Abstract
Aircraft noise is often perceived by communities living close to airports as the most serious impact on the environment, thus affecting both working activities and night sleep; various EC directives have recently dealt with this important problem. The Italian Ministry for Environment has decided to start a serious project in this field, financing noise monitoring systems close the main airports and promoting actions aimed to reduce aircraft environmental noise.

The Acoustic Laboratory of the University of Perugia has improved an expert system to record and evaluate aircraft noise; it is based on INM (Integrated Noise Model) simulation code and it is composed of various sheets concerning airport location and general data, runways characteristics, aircraft traffic data, acoustic zoning and mapping, climate and noise monitoring systems.

The expert system contains a data-base which has satisfactorily been filled with data from the main Italian airports and is therefore an useful tool both to verify the current situation and to simulate future scenarios.

INTRODUCTION

According to the Intergovernmental Panel on Climatic Change (IPCC), since 1960 passengers traffic on aircrafts increased all over the world by approximately 9% per year [1]. As far as Europe, the latest data [1] indicate that in the period 1997-2002
there has been an annual growth of about 6%, with a total number of passengers in 2002 of 328 millions (one third more than the value of 1997).

The problem of aircraft noise is becoming more and more serious, especially in those areas close to medium and large-size airports, and complaints from noise exposed communities are often strong and frequent [2], [3]. Recent EU legislation has dealt with the problem [4], [5] and a proposal concerning a new aircraft noise indicator is being discussed [6]; many researches and case-studies have been developed to measure, evaluate, predict and reduce aircraft noise [7], [8], [9], [10].

Also Italian legislation, with frame Law on Noise Pollution (n° 447/1995) and its applicative Decrees [11], [12], defines the methods for aircraft noise measurement and control; in particular a Decree of the Ministry for Environment [13] defines the Noise Monitoring System (NMS) characteristics; another Decree [12] introduces the indicator to assess noise pollution caused by airports.

Noise Monitoring Systems allow a real-time evaluation of the airport noise climate and represent an important tool to manage airport environmental policy. Anyway, data retrieved from NMS are often heterogeneous, not correctly presented and uncorrelated with aircraft traffic data. The paper presents an expert system to gather, store and organize airport traffic and Noise Monitoring Systems data, especially developed within a research carried out on behalf of the Italian Ministry for Environment. The aim is setting a common procedure to deal with these data from all Italian airports and building a data-base, available also to the public. The system is structured according to a logic procedure which allows cross queries for each data and airport; it is designed to be easily matched with INM (Integrated Noise Model) simulation code and can be therefore used to construct noise maps, according to the latest EU Directives prescriptions. The procedure has been implemented on a commercial data base environment and it has also been tested on some Italian airports jointly to INM code. Test results are satisfactory.

**ITALIAN LEGISLATION ON AIRCRAFT NOISE POLLUTION**

The Italian frame Law on noise pollution [12] attributes to applicative Decrees the definition of operative methods to achieve the control of aircraft noise. In particular, the decree D.M. Oct. 31. 1997 introduces the following index:

\[
L_{VA} = 10 \log \left[ \frac{1}{N} \sum_{j=1}^{N} 10^{L_{VAj}/10} \right] \text{dB(A)}
\]  

called aircraft noise level, where \(N\) is the number of days in a year representative of the acoustic phenomenon and \(L_{VAj}\) is the daily value of \(L_{VA}\), evaluated from the SEL (Single Event Levels) of the landing and take off events in a day. The Decree states that \(N\) must be equal to 21 days, corresponding to the three weeks with the
The highest number of aircraft movements in three different periods of the year (October, 1st - January 31st; February 1st – May 31st; June 1st – September 30th).

Evaluation of noise pollution status is determined by the evaluation of airport noise level distribution on airport area vicinity. The Decree also institutes an airport commission which has to determine the airport noise control procedures.

The decree of May 20th, 1999 [12] defines the characteristics and performances of airports Noise Monitoring Systems (NMS), establishing the typology, the number and the positioning criteria of microphone units. NMS must discriminate aircraft noise from different noise sources and must be equipped with a weather station; it is suggested to interface NMS with airport radar system in order to associate any flight operation to an acoustical data.

NMS must provide the following information:
- position of aircraft acoustical event;
- time and date of acoustical event;
- event duration;
- SEL and \( L_{AF_{max}} \);
- environmental noise level in absence of flight operation (residual level).

The previous characteristics makes NMS capable to verify whether noise reduction procedures have been accomplished. Furthermore, airport noise level \( L_{VA} \) (see eq.1) may be automatically calculated by NMS [3].

Other decrees indicate some more prescriptions such as:
- introduction of sanctions for noise procedure violations;
- periodical inspections made by ARPA (Regional Agency for Environmental Control) aimed to verifying NMS conditions and efficiency;
- verification of each aircraft noise emission level by ENAV (Italian agency for civil aviation);
- limitation of night aircraft traffic;
- definition of administrative and political criteria the Airport Authority must adopt to achieve airport noise reductions.

