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SUPPORT AND ORIGINAL CONTRIBUTIONS TO AIRPORT NOISE MONITORING

Adina IONESCU[1], Nicolae ENESCU[2], Ioan MAGHETI[3], Silviu IONESCU[4]

Creşterea traficului aerian din ultima perioadă a condus la creşterea reclamaţiilor de zgomot. Necesitatea monitorizării aeroportuare nu derivă doar din reclamaţii, ci şi pentru a demonstra deschiderea autorităţilor aeroportuare către comunitatea din vecinătatea aeroportuară.

Lucrarea prezintă cerinţele de monitorizarea acustică aeroportuară, aspectele teoretice legate de indicii necesari a fi monitorizaţi, precum şi o nouă aplicaţie software dezvoltată de către autori pentru vizualizarea şi raportarea datelor monitorizate.

La sfârşitul lucrării vor fi oferite concluziile cercetării efectuate şi vor fi identificate noi posibilităţi de îmbunătăţire ale aplicaţiei software.

The air traffic growth known in the latest period bring an increase of complaints on aircraft noise. Therefore, the need for noise emissions monitoring in the vicinity of the airport becomes necessary not only because of legislation, but also to demonstrate the airport opening to the community.

The paper illustrates the legal requirements for unattended airport noise monitoring, theoretical aspects of the noise indices and a new airport noise monitoring software – MyANMS, developed by the authors.

Further software improvements will be identified at the end of the paper and also conclusions will be offered.

Keywords: airport noise, monitoring, software

1. Introduction

Airport noise monitoring is necessary to all airports for the reason that it offers information regarding the real noise situation in the airport vicinity. Thanks to airport noise monitoring we can control, manage and reduce the aircraft noise impact on communities [1]. The issue between community and airport is not easy to be solved. Usually, the airports are under a continuous development due to

[1] Eng., Acoustics and Vibrations Laboratory, COMOTI-Romanian R&D Institute for Gas Turbines, Romania, e-mail: adina.ionescu@comoti.ro

[2] Prof., Department of Mechanics, University POLITEHNICA of Bucharest, Romania, e-mail: nae_enescu@yahoo.com

[3] Prof., Department of Mechanics, University POLITEHNICA of Bucharest, Romania, e-mail: ioan_magheti@yahoo.com

[4] Eng., Acoustics and Vibrations Laboratory, COMOTI-Romanian R&D Institute for Gas Turbines, Romania, e-mail: silviu.ionescu@comoti.ro

the air traffic growth, and the cities are expanding many times by creating residential areas in very close vicinity of the airports. Starting from those aspects, it is hard to outline a “win-win” situation for both parts. Many times the community is more affected by the road traffic, but the impossibility to submit any charges against the drivers, makes the community to focus to the airport noise. The airport noise monitoring helps airports by identifying the real noise sources. It is obvious that each airport wants such systems, but they are expensive, need maintenance and qualified personnel, so, it a big investment and periodical costs are needed. Beside the high costs of the monitoring system there are also issues regarding the flight parameters (ex. flight path), which are necessary to identify the source and its origin [2][3][4]. The existence of flight data allows the exact identification of the aircraft type and call sign and its flight trajectory, in such manner that we can make the correlation between the claim and what has caused this complaint, and if it is a matter of not respecting the flight trajectory the airline can be made responsible. The flight data are not easy to be obtained; they are managed by the air traffic services administrations, and are not public.

The objective of this paper is to present the research results obtained in the frame of the PhD thesis entitled “Contribution on airport noise monitoring and noise reduction in surroundings areas”, especially the new software application developed for real-time noise and air traffic monitoring, storage, processing and reporting purposes.

In the European market different software applications, which are offering a continuous and real-time monitoring process already exists. These are accessible through Bruel&Kjaer, Accon, DataAcoustic and Anotec Consulting.

The necessity to develop a new software application comes from the fact that small airports need a monitoring system which implies reduced costs.

