BNAM2012
Joint Baltic-Nordic Acoustics Meeting
June 18th - 20th 2012 Odense, Denmark

Strategic Noise Mapping of City of Tallinn, Estonia

Kadri-Piibe Luik
Akukon OY Estonian branch, Laki 3a-201, 10621 Tallinn, Estonia, piibe.luik@akukon.ee

Marko Ründva
Akukon OY Estonia branch, Laki 3a-201, 10621 Tallinn, Estonia, marko.ryndva@akukon.ee

Benoît Gouartabés
Akukon OY, Hiomotie 19, FI-00380 Helsinki, Finland, benoit.gouartabes@akukon.fi

Maris Vohta
Akukon OY Estonian branch, Laki 3a-201, 10621 Tallinn Estonia, maris.vohta@akukon.ee

This paper describes the results of strategic noise mapping for city of Tallinn. As the main part of the work was carried out in 2011 the strategic noise map of Tallinn shows the noise situation for 2010. City is divided into 8 districts and area of the city is 159 km^2, number of inhabitants is ~407 000. Strategic noise maps for road (including trams), rail traffic, aircraft and industrial activity cites were made; in addition separate noise maps for local use were made (calculation height 2 m). Interim calculations methods were used for calculations. Road, railway and air traffic calculations were performed based on detailed data; industrial noise calculations were made based on Good Practice Guide (WG-EAN), but it was necessary to adjust the suggested area source emission values downwards as otherwise the results would have been greatly overestimated. The area of road traffic noise zones $L_{den} \geq 55$ dB forms 43% from total area of the city and ~67% of inhabitants are affected by road traffic noise $L_{den} \geq 55$ dB; other noise sources influence minor part of inhabitants.

1 Introduction

Strategic noise mapping has to be done according to EU directive 2002/49/EC. Strategic noise maps have been made twice for city of Tallinn: for Tallinn first round of noise mapping were calculated for the year of 2006 in 2008 and for the year 2010 in 2012. This paper describes the strategic noise mapping for the year of 2010. The strategic noise mapping project began in June 2011 and ended in February 2012.

1.1 Tallinn

Tallinn, the capital of Estonia, is situated on the banks of the Gulf of Finland. It is divided into 8 districts and its area is 159,2 km^2. Based on the information from 1.1.2010 Tallinn had 406 703 inhabitants [1]. Tallinn and has one main airport inside its territory.

1.2 EU Directive

Directive 2002/49/EC of the European Parliament and of the Council of 25 June 2002 relates to the assessment and management of environmental noise. The main aim of this directive is to define a common approach intended to avoid, prevent or reduce on a prioritised basis the harmful effect, including annoyance, due to exposure to environmental noise [2].

The strategic noise mapping of Tallinn, which results shall be reported to European Union Council by 30.06.2012, was done for the year 2010. Strategic noise mapping results to be reported in 2012, had to be carried out for cities or agglomerations, what meet the criteria of 100 000 inhabitants. Strategic noise mapping are also carried out according to directive for major roads (criteria ≥ 3 000 000 vehicle passages per year, railways (criteria ≥30 000 train passages per year) and airports (criteria ≥50 000 movements per year). In Estonia there was separate strategic noise mapping projects for second largest city of Estonia named Tartu and for major roads.

Following noise indicators according to the directive 2002/49/EC were calculated for the year 2010 as described in directive:

- L_{den} – day-evening-night noise indicator for overall annoyance;
- L_{day} – day noise indicator for day time annoyance;
- $L_{evening}$ – evening noise indicator for evening time annoyance;
- L_{night} – night noise indicator for night time annoyance.

The height of the calculation according to the directive 2002/49/EC is 4m.

According to the directive following recommended interim computation methods were used:

- Road traffic noise – French national computing method *„NMPB-Routes-96 (SETRA-CERTU-LCPC-CSTB)“*[3];
- Railway noise – Netherlands national computing method *„Reken- en meetvoorschrift Railverkeerslawaai ’96. Ministerie Volkshuisvesting , Ruimtelijke Ordening en Milieubeheer”* [4];
- Industrial noise - ISO 9613-2 *„Acoustics – Abatement of sound propagation outdoors, Part 2: General method of calculation“* [6];
- Aircraft noise - ECAC, CEAC document 29 *„Report on Standard Method of Computing Noise Contours around Civil Airports“* [5].

1.3 Noise modelling process

Noise modelling process can be divided into following phases: first phase was to analyse the input data, second phase was to create acoustical model, third phase was to test the created model and fourth phase was to calculate the noise maps and count the inhabitants, dwellings and noise sensitive building in noise zones.

