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CALCULATING NOISE EXPOSURE IN GERMANY

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Aircraft noise is annoying for residents living near airports and may lead to serious health impacts. For the determination of the aircraft noise exposure, different methods are applied in Germany. For the establishment of noise protection areas at airports, a method is used which is called “Instructions on the Calculation of Noise Protection Areas, AzB”. It comprises aircraft noise emission data, the number of aircraft movements in a reference period and the flight routes near the airport. In addition, taxiing and the operation of auxiliary power units of aircraft are also considered. Moreover, aircraft noise calculations according to the European Environmental Noise Directive 2002/49/EC are carried out. Currently, for this task a national interim method is used. It will be replaced by a new calculation procedure in the future, because the European Commission has developed „Common Noise Assessment Methods in Europe, CNOSSOS-EU”. These methods have been implemented in Annex II to Directive 2002/49/EC in 2015. For aircraft noise, a procedure is chosen which is based on a method described in the 3rd edition of document 29 of the European Civil Aviation Conference. The transposition of this calculation procedure into German law will be explained. Furthermore, there exists a special calculation algorithm for the determination of the aircraft noise exposure at airfields with mainly general aviation traffic. It is published in the German standard DIN 45684-1. The various aircraft noise calculation methods in Germany will be presented and evaluated.

Keywords: aircraft noise, noise calculation, assessment

1. Introduction

Numerous national and international studies have shown that noise can disturb communication and relaxation and can be a considerable source of annoyance. According to a representative survey carried out in 2016, about 44 % of those interviewed complained of being disturbed or annoyed by air traffic in Germany [1]. Noise from aircraft surrounding of major airports is not only annoying for residents; it may also lead to serious health impacts. The risk of illness grows with increasing noise exposure. For the assessment of an aircraft noise situation, different methods are applied in Germany.

2. Calculation of noise protection areas

For airports and airfields with flight operations that cause a rather high noise exposure, the Act for Protection against Aircraft Noise is applied [2]. It requires the establishment of noise protection areas at commercial airports as well as military airfields with the operation of jet or heavy transport aircraft. The noise protection area is subdivided into two daytime protection zones and one night-time protection zone. The act contains different limit values for the individual zones. A distinction is made between existing and new or significantly expanded airports. Furthermore, there exist different limit values for airports and military airfields.

The aircraft noise exposure has to be determined on the basis of detailed forecast data on future flight operations as well as on the description of the flight routes in the surrounding of the airport. This information is gathered with standardized data sheets which are fully described in the "Instructions on the Acquisition of Data on Flight Operations" (AzD) [3, 4]. The calculation of the noise protection area is carried out on the basis of the data acquisition system. The algorithm is laid down in the "Instructions on the Calculation of Noise Protection Areas" (AzB) [3, 4]. It enables the calculation of equivalent continuous sound levels for day and night as well as of a number above threshold (NAT) criterion. The calculation comprises aircraft noise emission data, the number of aircraft movements during the six months of the forecast year as well as the flight routes. In addition, taxiing on the manoeuvring area of the airport and the operation of auxiliary power units (APUs) of the aircraft are also taken into consideration. This is a fundamental difference between the AzB and other aircraft aircraft noise calculation models which only consider the noise from departing and arriving aircraft.

The aircraft noise calculation is based on a segmentation approach which divides the three-dimensional flight path of an aircraft into a series of segments. Each of these segments provides a contribution to the total noise exposure. The model assumes a moving point source, for which sound power, speed and radiation characteristic are established at every point of the flight path. This source is modelled by a line source which consist of the aircraft classes of the AzB.

The flight path of the aircraft is divided into the following steps:

- First, the flight routes described in the data acquisition system are divided into segments of straight lines or arcs. The arcs are modelled by a series of secants.
- In the second step, the segmented flight routes in the horizontal plane are combined with the height profiles.
- Finally, the segments are further subdivided until the specific emissions between the segments differ by no more than 1 dB. Moreover, the segments must be further subdivided if the segment length is greater than one tenth of the distance from a point of exposure to the segment. This requirement improves the calculation results.

The directivity pattern of the aircraft noise emission is described by a directivity factor. It consists of three coefficients in octave bands from 63 to 8000 Hz. The coefficients are a series expansion in the cosine of the radiation angle.