2. Airport noise monitoring requirements

The minimum requirements to perform an accurate monitoring according with International Standard entitled “Unattended monitoring of aircraft sound in the vicinity of airports”, ISO 20906, from 15.12.2009 [5] can be categorized in different divisions. Combined with these requirements some author’s recommendations are presented:

a) ***Equipments***

For aircraft sound monitoring each measurement channel of the complete automated sound monitor, arranged as for normal use, shall conform to the electro-acoustical performance specifications of IEC 61672-1 for class 1 sound level meter. The sound monitor shall provide measurements of A-weighted measurement quantities.

The entire microphone assembly as used in normal operation (e.g. microphone, preamplifier, rain protection, windscreen, microphone device support, anti-bird devices, lightning conductor and any calibration device) shall fulfil the following requirements: the lightning conductor shall be at least 0.5 m from the microphone; all other devices (e.g. anemometer) shall be at least 1 m below the microphone and at least 1.5 m horizontally from the microphone support mast.

b) ***Sound-monitoring site selection***

Sites for unattended measuring microphones shall be chosen to minimize the effect of residual sound (e.g. from non-aircraft sound sources).To provide reliable event detection sites should be selected such that the maximum sound pressure level of the quietest aircraft to be detected is at least 15 dB greater than the residual long-term-average sound pressure level.

As a minimum requirement, all acoustically relevant surfaces other than the ground shall be at least 10 m away from the microphone, in order to provide minimum uncertainty in the sound level measurements. The standard microphone height shall be at least 6 m above ground. To minimize interference effects with ground reflections, microphone heights higher than 6 m are recommended, up to a 10 m height.

Sites for unattended measuring must be positioned under the corridor in the sky which includes the greatest portion of all the flight paths of the aircraft movements to be monitored. The site selection for unattended monitoring optimal decision is facilitated if the noise contours of the area are available (noise map) [6], calculated with real air traffic and with the real trajectories. Their availability allows minimizing the number of monitoring positions.

The noise monitoring systems can be permanent or temporarily. It is recommended that at least two permanent stations will be installed on each side of the runway, near to the closest residential area which is located under the flight trajectory path. In addition to the two permanent stations at least four temporary stations will be located [7].

c) ***Monitoring periods***

The monitoring periods are depending on their purpose. If it is aimed to monitor specific events (e.g. the approach procedure is changed and is wanted to quantify the differences between noise levels of the previously procedure and the new one), than the monitoring period is limited on the event period.

d) ***Preferred measured quantities***

The sound monitor shall measure continuously and shall display on demand the A-weighted sound pressure levels of the total sound in the form of time-series of 1 s. A sound event is characterized by the sound exposure level, L_{AE} and the maximum sound pressure level, $L_{p,Aeq,1s,\max}$. Also the A weighted equivalent continuous sound pressure level on one hour, L_{day}, $L_{evening}$, L_{night}, L_{dn}

and L_{den}, like they are defined in ISO 1996-1[8]. The sound pressure level range of the sound monitor shall be at least from 30 dB to 120 dB. The linear operating range shall be at least 60dB at 1 kHz.

The meteorological conditions shall be measured (e.g. wind speed, air temperature, relative humidity, occurrence of precipitation) and the hourly average values should be provided.

3. Theoretical features regarding the noise indices required to be measured

The formulae used to calculate indicators of noise [9], [10], [11]:

L_{AE} – Sound exposure level;

$$L_{AE} = 10 \cdot \log_{10}\left(\sum_{k=t_1}^{t_2} 10^{\frac{L_{Ak}}{10}}\right); \text{[dBA]} \quad (1)$$

or

$$L_{AE} = 10 \cdot \log_{10}\left(\frac{\int_{t_1}^{t_2} p^2(t)dt}{p_0^2}\right); \text{[dBA]} \quad (2)$$

p – Sound pressure A weighted;

p_0 – Reference value of the sound pressure $= 2 \cdot 10^{-5}$ Pa.

The sound exposure level also can be expressed by:

$$L_{AE} = L_{AeqT} + 10 \cdot \log_{10}(t_2 - t_1); \text{[dBA]} \quad (3)$$

L_{AeqT} – Equivalent continuous sound pressure level (time-averaged sound pressure level) for a period of time T is:

$$L_{AeqT} = 10 \cdot \log_{10}\left(\frac{1}{T}\sum_{k=t_1}^{t_2} 10^{\frac{L_{Ak}}{10}}\right); \text{[dBA]} \quad (4)$$

or

$$L_{AeqT} = 10 \cdot \log_{10}\left(\frac{\frac{1}{T}\int_{t_1}^{t_2} p^2(t)dt}{p_0^2}\right); \text{[dBA]} \quad (5)$$

p – Sound pressure A weighted;

p_0 – Reference value of the sound pressure $= 2 \cdot 10^{-5}$ Pa.