1.4 Calculated Noise maps

The noise maps were calculated for main noise sources separately. The city of Tallinn divided noise sources according to directive 2002/49/EC as following:

- Road and tram traffic noise;
- Railway traffic noise;
- Industrial noise;
- Aircraft noise.

Calculations for all the noise sources were made for all indicators (L_{den}, L_{day}, $L_{evening}$ and L_{night}), what resulted in 16 noise maps. Noise maps were presented with 5 dB bands with zones: 40-44 dB, 45-49 dB, 50-54dB; 55-59 dB, 60-64 dB, 65-69 dB, 70-74 dB and 75≤ dB (noise zones 40-44 dB and 45-49 dB were added compared to minimum requirements set in the directive to improve the classification of quiet areas in action plan phase).

2 Input data

Input data and its quality is the key issue for creating the acoustical model and calculating noise maps. The input data can be divided as noise source data (road traffic, rail traffic, aircraft traffic and emission levels in industrial areas), geometrical information data and other data (important to create acoustical model).

2.1 Road traffic

Road traffic input data was given as rush hour traffic, speed limitation of streets and survey "Traffic Flow Changes in Tallinn and its borders in 2010" from Tallinn University of Technology.

The streets were divided into 4 groups mainly for traffic flow indicator. The rush hour modification to the 24 hour traffic data was made by analysing the traffic flow measurements points in survey "Traffic Flow Changes in Tallinn and its borders in 2010". The modification of 24 hour to day-evening-night differentiation was done according to recommendation what was given by the Good Practice Guide for Strategic Mapping and Production of associated Data on Noise Exposure (*WG-AEN "Good Practice Guide*"), strategic noise mapping for Tallinn in 2008 and Helsinki, Finland strategic noise mapping in 2007[7]. The city of Helsinki was taken as model for day-evening-night traffic flow differentiation because of its common size and geographical layout to Tallinn and its more detailed traffic flow studies.

The input data for road traffic noise consisted from 1392 roads, streets and their sections with different traffic flow. In Tallinn speed limits are 30 km/h, 40 km/h, 50 km/h and 70 km/h. Most of the streets have speed limit 50 km/h. The heavy traffic percentage day-evening-night differentiation was found according to recommendation what was given by the WG-AEN "Good Practice Guide" and Helsinki strategic noise mapping in 2007.

The input data for traffic flow what were used modelling the road traffic are given in Table 1 and 2.

Table 1. Day-evening-night differentation for traffic flow (%)

Group	Day(7-19)	Evening(19-23)	Night(23-7)
I/II	77	13	10
III/IV	81,3	10,9	7,8

Table 2. Day-evening-night differentation for heavy vehicle (%)

Group	Day(7-19)	Evening(19-23)	Night(23-7)
I/II	8	6	3
III/IV	5	2	1

The French method *„NMPB-Routes-96 (SETRA-CERTU-LCPC-CSTB“* gives different choices for traffic flow. Two different traffic flow types were used – "Continuous flow" (*fluide continu*) for 7 districts of Tallinn and "Pulsating continuous flow" (*Pulsé non différencié*) for only in the city centre district.

2.2 Rail traffic (railway and tramlines)

Rail traffic input data was given accordingly to the train and tram schedule, average or maximum speeds and length of the vehicles. Tallinn has 3 directions

Train traffic is not very intense in Tallinn. There are two passenger train types: electrical and diesel trains, their 24-hour average quantity is 274 for electrical and 40 for diesel trains for all the 3 directions what head out from Tallinn. 24-hour average quantity of freight train is about 6 trains (length 378-490 m) in the residential areas. The train tracks in Tallinn and in Estonia overall are not in very good shape, but in near future big investments are planned for improving the quality of the tracks, so modern passenger trains can be bought (first new trains will arrive 2014).

From RMR'96 method category 1 train type was chosen for electrical passenger trains, category 6 was chosen for diesel passenger trains and category 4 was chosen for freight trains [4]. The category choices were made based on the breaking system of the train and the emission data analysed for each category in the model. Mainly 60 km/h speed was entered into the model for all train types.

Tram traffic in Tallinn unifies 3 districts out of 8. Most of the trams are old but in near future investment for buying 14 new trams are planned. New trams require improving the quality of tracks and for that purpose tracks will be repaired. From RMR'96 method category 7 was chosen for trams [4].

The used Netherlands method *„Reken- en meetvoorschrift Railverkeerslawaai '96. Ministerie Volkshuisvesting , Ruimtelijke Ordening en Milieubeheer"* factors (track type, track condition) and train type choices were made in the comparison with Estonian train types and tracks.

