Nationaal Lucht- en Ruimtevaartlaboratorium

National Aerospace Laboratory NLR

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Summary

Especially in highly dense populated areas, like The Netherlands, environmental aspects are, and always have been, a major issue in the relationship between airports and their neighbours. To deal with these aspects, airport and governmental authorities must have adequate information.

In the early eighties this information often was limited to the noise level registration for a small number of (fixed) monitoring positions only. To gain additional knowledge about the environmental aspects related to the still ongoing growth of air transport, airports realised more and more complex noise and flight track monitoring systems.

These complex systems provide an increasing amount of (correlated) data and functionality, related to noise and track monitoring, noise exposure calculation and complaint analysis. Information, obtained from life data, is used to validate and further optimise modelling used for e.g. airport planning purposes.

As a next step, monitoring systems nowadays becomes increasingly important in what can be regarded as a closed-loop process of information gathering, processes of planning and regulation based on this information. Airports and authorities in this way are provided with tools and information to manage impacts on the environment, as related to aircraft noise

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1 Introduction

In the last decades, the number of civil aircraft movements has increased rapidly. This increase already started in the early sixties, at the same time as the introduction of jet aircraft. Along with this growth and the introduction of new engine types, the environmental aspects related to aircraft operations, and noise in particular, became more and more an important issue. To obtain objective information on noise pollution in the neighbourhood of airports, measurement programmes were started.

Once the problems related to the environmental impact of aircraft operations were recognised and acknowledged, the need for information related to this subject increased. In relation to airport planning studies, this need for information resulted in the design and realisation of noise exposure models. To meet the requirements of (airport) authorities, data gathered from several sources were integrated into one, more complex, information system. This integration imposed strong requirements to the processing capacity of the computer systems used, as much more (correlated) data had to be handled.
The growth of the computer processing capacity during the past decade has enabled the required extensions to data management and processing functionality. Once the increased amount of data was available, new functionality was defined, such as flight track statistics processing.

Information gathered by environmental monitoring systems started to play an important role in (improvements of) the process of planning and the establishment of new rules. The information also became the basis for processes that continuously check adherence to rules imposed for e.g. flight departure routes and noise exposure.
This paper deals with the aspects of integrated environmental monitoring systems, with the FANOMOS system as an example.

2 Noise monitoring systems

Noise can be regarded as the first major environmental problem related to aircraft operations. Therefore, noise impact was the first subject studied in the early seventies; to obtain the information to support these studies, noise measurement programs where started. The first measurements mainly served to collect (aircraft) noise data and extend the knowledge about the noise imission at specific locations around airports.

This data collection task could be performed by rather simple noise measurement techniques such as mobile (handhold) equipment. The evaluation of measurements, including the classification of aircraft noise, was a time-consuming job. In the early eighties, airport noise monitoring systems were built as closed-loop rings of datacommunication lines. The monitoring terminals were connected to, and fully controlled by, a central system and only acted as remote measuring devices (Bekebrede, Ref. 1).

At the end of the eighties permanently installed, stand-alone, noise monitoring systems were provided with local processing capacity. A continuous process of noise event detection was used, to reduce the amount of information to be handled by central processing systems.
However, information that can be obtained from noise measurements is still only valid for a small region around the noise monitoring terminals, of which the number is limited. The scope of the information is limited to the noise level registration itself. A positive, reliable, detection of the noise source (i.e. aircraft or not) often requires more information, such as the actual flightpaths.

If noise levels are to be used in the determination of counter measures, the limitations mentioned lead to unacceptable inaccuracies:

a) With complex standard instrument departure routes, as flown around e.g. Amsterdam Airport Schiphol, monitoring at many positions is required to obtain noise levels for effective counter measures covering <u>all</u> flights.
b) Aircraft noise classification for lower noise levels is not reliable when based on the noise level values only.

3 Flight track monitoring

To initiate effective counter measures, it was the Netherlands Department of Civil Aviation, RLD, who started research on flight track monitoring at the end of the seventies. Noise preferential departure routes were put in place around Schiphol airport. To continuously check the adherence to these flight rules, a flight track monitoring system was realised.

So-called flightplan data is automatically correlated to reconstructed flight tracks to accomplish the flight route checking. This information fully identifies the flights gathered and enables subsets of flights to be selected for presentation and research.