Noise level for day, evening and night can be expressed:

$$L_{den} = 10 \cdot \log_{10}\left[\frac{1}{24}\cdot\left(12\cdot 10^{\frac{L_{day}}{10}} + 4\cdot 10^{\frac{L_{evening}+5}{10}} + 8\cdot 10^{\frac{L_{night}+10}{10}}\right)\right]; \text{[dBA]} \qquad (6)$$

The periods used to determine L_{day}, $L_{evening}$ and L_{night} are:
L_{day} → 07,00 : 19,00;
$L_{evening}$ → 19,00 : 23,00;
L_{night} → 23,00 : 07,00.

In fact the L_{day}, $L_{evening}$ and L_{night} are equivalent continuous sound pressure levels calculated for the above mentioned periods.

4. Original contributions regarding a new airport monitoring software

The motivation to develop a noise monitoring software is based on the fact that all the existent software applications on the market are dedicated to some equipments, being available only at acquiring the entire system (hardware and software). Due to this aspect, the aircraft noise monitoring is accessible only for major airports.

„MyANMS" – My Aircraft Noise Monitoring Software is designed to be compatible with all acoustic equipments from the market which have the possibility to store data in real time in *.txt files or directly in a databases (MySQL). Also this application is designed to be used freely by users, only ensuring the acoustic equipments, a command and control unit (server unit and a PC for visualisation) and implementation and regular maintenance costs. In this way, significantly reducing costs for monitoring is achieved due to the fact there are airports that have equipments, but they don't have software application to enable online measured data viewing and automatically generate reports.

To prevent this situation, MyANMS provides all this features, without involving costs for a new noise monitoring system.

MyANMS is developed for the following function:

- Getting noise and radar data from equipments;
- Storing them in MySQL databases;
- Online visualisation of data through interactive website with user friendly interface;
- Site position configuration and quick search in databases;
- Automatic post-processing and reporting function accordingly with ISO 20906:2009.

The following applications have been used to develop MyANMS: Quanta Plus, HTML, PHP, Unix Shells (Bourne Shell or Shell), Python, MySQL and 3D view Google Earth Plugin. To realize the graphical design, Gimp and Inkscape have been used. All these applications are free for use and are under the „General Public Licence" agreement.

The MyANMS topological scheme is presented in Fig. 1.

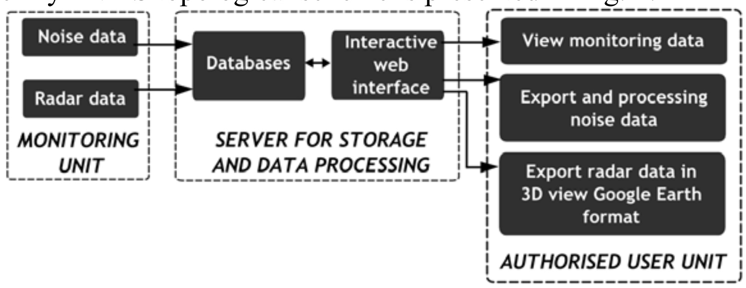

Fig. 1. My Aircraft Noise Monitoring Software topological scheme

MyANMS is developed to run on a UNIX or Linux server in order to store and proces noise and radar data and it is composed by the following programs which are interacting between them:

- **myanms** → Shell script to manage all system scripts;
- **radar.py** → Python script to extract radar data and store them in the MySQL databases;
- **micn.py** → Python script to extract noise data and store them in the MySQL databases;
- **gokml.py** → Python script to transform the radar data in the *.kml format and to update in real-time the web interface;
- **dbproc.py** → Python script for daily post-processing and reporting data of the stored parameters;
- **myanms_web-1.0** → interactive web interface realized in QuantaPlus, based on HTML and PHP language.