According to the German Act for Protection against Aircraft Noise, the establishment of noise protection areas at airports should be based on forecast data of flight operations in ten years. This requires a grouping of aircraft types because detailed information on aircraft types and its distribution on the flight routes are not available for this case. Therefore, the AzB uses 36 standardized aircraft groups which comprise civil and military aircraft. These are propeller-driven aircraft, jet aircraft and helicopters. Each aircraft class is defined by a set of standard acoustical and operational data.

A point of criticism is that some aircraft class data do not represent the real noise emission of modern jet aircraft. For instance, the Airbus A380 is substituted in the AzB by the Boeing 747-400. To improve this situation, the German Environment Agency has commissioned a research project. In this project, the acoustical and operational aircraft data will be checked and updated. The revision of the aircraft class data will be done on the basis of the results of aircraft noise monitoring systems which are installed in the vicinity of German airports. The measurement results are correlated with radar data to determine an exact correlation between passing aircraft and air traffic noise incident. Results of this ongoing study will be available in 2020.

The establishment of aircraft noise protection areas has essential financial and legal consequences. To ensure a correct transformation of the AzB algorithm to computer software, an extensive quality assurance has been conducted. For this purpose, a test case was developed. It consists of nine individual test scenarios and a cumulative scenario. Each scenario represents a typical flight operational or acoustic situation. For these scenarios, several immission points in the surrounding of the test airport are defined. At these points, equivalent continuous sound levels for day- and night-time as well as of the number above threshold (NAT) criterion should be determined. In addition to this, the aircraft noise contours of the whole test airport should be calculated. Furthermore, there exists a standardized interface for data import and export. Figure 1 shows the flight routes and the immission points of the test airport.

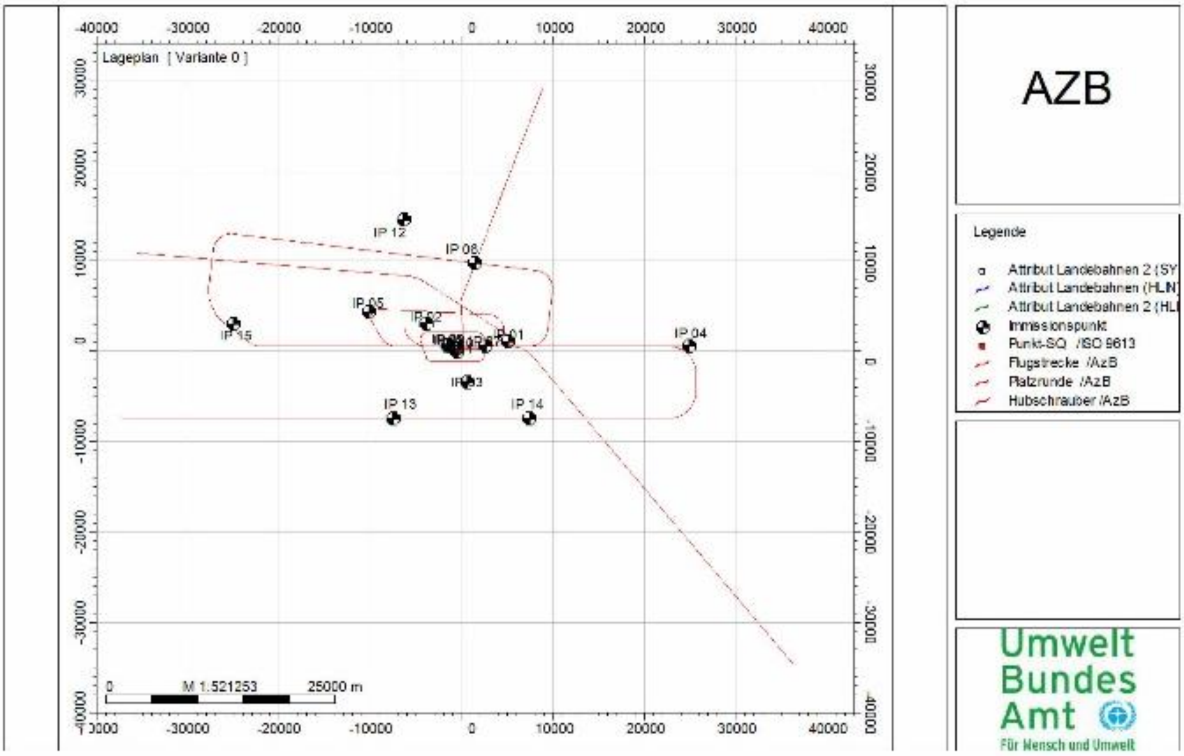

Figure 1: Flight routes and immission points of the test case for AzB.

