ANALYSIS OF TRAFFIC NOISE
FROM A MAIN ROAD CROSSING A CITY

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Abstract. The impact of road traffic on the environment is practically determined by a calculation procedure. Reliable calculation results require reliable sources determination. The theme of this study was to prepare the noise map of the area traversed by a major road, inside a neighbourhood which is part of an urban agglomeration, and to assess the effect of the noise on the population. No input data was available, so all the necessary data was collected on site, or taken from free available sources. The paper presents the sources of map data, the methods used to collect and process road traffic data, and the methods and tools used to process the outputs. Beside the noise mapping software, are used GPS, GIS and CAD techniques.

Key words: strategic noise map, road traffic, environmental noise, instrumented vehicle, vehicle speed.

1. INTRODUCTION

Nowadays it is well known that the noise maps are useful tools for representing the effect of the noise coming from various sources on the environment, including on the population. The purpose of the strategic noise maps is to provide practical information to the public, and also to assist the local authorities in decisions making regarding territorial development. Because of the rapid growth of urbanization, the road traffic noise causes annoyance and a wide range of negative effects on the health in many urban areas. Construction of new buildings will produce noise not only during construction, but also after completion, especially in the form of increased road traffic noise [1]. Noise is an important factor to consider in urban planning, as new traffic routes and changes to the movement patterns of the vehicles can be identified. Noise maps can be used to predict the sound levels when new buildings and roads are planned, and also to monitor the noise in agglomerated areas, where many dwellings are neighboring with major roads.

In European Union, following the Directive 2002/49/EC, it is mandatory for major urban agglomerations, major roads, railways and airports, to prepare noise maps and to develop actions plans for noise mitigation. In large urban areas the main noise source is the road traffic. The cities with a population over 100,000 should already have noise maps for the year 2011, since cities with over 250,000

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have the noise maps from 2007. There are also special situations when major roads are traversing cities, with less than 100k inhabitants. Even in this case it is required to analyze the influence of the road traffic noise on the population. The general methodology is presented in the “Good practice guide for strategic noise mapping” [2] and there are many commercial software tools available for data processing. A calculation method is based on a summary of many measurements undertaken by the acoustic community and therefore in many cases is more representative than an individual measurement that is more or less a snapshot. Different noise prediction methods were developed, and a comparison of the most used methods is presented in literature [3]. The methodology includes various instruments for producing the input data, defined for each noise source. Depending on the instrument used, the results may be more or less accurate. The methodology is described and commented also in other articles, like [4] and [5]. A review of the existing tools for traffic noise prediction is presented in [6]. Other studies were conducted to predict the ambient levels of road traffic noise and to estimate the population exposed for certain cities [7, 8], then the results were compared with results from other cities.

The impact of road traffic on the acoustic quality in the environment is determined by calculation procedures, which depend on the quality of input data. Data needed to ascertain the level of noise generated by the road traffic are: vehicle count (traffic volume), traffic speed, traffic flow type, and road characteristics (pavement, gradient). A complete set of these variables rarely exists [9], and certain assumptions and averages should be introduced to the modeling process, with more or less influence on the final result. Some usual assumptions include: the number of heavy vehicles in the flow; the average speed of vehicles; topographical data of the area; the road surface type for each road segment. The input data are among the uncertainties included in any model used in noise mapping software [10], and these are the only sources of uncertainty that can be controlled by the user. A way to reduce the uncertainty given by inaccurate input data is to use a network of noise monitoring stations [11]; however, this involves some important costs.

2. METHODOLOGY

2.1. Basic elements for road noise assessment

The effect of noise on the environment is described using an indicator named *equivalent sound level, LAeq*. *LAeq* is a conventional measure that represents the sound level which, if should be constant for the entire reference duration, will give the same acoustic energy like the fluctuating noise of the road [12]. The equivalent sound level is expressed in dB(A), unit that consider the sensitivity of the human ear. The measurable parameter that is at the base of the equivalent sound level estimation is the sound pressure level, calculated using the formula:

$$P_a = 20 \cdot \log_{10} \frac{P_{\text{meas}}}{P_{\text{ref}}}, \tag{1}$$

where P_a is the sound pressure level (in dB), P_{meas} is the measured sound pressure and P_{ref} is the reference sound pressure.

