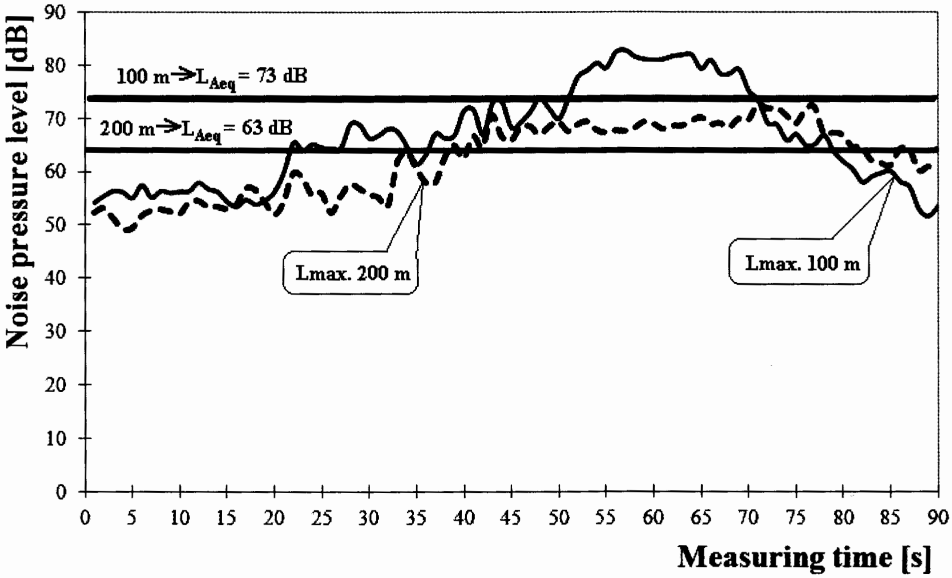

Figure 1. Noise Load – Time Function in Cases of Different AGLs (source: [1])

3. THE MONTE-CARLO SIMULATION

One of the most well-known probabilistic parametric uncertainty investigation methods is the Monte-Carlo Simulation. The „classical" MCS 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.

The idea of the Monte-Carlo calculation is much older than the computer. The name "Monte-Carlo" is relatively recent — it was coined by Nicolas Metropolis in 1949 — but under the older name of "statistical sampling" the method has a history stretching back well into the last century, when numerical calculations were performed by hand using pencil and paper and perhaps a slide-rule. An early example of what was effectively a Monte-Carlo calculation of the motion and collision of the molecules in a gas was described by William Thomson (Lord Kelvin) in 1901 [8]. Thomson's calculations were aimed at demonstrating the truth of the equipartition theorem for the internal energy of a classical system. The exponential growth in computer power since those early days is by now a familiar story to us all, and with this increase — in computational resources Monte-Carlo techniques have looked deeper and deeper into the subject of statistical physics. The Monte-Carlo simulations have also become more accurate as a result of the invention of a new algorithm.

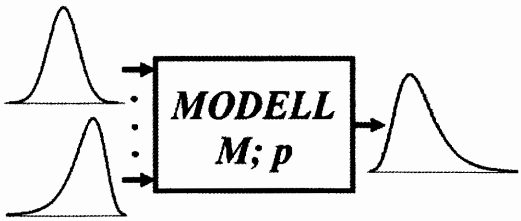

Fig. 2. The Monte-Carlo Simulation (source: [9])

The body of this simulation is that values of uncertain input variables are chosen randomly based on taken probability distributions. Using aforementioned input data determined above as excitation values solving the mathematical model to get an output of system (see Fig. 2.). The system behavior can be characterized by statistical analysis.

The biggest advantage of the Monte-Carlo Simulation is that it does not require complex and complicated analytical model investigations. Its disadvantage is that the mathematical model of investigated system should be solved scores of times to get acceptable population for statistical analysis which should require prolonged computing time.

The main step of Monte-Carlo Simulation is the random variables generation. Basically three generation methods are used:

- Inverse Transform Method;
- Composition Method;
- Acceptance–Rejection Method.

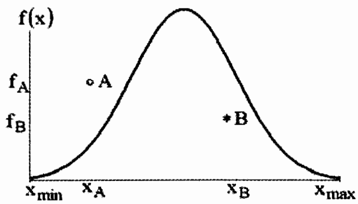

Fig. 3. Ilustration of Acceptance-Rejection Method

During our investigation the Acceptance–Rejection (Hit and Miss) Method was used. This method is due to von Neumann and consists of sampling a random variate from an appropriate distribution and subjecting it to a test to determine whether or not it will be acceptable for use.