THE EXPERT SYSTEM

The proposed system for NMS data gathering, storage and processing has been designed by analyzing several Italian airport peculiarities in terms of available data and data format. The synthesis of that analysis allowed to draw a logical procedure which assembles the characteristics of each airport; the proposed system is therefore suitable to be filled with data from any Italian airport.

Data gathering and storage is carried out for each airport by means of input masks. For example, mask 1 (fig.1) deals with general data of the airport (name, location, weather conditions); mask 3 contains geographical data and landing/take off procedures for each airport runway. Mask 8 (fig. 2) must be filled with NMS characteristics, such as the number and position of microphone units, the noise events discrimination method; the mask also asks whether a preliminary investigation has
been carried out to design the NMS. Mask 10 (fig. 3) reports Noise Monitoring Systems output data ($L_{VA}$ levels), while the mask reported in fig. 4 must be filled with each flight movement information which has occurred within the three representative weeks used to calculate $L_{VA}$; the main data contained in the mask are: aircraft type, take off/landing movement, flight hour and date, flight profile, flight procedure.

All the masks of the expert system, concerning aircraft traffic data, airport noise control procedures, noise monitoring systems, along with the airport general informations, have been assembled into an expert system, implemented on a commercial data base environment (Access), called “Airport noise”, the logical scheme of which is sketched in fig. 5. The system allows to input data concerning a new airport and/or to recall and update data concerning the already existing airports. Cross queries for each data and airport can be made, in order to elaborate reports and statistics according to a homogenous method. The system can import files in Excel format concerning air traffic data and can be therefore easily updated.

The expert system has been tested in some Italian airports; in particular all the various masks have been filled and aircraft traffic data have been inserted. The test was useful to add new items in the masks, to create cross-queries, to eliminate items which were redundant. Simulations on typical Italian airports were also carried out by employing the proposed expert system. The Ministry for Environment therefore disposes a flexible tool, useful to gather, store and organize airport traffic and noise monitoring systems data; a part of the expert system will be also available on the web site of the Ministry with public free access.

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**GENERAL DATA**

Airport Geographic Data

- City: _______________________
- Location: ____________________
- Airport Name: ____________________
- Number of Runways: __________

Airport Reference Point

Geographic Data

- Latitude: ____________________
- Longitude: ____________________
- Altitude: ____________________

Climate Data

- Temperature: ____________________
- Pressure: ____________________
- Wind Speed: ____________________
- Relative Humidity: ____________________
- Wind Direction: Summer: ____________________
- Wind Direction: Winter: ____________________

Requested data are indispensable for geographic identification, interfering with digital cartographic map and processing by evaluation models.

Fig. 1: Expert system, mask 1: airport geographic data.
Fig. 2: Expert system, mask 8: noise monitoring systems characteristics.

Fig. 3: Mask 10, Noise Monitoring System output data.
SIMULATIONS

The system contains data in Excel format concerning aircraft traffic data (fig. 4); this part of the system has been developed so that it can be matched with INM simulation code to create noise maps at ground level of the airport and the surrounding areas.
Simulations were carried out for some Italian large and middle-size airports, with regard to the following noise indicators: $L_{eq}(A)$ day, $L_{eq}(A)$ night, $L_{VA}$ day, $L_{VA}$ night, SEL. The results show that the system is reliable and flexible and can be therefore used for verifying current conditions or simulate future scenarios.

In fig. 6 a comparison between simulated $L_{VA}$ for a typical Italian airport retrieved by alternatively using the proposed expert system and a previous procedure which consisted of a not systematic aircraft traffic data acquisition. The proposed system determines a different $L_{VA}$ distribution interesting a closer area. A measurement campaign will be carried out to validate the proposed system.

Fig. 6: $L_{VA}$ values simulated thanks to expert system (thick lines) and with a previous procedure (thin lines).

**CONCLUSIONS**

The continuous increase of aircraft traffic makes in most cases noise impact of airports an environmental emergency.

The paper illustrates an expert system to gather, store and organize airport traffic and noise monitoring systems data, especially developed within a research carried out on behalf of the Italian Ministry for Environment. The aim is setting a common procedure to deal with these data from all Italian airports and making up a database, available also to the public. The system, implemented in Access environment, is structured according to a logic procedure which permits cross queries for each kind of data and airport. The system is designed to be matched with INM code (Integrated Noise Model) and can be therefore used to construct noise maps, according to the latest EU Directives prescriptions.

The procedure has been satisfactorily tested on several Italian airports. Noise estimations carried out by the proposed expert system showed relevant differences with regard to simulations made by previous not systematic procedures. It is therefore extremely important to have established a unique procedure which will allow comparison between different situations.

Future work will include the application of the expert system to other Italian airports, the creation of a website to diffuse the results to the public and the updating of the already collected data.
REFERENCES