When the noise is generated by multiple sources (many vehicles travelling on the same road segment), the effect of summation of all sources is calculated using the relation:

$$P_{a,\text{tot}} = 10 \cdot \log_{10} \sum_{i=1}^{n} 10^{\frac{P_{a,i}}{10}} . \quad (2)$$

The noise indicators used for the noise maps, as defined by Directive 2002/49/EC [2] are: L_{day} (day-time indicator), L_{evening} (evening-time indicator), L_{night} (night-time indicator), and the compound indicator L_{den} (day-evening-night) noise indicator. The noise indicators L_{den} and L_{night} must be used for the calculation of strategic noise maps. L_{den} is derived from L_{day}, L_{evening} and L_{night} using the following formula:

$$L_{\text{den}} = 10 \cdot \log_{10} \frac{1}{24}\left(12 \cdot 10^{\frac{L_{\text{day}}}{10}} + 4 \cdot 10^{\frac{L_{\text{evening}}+5}{10}} + 8 \cdot 10^{\frac{L_{\text{night}}+10}{10}} \right). \quad (3)$$

The estimation of the noise generated by the road traffic can be made using statistical Traffic Noise Models, which are implemented in noise mapping software. Acoustic models of road traffic noise are based, in part, on the speed of passing vehicles. There are more methods that can be used to ascertain the vehicles speed [2]:

– Measure vehicle speeds by means of radar or other suitable technology;

– Measure time vehicles take to travel along a road section of known length and calculate the average traffic speed;

– Determine the average traffic speed by driving in the average traffic flow;

– Use the speed limit;

– Make an assumption of average traffic speed based on experience from similar road types.

A method considered as very accurate is to use devices for automatic traffic flows analysis, like traffic counters-classifiers. The stationary counter-classifier can be used to identify the average flow for different vehicle classification groups, for the segment where the device is mounted. In most cases, it is not affordable to mount classifiers on each road segment, it is necessary to make a decision to approximate the data sets, and to apply a corrective factor [13], resulting approximated data. The traffic classifiers are convenient for measuring traffic volumes, but the measured speeds are instantaneous speeds for the point where the device is mounted, usually in the middle area of each road segment. The speed values will be, most probable, higher than in other parts of the road. It is easy to calculate the average speed of the traffic flow in the measuring point, but this value cannot be applied with a good accuracy for the entire road segment when the traffic flow is not continuous.

An easy, efficient, and cost-effective method for acquiring vehicle speed data for acoustic road traffic modelling, which improves the accuracy of the noise pollution map, is the use of global positioning systems (GPS) technology, as described in [14] and [15]. This means one or more vehicles equipped with GPS receivers will travel following the traffic flow, so that the speed measured by the GPS device is approximately equal with the average speed of the traffic flow. More passing on each road segment will improve the accuracy of the average speed value.

2.2. Theme and objectives of the study

The theme of the study was to realize the noise map for the noise generated by the road traffic on the road DJ200B, traversing a small city near Bucharest. A previous traffic study revealed on this road a traffic volume of 3,725,555 vehicles, so it was considered major road (over 3 million vehicles/year) and consequently is necessary to evaluate the effect of the noise on the population of the traversed city. This area can be considered as part of the urban agglomeration of Bucharest, but since is not contained in the administrative borders of the big city, it was not taken into consideration for the strategic noise map of Bucharest [12].

There was no data available about the road traffic in the area, and no base map. Only the ends of the road sector that had to be considered as noise source were specified. Considering these, the study objectives and steps were defined as follows:

– prepare the layers of the base map - streets, buildings, etc;

– estimate the number of inhabitants for each dwelling;

– collect traffic data (volume, speed);

– create the noise map for the time intervals day/evening/night (L_{den}) and night (L_{night});

– estimate the number of inhabitants exposed to noise level over 55 dB(A) L_{den} and over 45 dB(A) L_{night};

– propose action plans for noise mitigation;

– create noise maps for the proposed situation, estimate the exposure of inhabitants and generate difference maps.

In this paper are presented the steps until estimation of the inhabitants exposed to current noise level, without the proposed action plans.

2.3. Description of the noise mapping process

The entire process of creating a noise map is described in the diagram shown in Fig. 1. Basically, it is a three step process: prepare the inputs, calculate, process the outputs.

The road traffic data are attached to the GIS map layers (base map) and together represent input data for the calculation software. The program used for noise calculation in this study is Lima 7812 [16]. The program has features, included in the graphical user interface, for preparing the input data and also for processing the calculation outputs, but for this study only the calculation feature was used.