2.3 Industries

Input data for industries were given as the areas of the real estate what had industrial estate intended purpose. Noise emission input data were taken from recommendation by WG-AEN "Good Practice Guide" and area sources height input data was an expert opinion made by project team. Although many industrial unities are subject to IPPC what also requires performance of the noise evaluation, the noise evaluations are carried only for few areas and unities and cannot be taken into account in generalization of industrial noise in Tallinn. The input data for industrial activity cites was modelled as area sources with emission L_w" 45, 55, 60 dB(A)/m^2 and their combinations according to the area's character. The noise sources were inserted around buildings about 10 m wide and the height of the source was 5 m. The methodology of areas source height and range among the real estate differed quite much from the methodology used for strategic noise mapping in Tallinn for 2006. For 2006 area source was entered ta all real estate area with intended purpose of industrial estate and area source L_w" 60 dB(A)/m^2 was used.

2.4 Aircraft traffic

Tallinn airport is situated 4 km away from the city centre and is the largest international airport in Estonia. The airport has one east-west directional elevation and landing track with the length of 3070 m. Tallinn Airport has less than 34 000 movements per year (33 585 movements in 2010) and does not meet the criteria for major airport with the number of movements per year. The noise map was calculated because the airport is situated in the territory of Tallinn.

In order to create a model and calculate the aircraft noise for Tallinn Airport according to CEAC document 29 *„Report on Standard Method of Computing Noise Contours around Civil Airports"* analysis needed to be carried out from the data given by the Tallinn Airport. First analysis was about the ratio between usages of the flight paths (altogether 20 in Tallinn Airport). The analysis showed that the ratio what was used before to evaluate the usage of the flight paths differed considerably from the analysis results what was used for 2010 noise mapping.

The second analysis was about the types of aircrafts visiting the airport; totally 174 different types of aircrafts visited Tallinn in 2010. The most number of movements were made by Fokker 50, Boeing 737-500 and Boeing 737-300. As the used calculation programme IMN 7.0 does not included all the types of aircrafts visiting Tallinn airport, substitutions had to be made.

2.5 Geometrical information

Contour lines and road height information is needed to create the area's ground model. The quality of height information was good - the contour lines for Tallinn was given as 2-dimensional lines with 1 meter height difference and the height information for roads were given by 3-dimensional lines. All together about 134 000 contour lines were used to create ground model of Tallinn.

The building information layer was divided into dwellings and other buildings and needed to be modified so that also other noise sensitive buildings (kindergardens, schools, hospitals) could be in a separate layer. The parts of buildings what had different heights were divided into separate buildings.

The quality of building layer was different in areas and districts of Tallinn - the main problems were faulty height of the building what was usually was the height of the basement and the wrong differentiation between residential and other buildings. All these problems were solved with changing the buildings according to other buildings around it and changing the building differentiation according to its real purpose by the Estonian Land Board Office. The absorption coefficient of all buildings in the model was set to 0, 21, what is the indicator of the plane masonry wall.

The number of inhabitants was given for the 8 districts of Tallinn. The inhabitants were allocated to the dwellings according to the average households' size (in persons and m^2). The household size per m^2 differed based on type of dwellings in districts of Tallinn.

Weather conditions were chosen by the recommendation in WG-AEN "Good Practice Guide"[7].

Other important objects for creating acoustical model are the attribute of the ground/water areas, noise barriers and crossovers.

The attribute of the ground means acoustically hard and soft areas and was divided into 3 groups, values with 0, 0,5 and 1. Acoustically hard surfaces (ground absorption 0) were entered as water bodies, parking lots and roads. Acoustically soft surfaces (ground absorption 1) were entered as parks and recreational areas. All the rest ground, what was not soft nor hard, was entered as ground absorption 0,5.

There are 5 noise barriers built to protect the inhabitants. All the 5 barriers were taken into account in creating the model. The noise barriers are located beside very intensive road traffic roads and their height varies from 2,5 m till 4,05 m and length varies from 46 m till 282 m . Three noise barriers were built 15 or more years ago and 2 noise barriers are built 2 years ago.

All the overpasses what included the bridges were drawn into the model one at the time.

3 Work process

3.1 Creating the model

The acoustical model for road, tram, train and industrial sources was created with Datakustik GmbH Cadna/A 4.2 according to recommendations given by WG-AEN "Good Practice Guide". The model for aircraft traffic was created with FAA INM 7.0.

The creation of model began with analysing the input data and finished with testing the model. It took 6 months work by 2 persons to finish analysing input data, creating the model and testing the model.

