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ICAN – INSTRUCTION FOR THE CALCULATION OF AIR-CRAFT NOISE AND FOR NOISE MAPPING AROUND AIRPORTS

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Noise exposure at airports has to be predicted to decide about necessary and possible mitigation measures and in some cases about compensation for residents where limiting levels are exceeded. A calculation method that is state of the art should fit seamlessly into the system of noise calculation for roads, railways and industrial sources. Such a method is the new ICAN – method [1], that has been developed to be used for legal purposes in Germany [2]. Some important properties and features of the method are presented and discussed.

1. Introduction and general requirements

International and National Standards and Guidelines use A-weighted equivalent continuous sound pressure levels to describe the noise impact at residential areas. These L_{eq} levels are related to day and night separately or – as it is required by the European Directive 2002/49/EC – a combined noise index L_{den} is used additionally to the night level L_{night}.

For all sources road, railway and for industrial sources these L_{eq} levels are exclusively used and legal requirements are fulfilled if these levels don't exceed certain limiting values. With aircraft noise the use of L_{eq} levels is often critisised to be not sufficient to describe the sleep disturbance, if such events are few and far between. Physicians ask for limits that prevent people more realistically and to restrict the number of maximum levels that exceed a defined threshold. Therefore the calculation method for aircraft noise should not only determine L_{eq} levels, but also the number of noise events above a defined threshold (NAT).

Modern prediction methods separate clearly the acoustical description of the source and the calculation of the emission values from the calculation of sound propagation. This is not the case with older calculation methods for aircraft noise – the Integrated Noise Model INM uses power setting – distance – level databases and is therefore a mixture of emission and propagation calculation. On long term such methods are a road with a dead end – they don't allow to include physically important phenomena like reflection, screening and other influences that may be relevant in special cases.

The aim of the ICAN – method was to avoid these shortcomings. Even if screening, reflection and other phenomena are not included in the existing version, the method is open to take them into account if it is necessary or with further development of the method. In the following some important aspects of the method are discussed – for a more detailed description see [3] and [4].

The calculation of aircraft noise to control legal requirements needs extremely good precision – it is necessary that different experts performing such calculations get the "same" result for a given scenario or test case. With "ancient" strategies this was ensured by the requirement that only one defined software package was allowed to be used if legal aspects come into play. Experience shows that this produces monopolistic structures and inhibits progress. It must be possible that the calculation method can be performed with any software package where the developers have integrated the methodology correctly.

This is only possible if the method itself is transparent and very precise. The algorithms must be described in a way that they are open to be discussed between experts and that they can be integrated in software packages without any restriction. The ICAN methodology is quality ensured – all steps are described precisely and maximal acceptable deviations of calculation results are defined. A testcase has been developed describing an artificial little airport with receiver points that allows to check if a software applying the method works correctly. Therefore all requirements to proof the quality of a calculation with a given software package according to DIN 45 687 (Software products for the calculation of sound propagation outdoors – Quality requirements and test conditions) are fulfilled with the ICAN methodology.

Another very important restriction is that a noise calculation methodology should use only those parameters that are available in an early planning phase. With road traffic it makes no sense to define the emission differently for car types like Volkswagen Golf TDI, BMW Z5 or Renault Twingo, because the numbers of these types on a road are not available. It is by far more efficient to differentiate only passenger cars and trucks, because these groups are relevant and the numbers are available. The same is true for aircraft types – if a certain carrier leaves an airport and another carrier is contracted, this may cause the change of aircraft types according to the fleet of these companies. It has proven to be advantageous to define aircraft groups with similar properties (MTOM, passenger capacity and engines) and similar noise emissions, because these numbers can be extrapolated from former years. This grouping concept is used by the ICAN method and the emission data of all necessary groups including helicopters and military aircraft are precisely defined.

Last not least it was a requirement to take into account all operations that can be relevant for the exposure of the population in the vicinity of an airport. This includes the movement of aircraft along taxiways, the operation of auxiliary power units and the hovering of helicopters in some meters height above ground.

2. Source data

Basis of the calculation model are the emissions that are defined for up to 41 groups of aircraft. Each aircraft group consists the two classes departure and approach. For each of these classes the sound emission is defined as sound pressure level in defined distance and three coefficients to characterize the directivity – both for each octave band frequency separately. Further the vertical profile of the flight path – for approaches in dependence of the arc length from the landing point and for departures in dependence from the arc length from the start of roll – is defined with heights in some supporting points relative to the class specific reference point and with linear interpolation of the heights between. The height of the reference points is defined relative to the digital terrain model that takes into account the real shape of the ground surface. For each of these segments the speed and a level correction is defined.

The simple and artificial airport model shown in figures 1 and 2 was used as test problem to check the software packages and to certify that they calculate with acceptable precision in accordance with ICAN. The main noise sources are the flight tracks shown in figure 1.