Firstly the f(x) probability density function and interval of the generated parameter should be determined (see Fig. 2.). They can be defined by statistical investigation of the real measured data or they can be assumed by preliminary experiences.

Then two independent random values x from $[x_{min}; x_{max}]$ and y_x from (0; 1) intervals are generated, and test to see whether or not the inequality

$$y_X < f(x) \ . \tag{2}$$

holds:

- if the inequality holds, then accept x as a variate generated from f(x) (see B point in Fig. 3.);
- if the inequality is violated, reject the pair x, y_x (see A point in Fig. 3.) and try again.

The Acceptance-Rejection Method, which is simple to implement and can generate random numbers according to any distribution, whether it is integrable or not. The method has some drawbacks, however, which make it inferior to the transformation method in case integrable functions.

4. MONTE-CARLO SIMULATION OF HELIPORT NOISE EMISSION (CASE STUDY)

If there is common air-transport, the numbers of operation of the investigated heliport are between 1 and 5, and their distribution is approximately uniform one. The noise levels generate by helicopters use the heliport are between 78 and 89 dB. From a simply statistical analysis it is verifiable, that they have normal distribution parameters of which can be seen in Table 1.

During a planed two-day sport event the number of operation of heliport will increase to 6 – 10. The tasks were the followings:

- to determine the measure of noise load during the event;
- to estimate the probability of that noise load will be more then 65 dB.

The Authors solved these tasks by Monte-Carlo Simulation.

4.1 The Simulation

During the investigation the Eq. (1) was the deterministic model which has been excited by different M numbers of operation and L'_{AX} average noise levels. The histograms of applied excitation values can are shown by Figs 4–6. The Figs. 7 and 8 demonstrate histograms of the "base" and "event" simulated noise loads.

	Minimum	Mean	Maximum	Deviation
$L'_{AX-measured}$ [dB]	78	84	89	1.830
$L'_{AX-excited}$ [dB]	78.031	84.083	89.362	1.782
M_{base}	1	2.958	5	1.404
$L_{AM,re-base}$ [dB]	44.900	52.673	60.100	3.100
M_{event}	5	7.98	10	1.148
$L_{AM,re-event}$ [dB]	39.100	59.878	85.400	9.223

Table 1. Statistical Data of Simulation

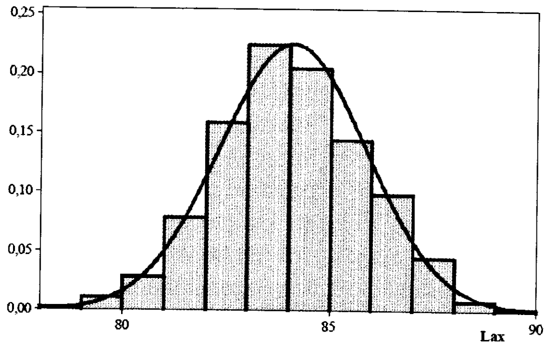

Fig. 4. Histogram of Average Noise Levels ($L'_{AX-excited}$)