3.2 Calculations

Together with the Estonian domestic noise maps, the actual calculations lasted from the first calculations til the last calculation about 2 months. The calculations were made according to the borders of Tallinn.

Altogether 1,6 billion calculated squares were calculates with 10x10m calculating step.

Two different calculations were carried out to meet the criteria of EU directive 2002/49/EC. First calculation was made for noise zones on the ground from 4 m height to evaluate the size of noise zone areas. The second calculation was made for noise level on the dwellings facades from 4 m height to evaluate the inhabitants and residential/noise sensitive buildings in noise zones.

4 Results

The results of the noise calculation results were given accordingly the directive 2002/49/EC as following:

- The areas of noise zones for each calculated indicator;
- The inhabitants in noise zones;
- The dwellings /noise sensitive (kinder gardens, schools, hospitals) buildings in noise zones and;
- Dwelling with quiet facade.

The noise zone area calculations are showing for car traffic - L_{den} ≥55 dB area is 68 m^2 which makes ~43% of the area of Tallinn. The inhabitants calculation in noise zone are showing for car traffic – L_{den} ≥55dB people number is 270900 which makes ~67% of inhabitants of Tallinn. The results can be taken as trustworthy given the fact that main population on Tallinn is living in multi-storey buildings what are situated also on the side of the major roads and streets. In Tallinn, the highest contributor of annoyance by the L_{den} indicator is road traffic noise. Inhabitants who were affected by rail traffic noise, aircraft traffic noise and industrial activity cites L_{den} ≥55 dB was less than 9000 (rail traffic 6000 inhabitants, industrial activity cites 8600 inhabitants and aircraft traffic – 0 inhabitants). The inhabitant values given are according to directive 2002/49/EC rounding rules [1].

5 Comparison with 2006 results

The strategic noise map for 2006 was calculated with different computing methods, except air traffic noise. Road traffic, rail (train and tram) traffic and industrial noise were calculated with *Nordic Prediction* methods in 2008 (for 2006). [8]

The second very big difference in the strategic noise mapping in 2008 was the methodology of the inhabitant information and counting inhabitants in noise zones. In 2008 none of the inhabitant information was integrated to the model, all the inhabitant information was analysed by the Tallinn Planning Department. In 2010 model the inhabitant information was integrated to the model and all the inhabitant counting was made accordingly to WG-AEN "Good Practice Guide" principles.

The third considerable difference was the number of roads and streets used for calculating the road traffic noise. For the year 2006 only 602 roads, streets and their sections with different traffic flow were inserted to model as input data. The same number for 2010 was 1392. The number of the rush hour traffic flow what was taken in to account modelling for 2010 was 800 vehicles, in some sections even ≤ 800, the same figure for 2006 was ≤ 1000.

Although same computing methods were used to calculate air traffic noise for 2006 and for 2010 situation, the result came considerable differently. 2010 results show ~5 dB lower results then for 2006. One reason for difference can be found in the changed flight path statistic.

For road, rail traffic (train and tram) and industrial activity cites noise the comparison can't be made because the differences in methodology for calculating noise maps and inhabitant counting was too big.

6 Summary

Strategic noise mapping has been carried out 2 times – for the years 2006 (in 2008) and 2010 (in 2012). The strategic noise mapping for the year 2006 was carried out different methodology then the second round of the strategic noise mapping for 2010. Altogether 1, 6 billion calculated squares were calculates with 10x10m calculating step.

The results for noise zone area calculations show for road traffic noise L_{den} ≥55 dB area is 68 km^2, which makes ~43% of the area of Tallinn. The inhabitants calculation in noise zone are showing for road traffic noise L_{den} ≥55dB number of inhabitants is 270 900 which makes ~67% of inhabitants of Tallinn. The main population on Tallinn is living in multi-storey buildings what are situated also on the side of the major roads and streets. Given the fact what was represents in previous sentences, the results can be taken as trustworthy.

Road traffic noise can be held the highest contributor of annoyance by the L_{den} indicator. Influenced number of inhabitants by train traffic, aircraft traffic and industrial noise is considerably lower.

The main differences in the methodology of 2006 and 2010 strategic noise mapping rounds were the computing methods (road, tram, train traffic and industries) and the input data of the inhabitants. Considerable difference was also the number of roads and streets used calculating the car traffic noise.

Although same computing methods were used to calculate air traffic noise in 2006 and 2010, the result came considerable differently. 2010 results show ~5 dB lower results then 2006. One reason for difference can be found in the changed flight path statistic.

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