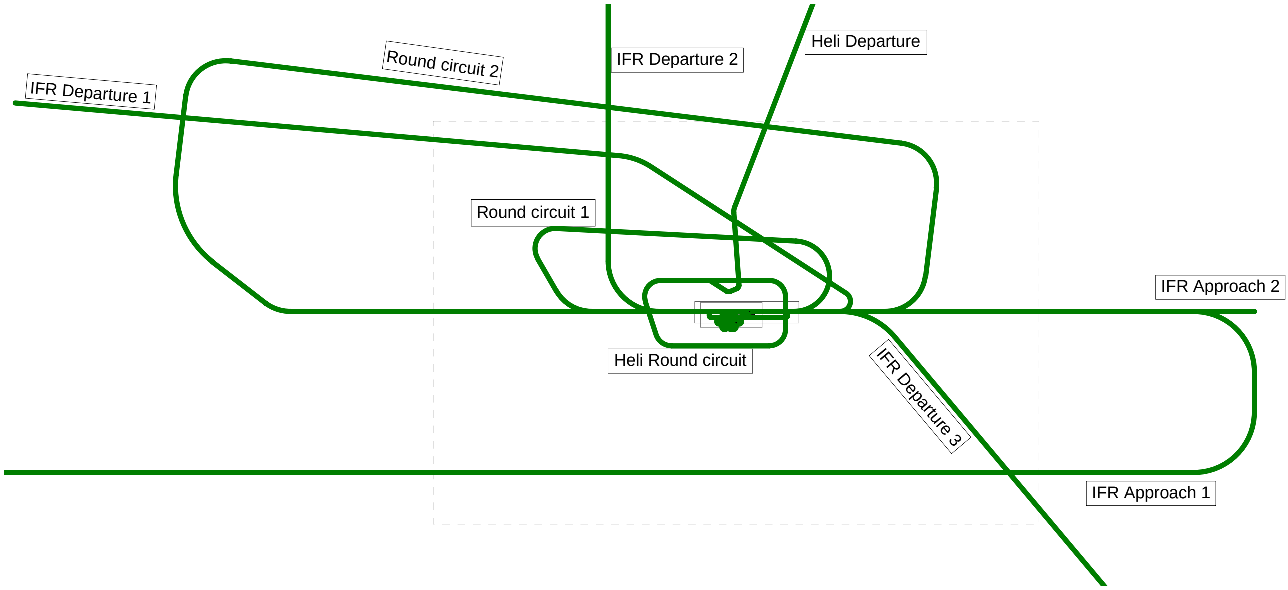

Figure 1. Test airport with departures, approaches and round circuits

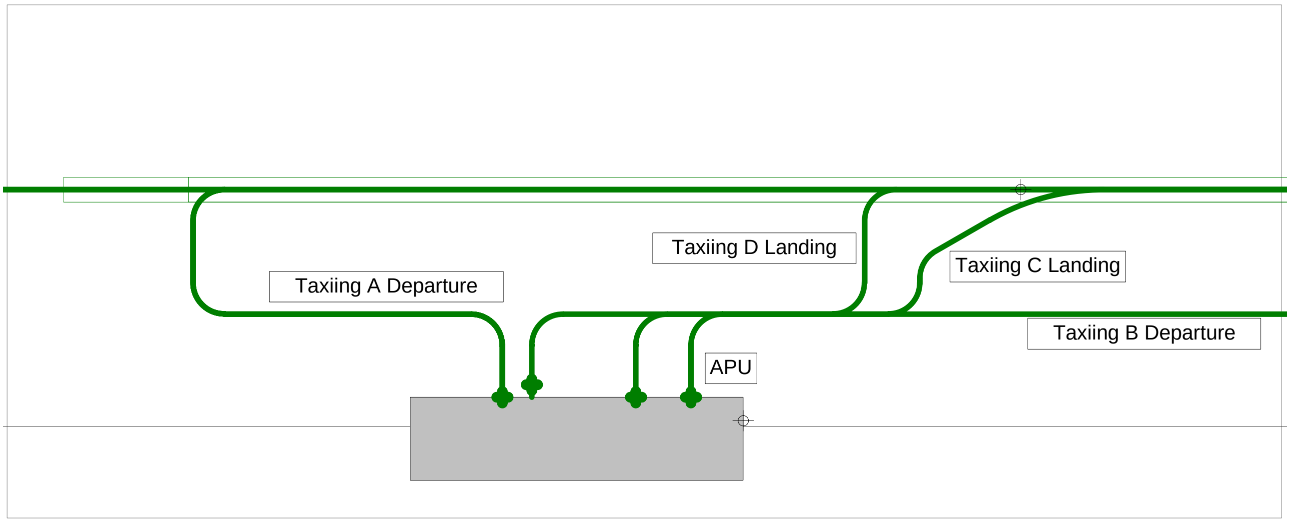

Figure 2. Detail of test airport with runway, taxiways and auxiliary power units (APU)

The flight tracks for departures, approaches and round circuits are polygon lines that are representative for the flight movements in the vicinity of the airport. They are described by straight and circular line segments where a corridor width can be defined for each segment to describe the horizontal distribution of the real flight movements. For each flight track numbers of aircraft movements separately for each aircraft class during day, evening and night are the basic source data to characterize the emission. For each of the different aircraft classes a separate vertical profile is used as described above.