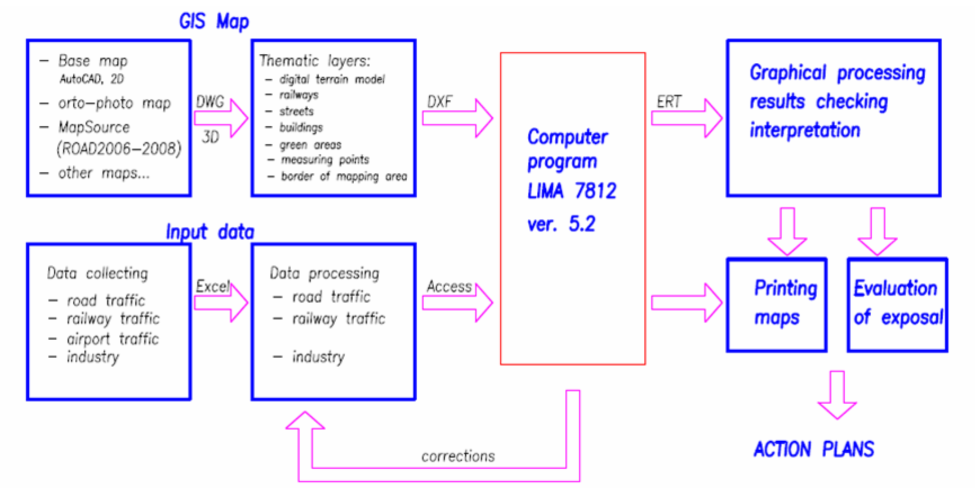


Fig. 1 – General diagram of noise mapping.

The noise map outputs can be considered as one or more layers in a Geographic Information System (GIS), with the graphical support and the associated properties according to the GIS rules. The raw outputs are the noise levels for all the points of a grid that covers the entire area of study. The output files are then processed using custom functions that allow the user to evaluate the exposure of each building and to estimate the number of inhabitants exposed to different noise levels.

The software tools used for preparing data are QGIS [17], which is a free and open source Geographic Information System, AutoCAD (with a custom application developed in Visual Lisp) for preparing the graphic support of the GIS layers and also for automatically processing the input and output data, and Microsoft Office for preparing input data according to Lima requirements. Beside these open source and commercial software packages, custom software developed by the project team was also used, as described further.

3. INPUT DATA

The input data (according to diagram in Figure 1) consist in two categories: map data and traffic data. The map data are included in the layers of the GIS map: digital terrain model, buildings, green areas (forestry, parks, gardens), streets. The traffic data are associated to the road segments, which represent the "streets" layer of the GIS map and include: traffic volumes, speed, type of traffic flow.

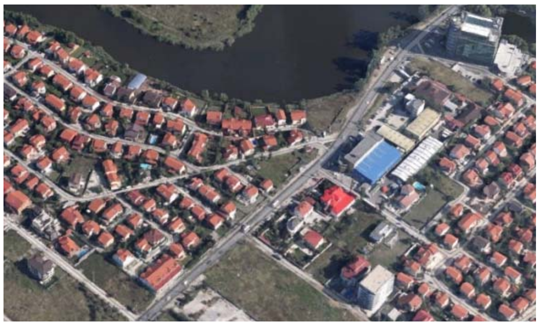
A similar approach is described in [18], where are mentioned also two types of basic data in traffic noise calculations: traffic flow information, which includes the traffic volume, the vehicle speed and the proportion of each vehicle type, and the attributes of roads and buildings, which includes the road names, road lengths, coordinates, building IDs (unique numbers that represent buildings).

3.1. Base map

Since a digital map of the area was not available, the sources for the base map were searched on web. A good resource for GIS layers, free available online, is OpenStreetMap [19] (http://www.openstreetmap.org), a map "built by a community of mappers that contribute and maintain data about roads, trails, cafés, railway stations, and much more, all over the world". The map data available from OpenStreetMap (Fig. 2a) are accurate, but not complete in the study area. The missing information is available instead with good details on Google Maps, for the study area being available also the 3D views (example in Fig. 2b). The views captured from Google Maps were geo-referenced using QGIS, then exported to AutoCAD where, using standard drafting commands and custom developed functions, was extracted only the necessary contours and were attached custom data, like the height of each building, the type of building and the estimated number of inhabitants.

The number of inhabitants for the entire neighbourhood was available from the last census reports, but there were no information available about the number of inhabitants for each dwelling. The contour of a building, as geometric entity in the CAD drawing, is a closed polyline. For each of these entities, some important properties were attached as custom data (using Visual Lisp functions): the height, which can be converted in number of floors, and the building category (school, hospital, dwelling etc.). For a closed contour, composed by straight segments, it is easy to calculate the area, in an automatic way, and so it was calculated the living area for the entire neighbourhood. This total area was then divided by the total population number, resulting the area/inhabitant. Then for each building (dwelling type), the living area was divided by the area available for each inhabitant, resulting the number of inhabitants in that building (rounded to integer value).