The **myanms** shell script was developed to check periodically other scripts status in background and to take action in different situations when a network connection problem appears. In the same time the **myanms** shell script is interacting with the **myanms_web-1.0** interface which takes the user input configuration and also the user input for post-processing requests. The input options of the authorized user are the following: disable/enable individually a script, applying the microphones coordinates, applying the IP address and each equipment TCP port, acting like a remote host.

The **radar.py** script is communicating with **myanms** in order to take the remote host configuration (user input), to initialize the connection and to extract in real-time all data received from active aircrafts. The extracted data are primarily saved into a MySQL database having as table destination the present day, and also a secondary database is used to save only active movements for real-time visualisation.

The **micn.py** script is communicating with **myanms** in order to take the microphones coordinates (user input), to take the remote host configuration, to initialize the connection and to extract in real-time the noise components of the

1/3 octave spectrum. Once data are extracted, the weighted curve A is first applied and then the global noise level for a second sample is calculated. Data are primarily saved into a MySQL database having as table destination the present day. A secondary database is also used to save only the global weighted noise level A at each second for real-time visualisation.

The **gokml.py** script is interacting with **radar.py** and **micn.py** for the secondary database in order to take the real-time data of active aircrafts respectively the real-time data of the noise levels with microphones coordinates. Data with active aircrafts and noise levels is then exported in real-time into a kml format for Google Earth Plugin which gives a very nice 3D view in the **myanms_web-1.0** interface.

At the end of each day, the **dbproc.py** script is starting automatically. The python script dbproc is a strong algorithm for post-processing of noise indicators according to ISO 20906:2009. The script is also interacting with **myanms** in order to start/stop or remove a post-processing for a specific day (user input). The algorithm takes all data from a day table, calculates the noise indicators for each microphone, identifies all noise events and correlates them with radar data in order to have aircraft noise information. The aircrafts events are then calculated and all the results are saved in a HTML format, in order to be accessed from the explore page of **myanms_web-1.0** interface by the user.

The **myanms_web-1.0** interface makes possible for the authorized users to control and visualise in real-time the **myanms** scripts, also to view or export the daily reports in a friendly graphic user interface.

The detailed scheme of the interaction between **myanms** scripts is presented in Fig. 2. It must be mentioned that all the remote equipments are synchronising the time over a NTP server service which runs on the same UNIX machine of MyANMS software.

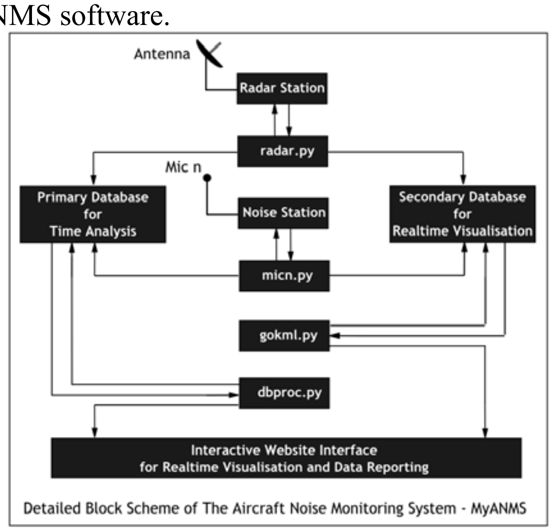

Fig. 2. – MyANMS scripts interaction ways bloc scheme

The connexion between MyANMS and equipments can be performed through local network (Fig. 3) or using a secured Virtual Private Network (VPN) connexion (Fig. 4).