The taxiways shown in figure 2 are treated in the same way like flight tracks – they are defined by straight and circular polygon lines. For each taxiway the aircraft classes and the number of movements are used as input data.

Further figure 2 shows the position of auxiliary power units – for each position the type of unit and time of operation has to be defined.

The structure of these source data is precisely defined. Although practically no uncertainties due to possible interpretations have to be taken into account, the system is flexible and open for future development because it is possible to define new aircraft classes and even types of auxiliary power units with new emission data.

3. Calculation procedure

The main advantage of the calculation procedure with respect to software realizations is the clear separation in three parts.

The first step is the complete geometric preprocessing of the geometries and emissions – this part is completely independent from receiver positions and therefore must be performed only once. Each flight track segment is included in the calculation as a backbone-element and additional 15 horizontally distributed elements according to the defined corridor width.

At the end of this process the model consists of all the positions of sources (center of line source elements) and their emission values with respect to L_{eq} contribution and L_{max}.

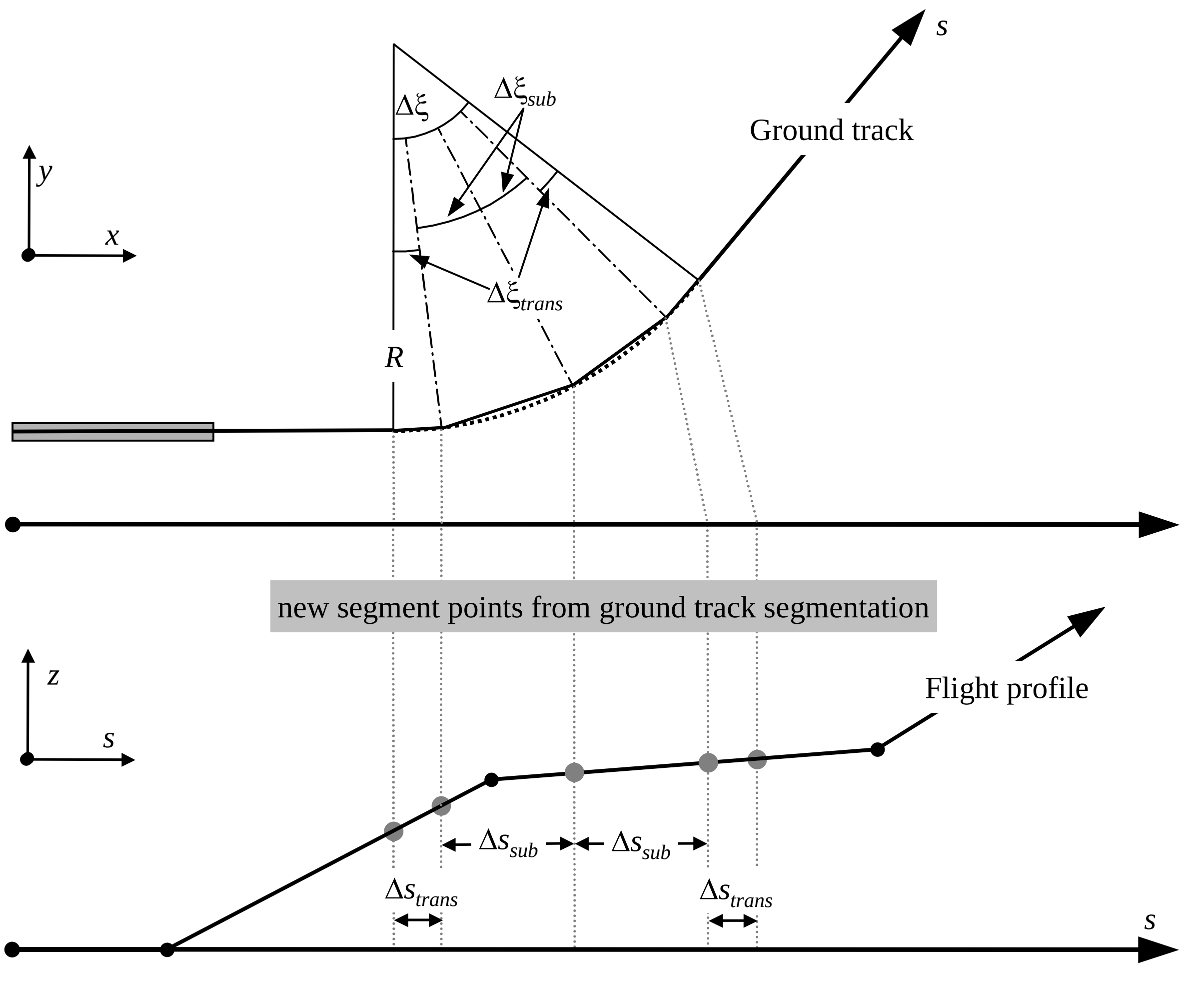

Figure 3. Segmentation of flight tracks

The second step is the calculation of L_{eq} contributions of all sources at the receiver points with defined position and/or positioned on a regular grid. This is a tremendous amount of calculations, because the contribution of all flight tracks with all 15 sub-tracks, with all segments separately and this multiplied by the number of aircraft classes (with different height profiles) have to be summed up. Additionally each aircraft class on a segment produces the relevant sound pressure level at the receiver position to determine the maximum level of each aircraft movement on this flight track.