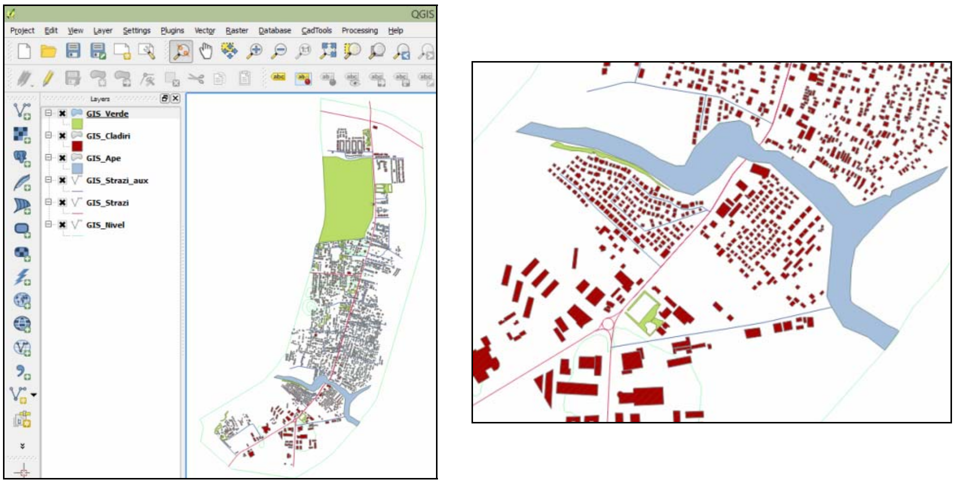
a)



b)

Fig. 2 – Free sources for the base map: OpenStreetMap (a) and Google Maps (b).

All the map layers have been defined in detail in the CAD files, then imported in QGIS as vector layers. Examples of the results in QGIS are shown in Fig. 3. An important property of each CAD entity is the *handle* of the entity (which is a standard unique identifier of each entity in CAD software that use the DWG format). The handle will be used as object identifier to synchronize the geometric objects with the database. This synchronization is very important especially for the street layer(s).



a) b)

Fig. 3 – Base map – all layers: full view in QGIS (a) and a detailed view (b).

The street layer is composed by open polylines (where a *polyline* is a geometric object consisting of a sequence of line segments, and “open” means the start and end points are not the same). Like the building entities, the entities that represents the street segments have some custom data attached, including the traffic volume and speed for the three intervals: day, evening, night. The length of each segment depends by the road curvature and the changes in the traffic parameters. Close to an intersection the road segments are shorter, in order to capture the quick changes of the vehicle speeds. The road gradient and pavement are similar for all the road segments; the road is considered horizontal and the pavement is smooth asphalt.

3.2. Traffic volumes

In Fig. 4 are marked the road segments (A–E) and the points of traffic counting (1–7). CB represents a part of the Bucharest ring road. On all road segments, the traffic runs on both directions, with a single lane for each direction, except for a part of the segment D where are two lanes in each direction. The methodology chosen for data collection was manual counting.

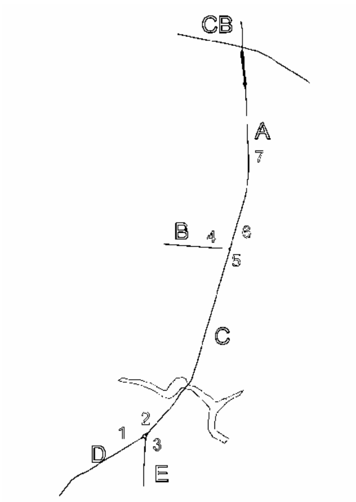


Fig. 4 – Road segments and points of traffic counting.

The calculation method adopted in the country legislation is the French method for road traffic noise prediction (NMPB – Routes ’96) [20]. The vehicle’s category used in this method are only two: light vehicles (under 3.5 t) and heavy vehicles (over 3.5 t). Vehicles of both categories were counted for each direction. A special attention was given to the roundabout area. Here the traffic volume differs for each entry and each arc of the roundabout, and also there are significant differences in vehicles speed. The influence of the speed accuracy on the calculated noise level is explained in [22]. The number of vehicles for each road segment in the intersection area is determined analytically, based on the counts taken in points 1, 2 and 3 (according to Fig. 4).