3. Transposition of CNOSSOS-EU for aircraft noise in Germany

The European Environmental Noise Directive (2002/49/EC) requires the development of noise maps and action plans for traffic noise sources as well as noise from industry by the member states [5]. For aircraft noise, all airports with more than 50,000 aircraft movements per year have to be taken into consideration. Currently, for this task an interim noise calculation procedure is used in Germany because there was no harmonized European method available. This situation has changed with the introduction of common noise assessment methods pursuant to Article 6 of the Environmental Noise Directive by the European Commission in 2015. These methods have been implemented in Annex II to Directive 2002/49/EC [6]. The methods comprise detailed noise calculation procedures for road traffic, railway traffic and air traffic as well as industry. For aircraft noise, a procedure is chosen which is based on a method described in the 3rd edition of document 29 of the European Civil Aviation Conference (ECAC). This method is called “Common Noise Assessment Methods in the EU” (CNOSSOS-EU) for aircraft noise.

CNOSSOS-EU divides the three-dimensional flight path into appropriate segments of length. This segmentation procedure consists of two steps. The first step is an arc-segmentation of the flight route in the horizontal plane which is combined with a segmentation of the height profile in the vertical plane. Then the segments will be further subdivided based on acoustic and geometric criteria. This process leads to numerous segments which describe take-off, airborne and approach phase of the aircraft. For the noise calculation CNOSSOS-EU uses an “Aircraft Noise and Performance Database (ANP)” which contains many civil aircraft. For these aircraft, engine performance coefficients and Noise-Power-Distance (NPD) data are given. The NPD data are an essential acoustic element of CNOSSOS-EU. They consist of maximum and time integrated weighted sound pressure levels as a function of distance for different engine power settings.

For the description of height profile, two different types are used. Standard operational parameters define fixed-point profiles. These parameters are altitude, flight speed and engine thrust of the aircraft. The second type are procedural profiles which depend on actual aircraft mass, take-off or landing procedures and meteorological conditions. The aerodynamic and performance parameters are listed in the ANP database.

For the application of CNOSSOS-EU in Germany, a transposition into national law is required. The objective of the German Government is to improve the quality of noise maps and the comparability of results throughout Europe and create a solid basis for future policy on the management of environmental noise. Therefore, the methods should be designed in such a way that they can be easily applied in practice. Moreover, a comprehensive and systematic quality assurance for the calculation process is needed. To reach these goals, the German Environment Agency commissioned a research project to a consortium under the leadership of the German company Wölfel Engineering. In this project, it should be investigated if there are interpretation gaps concerning the aircraft noise calculation. Furthermore, a test procedure for the implementation the CNOSSOS-EU aircraft noise algorithm into software should be developed.

The investigation of the CNOSSOS-EU aircraft noise algorithm showed that additional produces and data are necessary to describe the operational situation at German airports. For instance, the algorithm does not consider traffic circuits. However, traffic circuits are conducted at several airports in Germany. Consequently, an algorithm for traffic circuits is implemented in the German transposition of CNOSSOS-EU. Moreover, fix point profiles for most aircraft types operating at German airports are also added. Furthermore, the instructions on the acquisition of flight operational data described in CNOSSOS-EU are substantially extended. These additions enable an unambiguous and practical enforcement of the European Environmental Noise Directive in Germany.

To ensure that the CNOSSOS-EU algorithm is correctly implemented in noise calculation software, a test case is developed. Figure 2 illustrates the flight routes of the test airport. It comprises five typical flight operational situations. The situations are combined with three different aircraft types so that a total of 15 variants is considered. Since no reference results are available, the results of three different software packages are compared. If these results are within a margin of 0.1 dB, it is assumed that the CNOSSOS-EU algorithms are implemented correctly. In addition to the test case a standardized interface for data exchange according to the German standard DIN 45687 [7] is developed by the contractor.