Without going more into details of this calculation, it shall be mentioned that no information about aircraft data are necessary and must be loaded to perform this step. At the end all the necessary levels are known at all receivers and grid points to perform the next step.

This third step is the calculation of lines of equal L_{eq} levels and lines of equal NATs. According to the german law, for night time the outer envelope of the relevant L_{eq} and NAT contour defines the area where certain protection measures have to be applied.

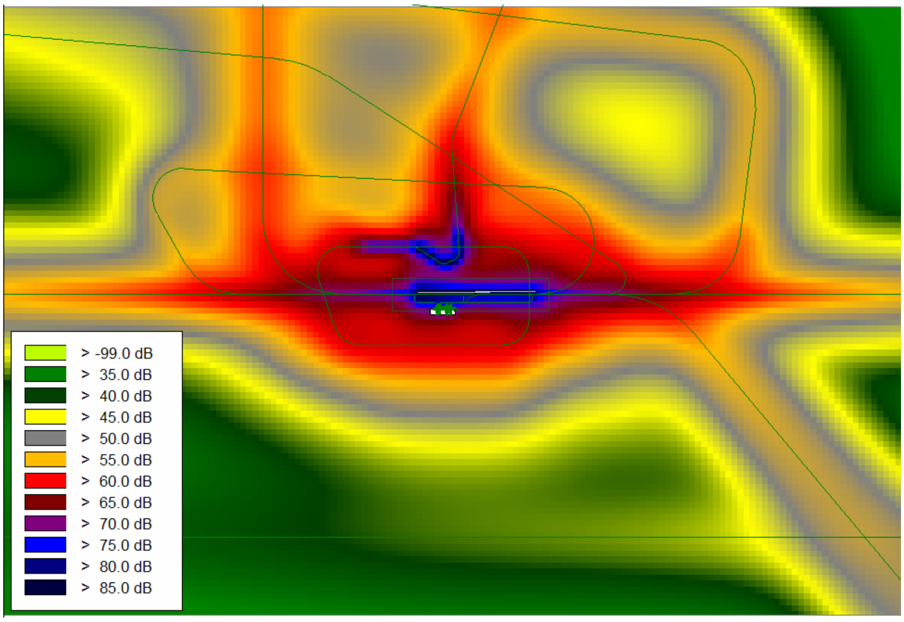

Figure 4. Map presentation of Leq levels

4. Time variation of flight operations

With existing airports the number of flights that is used for the calculation is based on the flight numbers of the last year. According to the german law the variation according to different distributions of flights on runways and directions during the last 10 years has to be taken into account for each receiver position. This is performed by adding to the calculated L_{eq} or NAT value a positive correction that is proportional to a standard deviation of the yearly average of this value. Even this statistical correction can be carried out in one step and no additional calculations are necessary with software of newest technology [5].

5. Quality requirements and test conditions

As it was mentioned above the requirements about accuracy and precision of the calculation of aircraft noise are extremely affording because the calculated contours decide about the possibility of claims and legal procedures. The necessary precision has nothing to do with the differences of levels that can be detected by residents – in fact noise effects like annoyance or sleep disturbance must not be scaled with fractions of decibels. But the line of L_{eq} = 50 dB(A) at night time may be shifted by 100 m if the level is increased by 0,002 dB in some cases and this is not acceptable if the position of this line decides about the possible usage and at the end about the worth of an estate.

The ICAN methodology takes this into account – only software packages should be used to control legal requirements that have proven to ensure the necessary quality by calculating results that don't differ more than these acceptable fractions.

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