The traffic volumes measured in each point are listed in Table 1. The values are given for an entire day.

Table 1

Traffic volumes in the measuring points

Measuring point	Light vehicles count				Heavy vehicles count				Average Daily Traffic
	Total	Day	Evening	Night	Total	Day	Evening	Night	
1	11616	9293	1162	1162	368	276	37	55	11984
2	13936	11149	1394	1394	160	120	16	24	14096
3	15280	12224	1528	1528	480	360	48	72	15760
4	10624	8499	1062	1062	160	120	16	24	10784
5	13552	10842	1355	1355	480	360	48	72	14032
6	7136	5709	714	714	416	312	42	62	7552
7	8256	6605	826	826	256	192	26	38	8512

The traffic volumes recorded revealed values over the average daily traffic obtained based on the 3,725,555 passing measured in the previous traffic study, meaning 10,207 vehicles per day. The new measurements show daily traffic volumes between 8,512 and 14,096 physical vehicles, and that is a variation of the annual volumes between 3,106,880 vehicles on the road segment A (as per Fig. 4) and 5,145,040 vehicles on the road segment C. A high daily traffic value was obtained for the road segment E, but this should not be considered as noise source, because is not part of the road DJ200B. A high volume was measured on the road segment B (1,350 vehicles/hour, or approx. 10,800 vehicles/day), which contributes to the discharge of the road segment A.

3.3. Vehicles' speed

The traffic flow inside cities can be generally considered to be pulsating, on horizontal roads. The reason for this assumption is the high number of intersections, where the speed profile includes accelerating and decelerating phases. The noise generated by this type of traffic has a higher level at lower speeds because it involves many accelerations and decelerations (caused by a higher contribution of the power train), and the effect of tyre-road interactions and of the air resistance is not so important at low speeds, as in the case of high speeds, on highways.

GIS data are combined with data acquired using GPS devices to determine average speeds of traffic flows. The speed values were measured driving an instrumented vehicle on the road of study. The measured device was the GPS receiver Garmin GPSmap 60CSx, with an output rate of 1 Hz. Data stored in the receiver memory was imported in the CAD drawing that contain the street layer of the GIS map, and attached to the polylines entities which represent the road segments [21]. There were 17 passes on the analysed road, in both directions. Each of the road segments is composed by at least three sub-segments, so that the speed data can be different near the junctions.

Using the data attached to the entities that compose the track, various diagrams can be generated using dedicated functions. In Fig. 5 is presented the variation of speed as function of time for one pass on the road segment C.

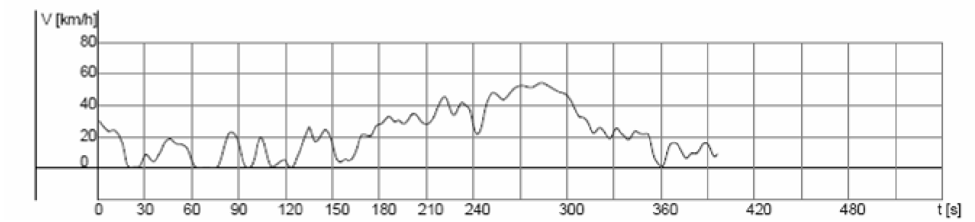


Fig. 5 – Speed *versus* time diagram for one pass on the road segment C.

Figure 6 shows the speed versus distance diagrams for more passes on the same road segment. At the left of the diagram appears the diagram of speed frequencies distribution, generated automatically by the software function. Using the same data in which is based this representation, with the formula (4) below, it can be calculated the mean speed for the analysed route:

$$\bar{v} = \frac{\sum_i f_i v_i}{N}, \tag{4}$$

where $\bar{v}$ is the mean speed, f_i is the frequency of observations in the speed group i, v_i is the middle value of speed in the group i and N is the total number of observations.

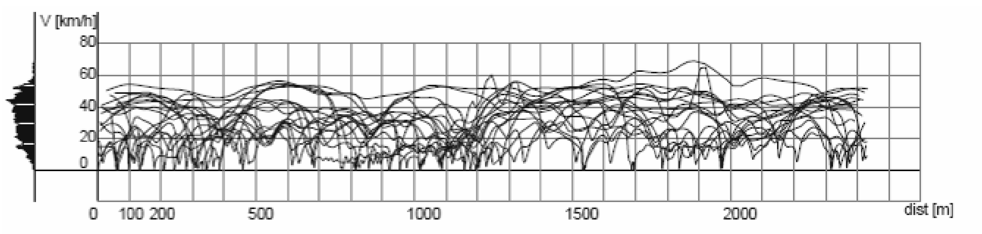


Fig. 6 – Speed versus distance diagram for multiple passes on the road segment C.