Growth in computer hardware capacity at the end of the eighties (workstations were introduced on the market) enabled large number of flights to be stored simultaneously. New functions operating on large selections of flights were introduced. Flight track statistics calculations are an example of such a function.

Statistical results, obtained from calculations based on live flight track data, offer comprehensive information. This information, e.g. average flight tracks and flight track dispersion, is used to validate the flight route design. Based on this validation, new rules with regard to departure route and their monitoring are put in place. In this way a first control loop has been closed (Fig. 1; right loop).

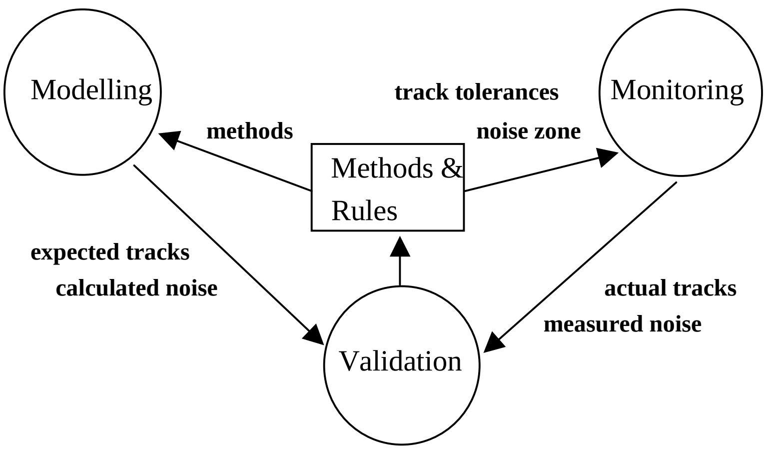

Fig. 1 Information and control loops

4 Noise exposure modelling

To support studies for future airport layouts, intensive use is made of noise exposure modelling. Models provide information in a wide area (calculation grid) around the airport for any scenario desired. Initially the level of detail as well as the amount of information was limited by the available processing capacity.
As soon as this limit was removed, in the late eighties, algorithms applied could be further refined and a higher level of detail, especially in input definition, was introduced. Important input parameters, apart from the number and type of aircraft operations, are the nominal flight route flown, and the dispersion of the flight tracks around it (Isermann, Ref. 2).

Information on actual flight track dispersion came available, in the required comprehensive way, from the flight track monitoring process. Based on this information new methods were introduced in the noise exposure modelling process to achieve an improvement in the level of detail for flight track dispersion modelling (ten Have, Ref. 3). In this way another information loop could be closed, reducing the gap between modelling and reality.

5 Integrated environmental monitoring systems

As stated before, the amount of information required to serve as input for processes of planning, rule making and checks on the adherence to the rules increased. To meet the time constraints imposed by the (airport) authorities for handling the available information, integrated and flexible information processing systems were required (Veerbeek, Ref. 4). For that reason functionality of noise and flight track monitoring systems and of noise exposure modelling were combined into integrated environmental monitoring systems.

As an extension to the noise and track data, new types of data were included in these systems, such as meteorological data and complaints. These data serve as background information (e.g. wind direction) or can be studied themselves in relation to the aircraft operations (e.g. noise events or complaints in relation to a certain departure route).

The extension of the type and amount of data has led to additional complexity of the environmental monitoring systems: a solid correlation is required to serve as a basis for data presentation and analysis tasks.
Data correlation is not always a clear and simple task to perform; especially in the surroundings of a busy airport, with complex flight routes, several problems can arise:

a) Several aircraft, of different types, being close to the airport at a certain time complicate correlation of noise and complaints to the originating aircraft movement.
b) Background noise in populated areas close to the airport can be high; this makes correlation of (low) noise levels, measured in built-up areas, to aircraft movements a difficult task to perform.

After system integration, and given the increased processing capacity, it became feasible to calculate noise exposure figures based on (individual) actual flights. In this process, modelled information is replaced by life data to realise monitoring functionality. In addition to this, rules (i.e. noise zones) were put in place to limit, and monitor, the “noise space” in a large number of (grid)points around the airport.
Apart from the monitoring function, the results obtained can be used to further validate the input data, and the methods applied, for the modelling process. Using more of the information available (e.g. actual noise levels) can even further extend this process of model validation.