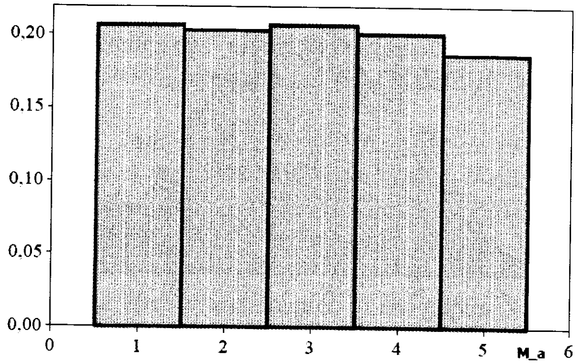

Fig. 5. Histogram of „Base" Numbers of Operation

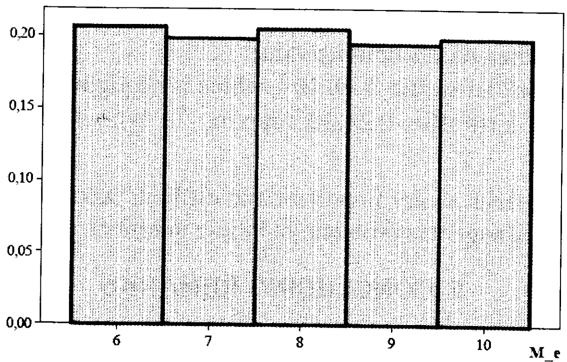

Fig. 6. Histogram of „Event" Numbers of Operation

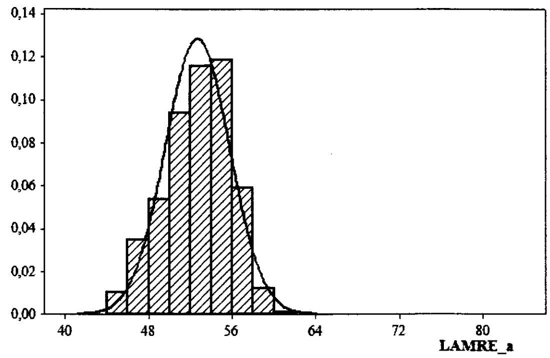

Fig. 7. Histogram of „Base" Noise Loads

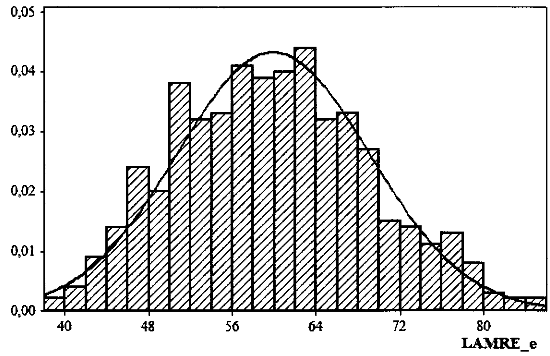

Fig. 8. Histogram of „Event" Noise Loads

4.2 Discussion of Simulation's Results

The results of simulations are shown by Fig. 7–8. and Table 1. Using these data — assuming normal distributions — the probability of noise loads raised by investigated heliport can be more then 65 dB limiting value:

- in case of "common" air-traffic, 3.48 10^{-5}, which is negligible;
- in case of "event" air-traffic, 0.28885 (approx. 29 %), which means considerable problems.

The last conclusion means a very important and difficult task for organizers of planed event. They have to manage this problem, but these questions go beyond of this study.

5. CONCLUDING REMARKS

This paper proposed a Monte-Carlo Simulation-based method to investigate noise load of heliports and airports. The proposed method can be used to simulate and estimate enviromnetal effects of a planed or to-come cultural, political or sport event. During prospective scientific research related to this field of applied mathematics and environmental protection. The Authors would like to work out other methodologies to model and investigate environmental effets of aviation and other transportation types.

6. REFERENCES

[1] **Bera J.**: Noiseprotectional Designe of Heliports, Repüléstudományi Közlemények Különszám, 2007. április, Szolnok. (CD-version) (in Hungarian) http://www.szrfk.hu/rtk/kulonszamok/2007_cikkek/bera_jozsef.pdf.

[2] **Bera J. - Pokorádi L.**: Actual Question of Measuring of the Aircraft Noise, The Challenge of Next Millennium on Hungarian Aeronautical Sciences (12th Hungarian Days of Aeronautical Sciences), p.114–123.

[3] **Bera J. - Pokorádi L. – Szabolcsi R.**: Investigation of the Helicopter Noise, Proceedings of 22nd International Congress of Aeronautical Sciences, ICAS 2000, Harrogate, 2000., p 801P.1–801P.2. (CD-version).

[4] **Bera J. - Pokorádi L.**: Noise Effect of Building Installation, Instalaţii Pentru Construcţii şi confortul ambiental, Conferenţia cu participare internaţională. Temesvár, Románia, 2008.04.17-2008.04.18. Temesvár, 2008, p. 498-506. (ISSN 1842–9491

[5] **Bera J. - Pokorádi L.**: Noise Protection Investigation of Heliports, Proceedings of the 11^{th} Mini Conference on Vehicle System Dynamics, Identification and Anomalies, Budapest, 10-12 November, 2008, (ISBN 978 963 313 011 7), p.577–581.

[6] **Bera J. - Pokorádi L.**: Industrial Helicopter Application and its Noise Protection Problems, Proceedings of the 12^{th} Mini Conference on Vehicle System Dynamics, Identification and Anomalies, (Ed. by Prof. I. Zobory), BME Dept. of Railway Vehicles and Vehicle System Analysis, Budapest, 2011, p. 343 – 350, ISBN: 978 963 313 058 2,.

[7] **Bera J. - Pokorádi L.**: Theory and Practice of Helicopter Noise, Campus Kiadó, Debrecen, 2010. 192 p. (in Hungarian)

[8] **Newman M.E.J., Barkema G.T.**: Monte-Carlo Methods in Statistical Physics, Oxford University Press Inc., New York, 1999. pp. 475

[9] **Pokorádi, L.**: Systems and Processes Modeling, Campus Kiadó, Debrecen, 2008, p. 242. (in Hungarian)