The mean speed calculated for this road segment is 33 km/h.

The lateral diagram in Fig. 6 is used to generate the diagram of cumulative frequencies, as can be seen in Fig. 7. This diagram allows the graphical determination of the median speed (V50), as well as other speed percentiles. The median speed is the speed under which are 50% of the recorded values, and it is used instead of the mean speed for discrete data (as are the records taken from the GPS receiver). The median speed for the road segment C is 33.44 km/h, which is very close to the value of the mean speed for the same road section.

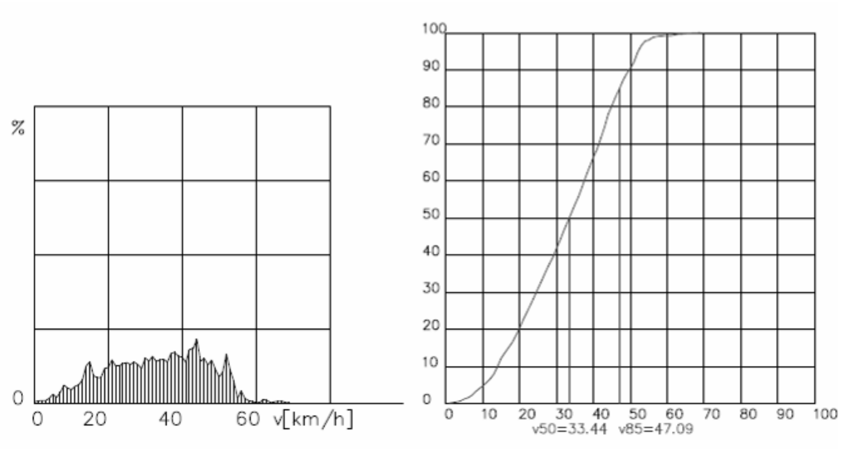


Fig. 7 – Speed frequencies distribution and cumulative frequencies diagram, road segment C.

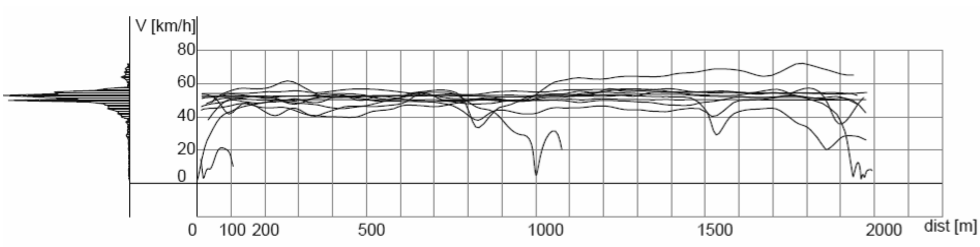


Fig. 8 – Speed versus distance diagram for multiple passes on the road segment A.

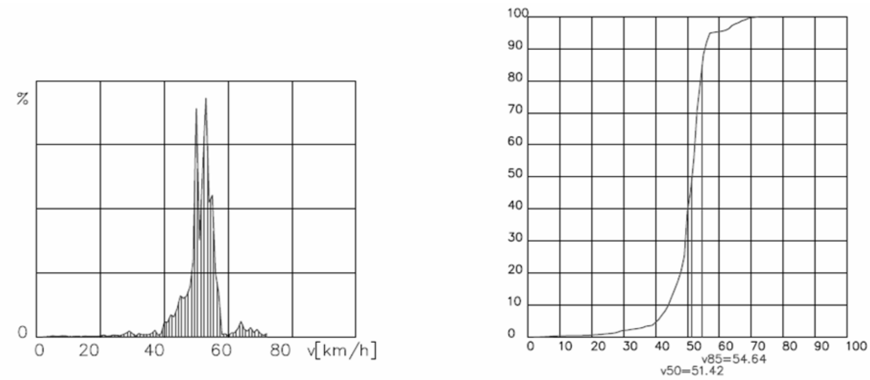


Fig. 9 – Speed frequencies distribution and cumulative frequencies diagram, road segment A.

The same type of data processing made for the road segment A results in the diagrams presented in Fig. 8 and Fig. 9.

The V50 value calculated for the road segment A is 51.42 km/h, and is significantly different by the V50 value calculated for the road segment C. This difference proves the importance of collected real data for each segment of a road.