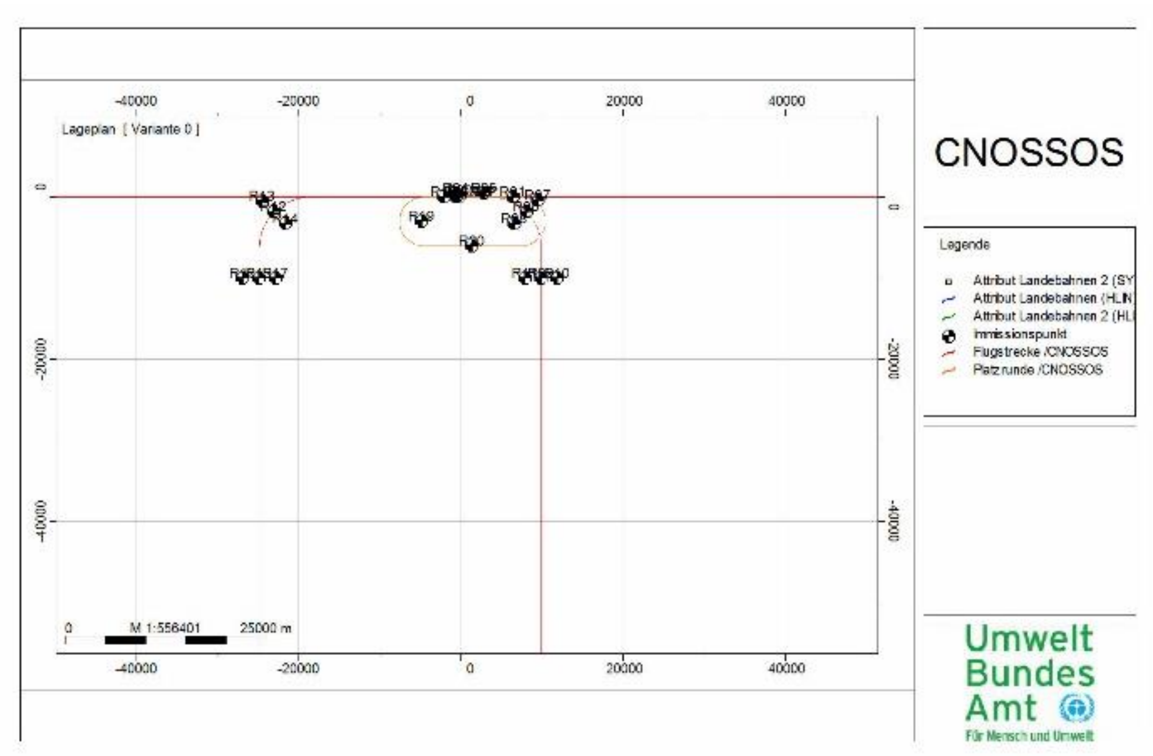

Figure 2: Flight routes and immission points of the test case for CNOSSOS-EU.

4. Calculation of aircraft noise exposure at civil airfields

The air traffic of an airport differs from that of a civil airfield in many ways. At these airfields, mainly general aviation traffic is carried out. Additionally, they are often characterized by a concentration of aircraft movements at weekends. For these reasons, the application of the complex AzB algorithm is inappropriate and a special calculation algorithm has been developed. It is published in the German standard DIN 45684-1 [8]. It also uses a segmentation procedure but requires less input data. Moreover, the operation of aircraft at certain times (e.g. at weekends) is considered. The calculation procedure according DIN 45684-1 provides therefore realistic aircraft noise contours at civil airfields.

5. Conclusions

There are different fields of application for aircraft noise calculation procedures. CNOSSOS-EU is designed to meet the requirements of the European Environmental Noise Directive. It enables the determination of the aircraft noise exposure in the past year, whereas the AzB is developed for future flight operations at airports or airfields. In contrast to CNOSSOS-EU the AzB can be applied for civil airports and for military airfields. DIN 45684-1 is tailored especially for airfields with mainly general aviation traffic. All three models are best-practice methods for calculating aircraft noise. It is desirable to combine the best qualities of these models to get a further developed aircraft noise calculation model in the future. To reach this goal, a new German standard called DIN 45689 [9, 10] is currently elaborated. In particular, it works with the use of radar data for aircraft noise calculations. For this purpose, information from airport surveillance radar as well as airport surface detection equipment are processed. Based on this data, the aircraft noise exposure generated from flight operations and taxiing on the airport can be realistically determined. Moreover, test cases are in the process of development and uncertainty aspects of aircraft noise calculations will be described.

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