6 FANOMOS: integrated monitoring example

The FANOMOS system, originally built in 1982, has been further developed to a complex integrated environmental monitoring system; in this process of system upgrade, the available knowledge gathered in the past decade has been applied.

The FANOMOS system was extended and renewed, to enable the governmental authorities to fulfil their tasks of planning, rule making, inspections and validations related to the environmental aspects of air traffic. The database and the user interface of the system are upgraded to be fully compliant with standards applied in modern information technology.

The renewed FANOMOS server for information storage, analysis and presentation, is designed to handle data of several sources (Fig. 2):

- Flight track data.
- Flight identification data.
- Measured noise.
- Meteorological data.
- Complaint information.

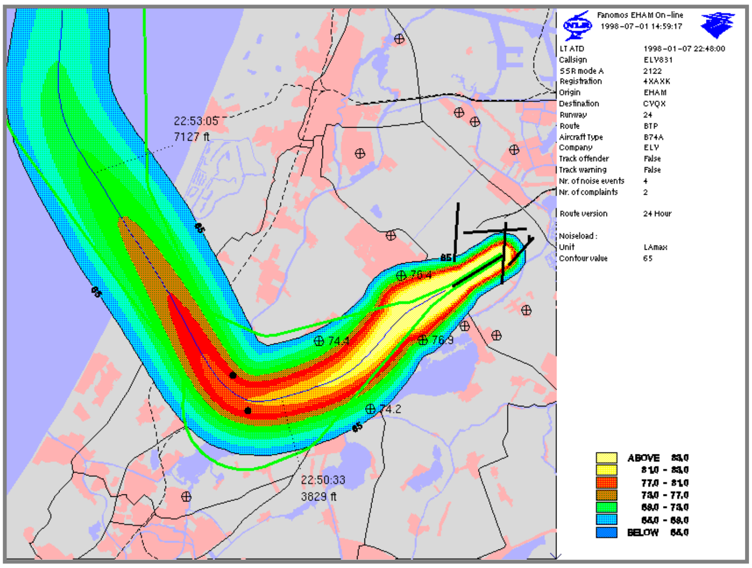

Fig. 2 FANOMOS output example

During data storage, great attention is paid to the algorithms applied to correlate the information of all these data sources. Flight data are the central source of information offered in the inspection and presentation process; the other data, correlated to flights, can be inspected to provide as much background information as possible.

Based on these types of (different) information, FANOMOS fulfils several tasks:

- Flight track tolerance offender checking.
- Continuously noise exposure updates and zone checking.
- Inspection and research, initiated by e.g. complaints.
- Providing information for research projects and improvements of modelling (e.g. flight track dispersion).

This set of tasks, make FANOMOS a sophisticated tool, which is used for information gathering, checking for adherence to rules established, as well as for support in processes to validate and further improve the models and rule-making.

7 Concluding remarks

Traditionally, airport environment monitoring was restricted to noise monitoring on a limited number of locations around an airport. To satisfy the need for more information to support the airport and governmental authorities, more complex systems are applied for environmental monitoring purposes.

Especially around large airports, in densely populated areas, several data sources have to be combined to obtain additional information on environmental matters related to aircraft operations.
Correlation of all this information is not always a simple task to perform. Careful tuning of system (correlation) parameters is an important part of system installation tasks. The result of such a tuning process must be validated regularly during operational use, as the environmental or operational conditions, which affect e.g. the correlation algorithms, can change.

Given the information supplied by environmental monitoring systems, also the rules established, with respect to e.g. flight route tolerances and noise exposure zones, can be validated. Useful information is collected to further improve and validate models used for airport planning purposes.

During the last two decades NLR gained a lot of experience in relation to the design, development and operational use of environmental monitoring systems. This experience can be of great help to further utilise information available in integrated monitoring systems; this to support the reduction of environmental problems raised by aircraft noise:
- Add additional loops of information and control for e.g. complaint information and actual noise measurement.
- Add loop to manage the development of the actual and expected noise exposure.
- Extend noise exposure calculation model to enable more complete replacement with actual data in modelled information; i.e. improve monitoring of actual noise exposure.
- Improve the validation loop for noise exposure modelling, using both, calculated and measured noise levels of actual flight tracks.

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