Table 2

Median speed determined for all road segments

Road segment	Light vehicles speed			Heavy vehicles speed		
	Day	Evening	Night	Day	Evening	Night
CB	90	90	90	80	80	80
A-CB	55	55	60	55	55	60
A	51	51	60	51	51	60
A-6	23	23	30	23	23	30
B-4	23	23	30	23	23	30
B	42	42	50	42	42	50
C-5	23	23	30	23	23	30
C	33	33	50	33	33	50
C-2	24	24	30	24	24	30
D-1	24	24	30	24	24	30
D	46	46	50	46	46	50
E-3	24	24	30	24	24	30
E	46	46	50	46	46	50

The values determined for the median speed (V50) for all the road segments used in this study are given in the Table 2. The segment IDs which are not clearly identified in Fig. 4 are those located near the intersections, like A-6 which is at the end of the road segment A, in the area of the traffic counting point 6. In a similar way are defined the short segments near and inside the roundabout (C-2, D-1, E-3). Some small road segments, like those that compose the roundabout, are not explicitly listed in the table because the median speed has the same value as for the adjacent segments. The speed values for CB and all values for the night interval are adopted.

The traffic volumes and speeds, as well as any other information available about the road (pavement, gradient, etc.), are attached to the polylines that represent the road segments. When the input data are ready, all information is stored inside the CAD drawings, using the extended data feature to attach custom data to the geometric objects.

4. CALCULATION AND RESULTS

4.1. Use of the noise mapping software

The software use to calculate the noise level was LimA 7812 [24]. The calculation result is a grid where for each node it is calculated the equivalent noise level. The grid is composed by square cells with the side length of 5 meters.

Data are imported in the calculation program as Microsoft Access tables and attached to the objects (road segments, buildings) using the object ID as reference. In order to have the object IDs synchronized in the base map and in the database, all tables are exported from the CAD system, using custom functions.

After the completion of the noise calculations the noise level results can be mapped, presented graphically, and used as the basis for supplementary analysis. The results delivered from the noise mapping software consist in a grid of noise assessment and can be exported as text files, where each line contains the coordinates of a point and the noise levels (including L_{den} and L_{night}) calculated for that point. The noise mapping software (LimA 7812) offers features for presenting and printing the noise maps and also for estimation of population exposure, but a better control of the results is obtained if the raw data are exported and processed with other software. The software tools used for presenting and processing the output data are, as for preparing the input data, QGIS and AutoCAD, with custom designed applications.

4.2. Noise maps

The processed noise results grid files may be used for production of 5 dB noise contour bands, for graphical mapping of results. QGIS allows the user to import data from text files organized in rows and columns, and the user has to specify which columns represent the coordinates of the point corresponding to each line, and the other columns will represent properties of that point. Such properties are the noise level indicators. An available plug-in for QGIS can calculate the contours defined by certain values of the point properties and creates contour or polygon layers based on those properties.

The 5 dB bands required in noise maps are at least:

– L_{den}: < 55, 55 – 59, 60 – 64, 65 – 69, 70 – 74, ≥ 75;

– L_{night}: < 50, 50 – 54, 55 – 59, 60 – 64, 65 – 69, ≥ 70.

In Figs. 10 and 11 are presented the noise maps obtained for the study area, for the L_{den} indicator (a) and for the L_{night} indicator (b). The figure shows screen captures from QGIS, but the program includes also a tool for preparing the maps for printing. The lowest noise level band displayed is 30−35 dB.

The coordinates transformations required for reporting the noise maps (Stereo70 projection system for prints and ETRS89 for sending the maps to European Commission), as well as export of maps as shape files, are done also using QGIS features.

