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NOISE CONTROL FOR QUALITY OF LIFE

Optimized and quality assured aircraft noise calculation on the basis of radar tracks.

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ABSTRACT

Modern aircraft noise prediction methods afford a tremendous amount of work to convert flown flight patterns into model data which can be used for calculations. Especially for existing situations this procedure could be much quicker and errors could be avoided, if prediction methods would allow the direct use of radar tracks. During this study the efficient use of radar tracks (STANLY and FANOMOS) was evaluated and compared against measurement results. There were several difficulties to overcome, such as automatic conversion of coordinates, automatic conversion of UTC time to local time (including DST), assignment of tracks to the correct runway, assignment of emission data, the use of spline and filter functions to adopt the tracks and reduce at the same time the amount of track points, selection of unusable tracks (to short, pattern flights, no emission data).

Keywords: Simulation, aircraft noise, radar tracks

1. INTRODUCTION

In Germany the official calculation method according to the law for protection against aircraft noise [1] is the instruction on the calculation of noise protection areas (AzB 2008) [3]. This calculation procedure is based on the instruction on the acquisition of data on flight operations (AzD) [4]. The forecasted flights are aggregated to some flight patterns, normally within a radius of 25 km of the vicinity of the airport and with a certain corridor width to describe the typical deviation from the defined track (back bone).

Within a retrospectively evaluation of aircraft noise it might be necessary to evaluate the historic noise pollution as detailed as possible. It would be a big advantage if this could be done without the additional necessity and effort to merge the flight movements into typical flight patterns. Furthermore annoyance reactions occur already at very low levels, which make it in certain cases necessary to extend the calculation area to more than a distance of 25 km from the airport. For example for very large airports the departure patterns of the officially used DES are considerably too short to be used for the calculation of the 40 dB isoline (night) because of the high number of movements. This has the

implication that areas with low noise levels cannot be calculated even though they are crucial areas for the evaluation of noise effects. In this case it would be necessary to extend existing calculation models according to the scope of work. A competitive and less time-consuming method could be in this case the calculation based on radar tracks. They contain also the relevant information needed for a noise prediction, such as aircraft type, speed and elevation of each flight. With this background the calculation based on radar tracks seems to be a cost-efficient alternative. On the other hand we face the demand to stay within the frame of the official calculation method (AzB) to avoid a systematic brake in the predicted results, depending on the task we perform.

In the following paragraphs we present a calculation method, based on the algorithms (source description and spreading) and the published aircraft classes of the German AzB 2008 [3], but is using this in combination with the radar tracks of each single flight. Since this is not a publicly accepted calculation method, extensive examinations and validations on the basis of measured noise levels were performed.

2. DATA IMPORT

2.1 Data structure

Worldwide we face numerous different data formats, but all of them have the following in common. Each recorded flight (track) consists of a header containing general information about the recorded event. This is for example origin and destination of the flight, actual time of arrival or departure in UTM, flight type, aircraft designator and runway. This general information is followed by a list of coordinates describing the three-dimensional flight path. The resolution (time steps) is very different depending on the origin of the imported data. For example STANLY data has with one point every 60 seconds a very low resolution, whereas FANOMOS data records a point every 5 seconds. This leads sometimes to the problem that STANLY data is too rough to describe the flight path precisely enough in curves and close to the airport and on the other hand FANOMOS data leads to enormous data files (several GB for a whole year are possible). For this reason we have to perform a preprocessing during the data import of such data to correct, adjust and prepare it before it can be used in a meaningful way for the calculation.

2.2 Automated data processing and data control

During the import of radar track data into the noise propagation software (SoundPLAN®) automatic tools are needed to preprocess the data.

1. Convert the UTC time of the flight track to local time and consider during this process the daylight saving time.
2. Convert the track data into the project coordinate system.
3. Efficient tools to improve (spline) and/or reduce (filter) the number of object points. The goal is to have only the minimum number of object points and at the same time a good description of the flight track.
4. Automatic assignment of the corresponding aircraft class or type according to the used calculation standard.
5. Flight tracks do not always start or end precisely on a runway. Therefore the software has to assign a runway to each track and adopt the flight track to this runway. The algorithm deletes all points closer than 3 km to the runway reference point and then inserts new points. The landing track ends after the deceleration section and the departure track ends at the start of roll.
6. Introduce additional columns into the data containing additional information like the minimum angle between track segments, angle between two segments, distance between coordinates (sigma'), ground speed, maximum slope of track.
7. Mark flight tracks with errors, such as: no coordinates, implausible time information, no assignment to a certain runway possible, no assignment to a certain aircraft class possible, pattern flight.

Especially the additional columns help to filter tracks with implausible definitions and to check if they can be corrected. Erroneous flight tracks are automatically excluded from the aircraft noise calculation. Statistical information informs the user about the number of excluded tracks, to help the user to decide if this is on an acceptable level.

3. CALCULATION

The calculation of aircraft noise based on recorded radar tracks can be performed in SoundPLAN® on the basis of the German AzB 2008 [3] and also the European ECAC Doc. 29, 3rd edition. The used procedure is within the frame of the mentioned guidelines and is suitable for the evaluation of very specific situations (for example meteorological situation, one day or even one flight). With the given filter possibilities in the software these tasks can be performed easily based on the imported database of imported tracks. Flexible definitions allow us the calculation of any required time slice (e.g. Lday, Lnight, Lden or any other) and of several noise descriptors (Leq, Lmax, NAT).