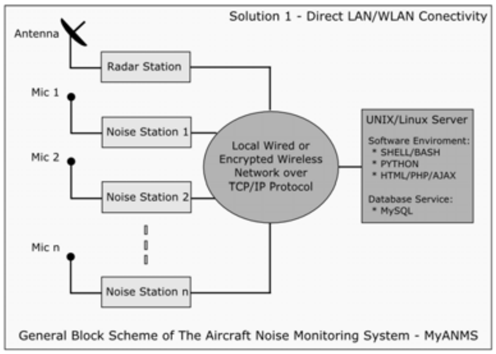

Fig. 3. Local network monitoring system scheme

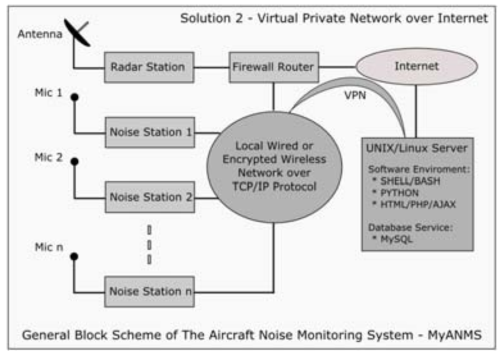

Fig. 4.VPN monitoring system scheme

Fig. 5 presents one print screen of the MyANMS web interface.

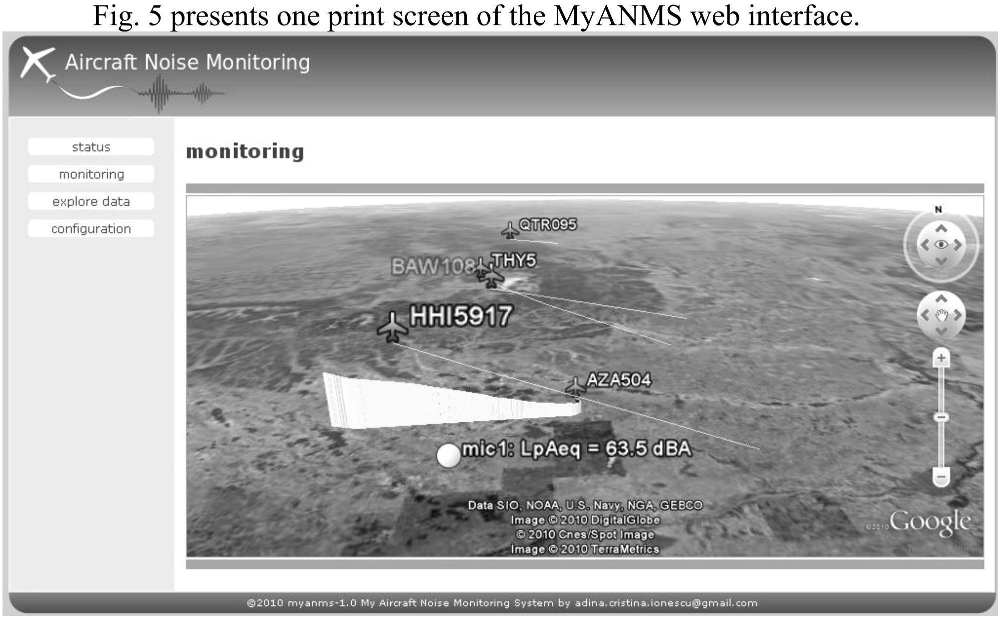

Fig. 5. MyANMS Software - 3D monitoring page

5. Discussions and Conclusions

MyANMS is a new software application for visualisation, storage and processing aircraft noise and radar data developed under the PhD thesis entitled: “Contribution on airport noise monitoring and noise reduction in surrounding areas”. The application can be used freely by third party beneficiary only ensuring the equipments and implementation and periodically maintenance costs.

In future MyANMS can be improved with the following features:

- Validation of the software application by performing an acoustic monitoring study case using in parallel another software agreed by the airport authorities. This step was impossible to be accomplished due to the fact that the research carried out in the frame of the PhD thesis doesn’t have any financial support;
- Extendion of the capabilities to automatically perform noise contours based on the real measured data (both air traffic and noise);
- Implemention of the software for industrial application.

In order to improve MyANMS the authors are aspiring to attract research funds either by submitting proposal for new research projects or by airport authorities which are willing to support Romanian research.

The following original aspects of the paper can be considered:

1. Developion of MyANMS software application which allows to visualise the monitored data from distance, to store them in real time in a MYSQL database, to automatically process them at the end of each day and to create reports in *html formats for a simplified reporting process.
2. Programming in a personal way the radar.py, micn.py, gokmal.py and dbproc.py scripts which together are forming the MyANMS Software.
3. Realizion of the MyANMS web interface (website), which allows the users to connect with the noise monitoring system from anywhere via internet or local network.

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