4. Validation

Exemplary for a large German airport the calculation method of the AzB 2008 [3] based on a DES and also radar tracks (FANOMOS and STANLY) were compared to measured noise levels, to eliminate a systematic difference between the different calculation methods. The calculated noise levels were compared to the monthly aggregated noise levels of the publicly available noise levels of 22 measurement stations in the vicinity of 19 km around the airport. The calculated noise levels were calculated on the basis of the recorded radar flight tracks of each month and also on the basis of the DES for each relevant month.

The table below documents the deviation between the calculated and the measured noise levels. To ensure a high comparability between the calculated results based on radar tracks and DES, the differences between the calculated values (independent on the procedure) should show similar differences compared to the measured values. Positive values show higher measured levels, negative differences higher calculation levels.

Table 1 – Differences between measured and calculated noise levels, day

	Difference between measured and calculated $L_{Aeq,day}$ based on		
	DES	FANOMOS	STANLY-Track
Mean	0.5	0.4	0.2
Std. dev.	1.0	1.0	1.3
N	22	22	22
Level range	44-64		

The results show that for all three calculation procedures the difference to the measured levels is smaller than the standard deviation of the difference to the measured levels. This shows that in all cases the difference to the calculated levels can be assumed to be not significant. In addition the results show that there is no significant difference between the diverse calculation methods. Similar results are also found for the night period (see table 2).

Table 2 – Differences between measured and calculated noise levels, night

	Difference between measured and calculated $L_{Aeq,night}$ based on		
	DES	FANOMOS	STANLY-Track
Mean	-0.5	0.4	0.1
Std. dev.	2.3	1.7	1.7
N	22	22	22
Level range	39-57		

During the night time the standard deviation of the differences compared to the measured levels is even larger. According to this neither the differences between the calculated compared to the measured levels nor the differences between the different calculation methods are significant. A direct comparison between the two different calculation methods on the basis of a larger amount of calculation points and also larger distances is shown in the following figure. In this case around 9.000 randomly selected receiver points are selected in the vicinity of the above mentioned airport and the results are displayed for the time slice day. For each receiver point a calculation on the basis of the official DES and also with the recorded radar tracks (FANOMOS) was performed and the results are compared in figure 1.

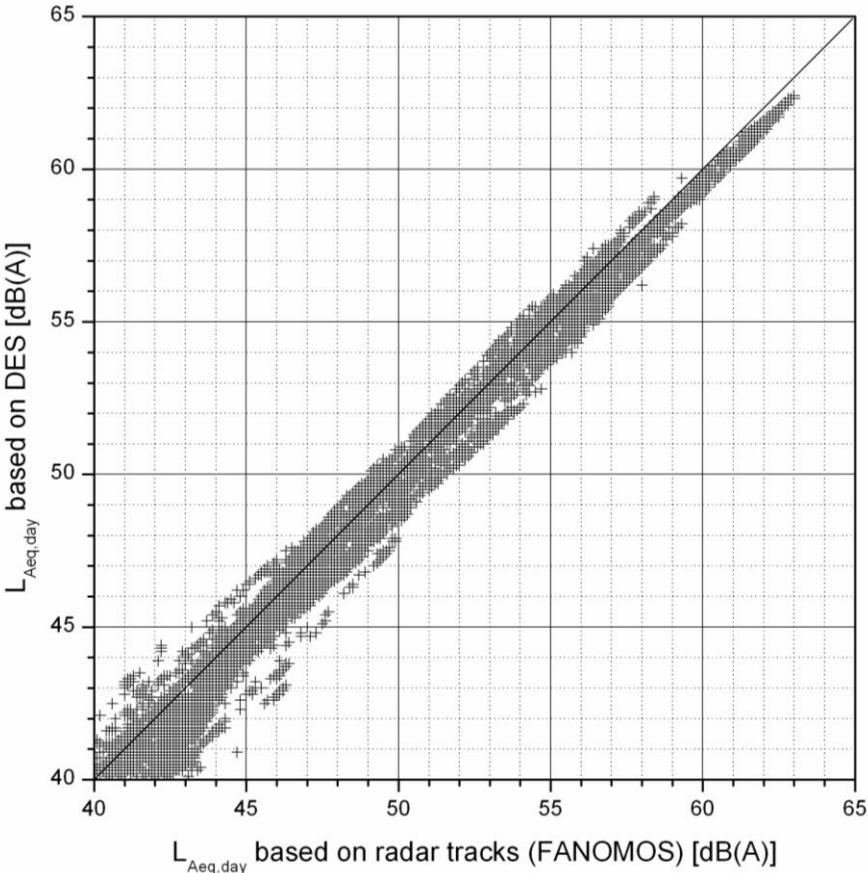


Figure 1 – Scatterplot of noise level $L_{Aeq,day}$ calculated based on DES versus based on radar tracks

The distribution shows especially for high noise levels a very good correspondence between the two calculation methods. Whereat the method based on the radar tracks is predicting slightly higher levels (around 0.5 dB) compared to the DES-method (standard approach). In the range of lower noise levels, which is the area where the calculation algorithms of the AzB [3] shows more and more uncertainties, a higher variation of the results around the bisection line is observed.

5. CONCLUSIONS

The direct calculation of aircraft noise on the basis of recorded radar tracks is a very fast and efficient possibility since the extremely time consuming effort of a manual definition of a calculation model is not necessary. For this reason this procedure is predestined for the evaluation of past situations, like the evaluation of specific meteorological conditions or even single flights. Making it possible to show the noise situation for specific conditions, which might enable us to find a better understanding or explanation for certain complains. Since the results are within the frame of the used calculation method, the procedure is also a very valuable possibility to complete noise mapping tasks according to the EU Environmental Noise Directive (END) [5] with very low effort.

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