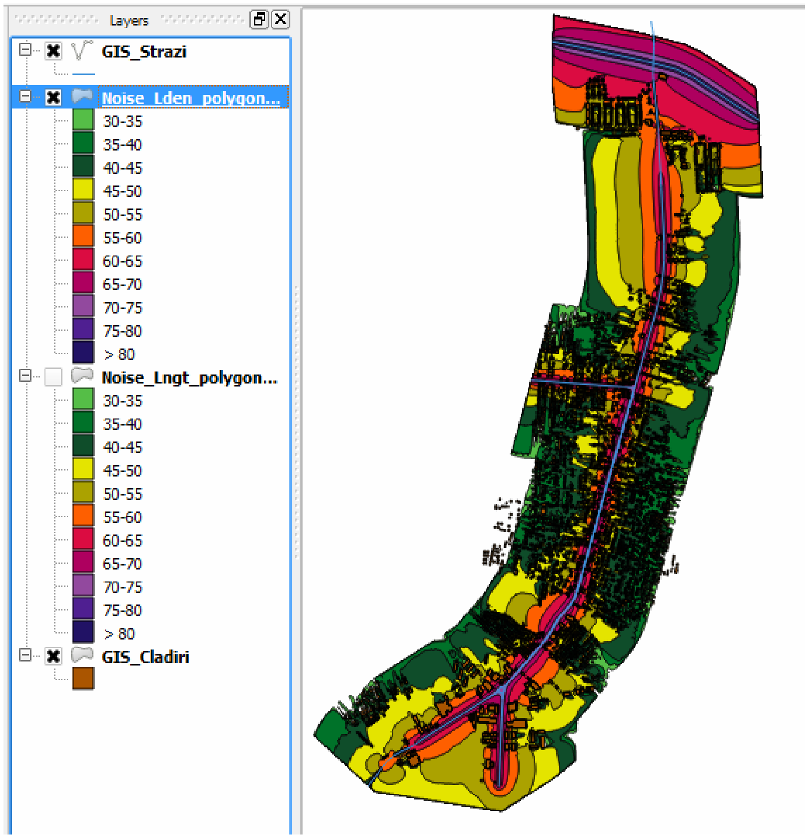


Fig. 10 – Noise map – L_{den} (day).

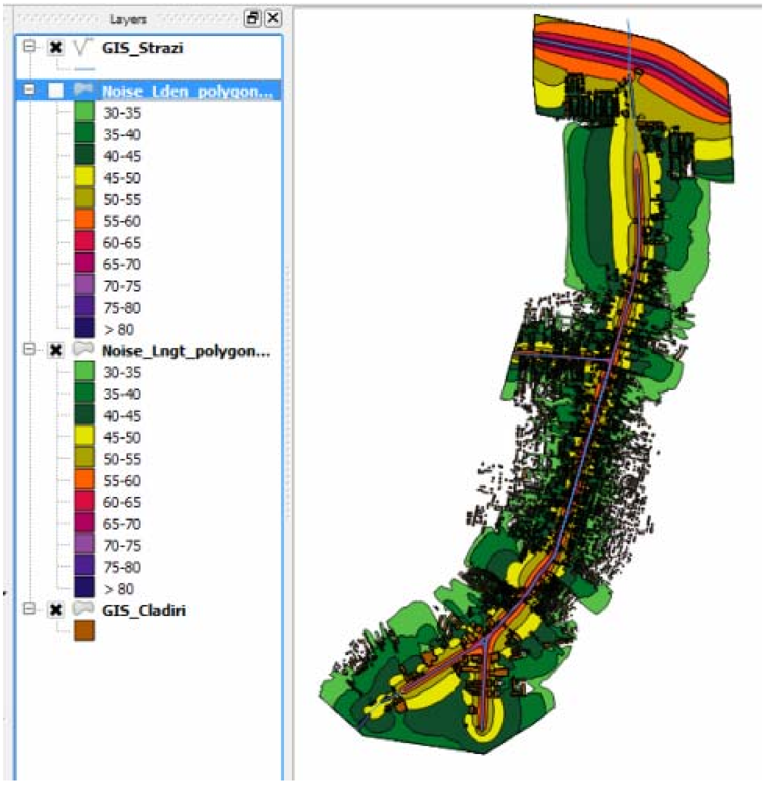


Fig. 11 – Noise map – L_{night} (night).

4.3. Validation of the calculation results

At the same time with vehicles counting, measurements of the sound level were made using a sound level meter (Bruel&Kjaer, Type 2250), in the points 1, 6 and 7 (as per Figure 4). The duration of each measurement was 30 minutes. The differences between the measured and calculated sound levels should not me higher than 3 dB. The measured and calculated values are listed in Table 3. The resulted differences are less than 3 dB (max. 2.5 dB in the table).

Table 3

Validation of the calculated sound levels

Measuring point	Sound level [dB(A)]		
	Measured (L_{Aeq})	Calculated (L_{den})	Difference
1	73.7	71.2	2.5
6	73.3	70.9	2.4
7	72.4	69.9	2.5

4.4. Population exposure

As results of the noise mapping process, it is required to report the total number of dwellings (in hundreds) exposed to L_{den} and L_{night} higher than 55, 65 and 75 dB for major roads. It is also required the estimated number of people (in hundreds) living in dwellings that are exposed to noise, in 5 dB bands, for the various scenarios mapped.

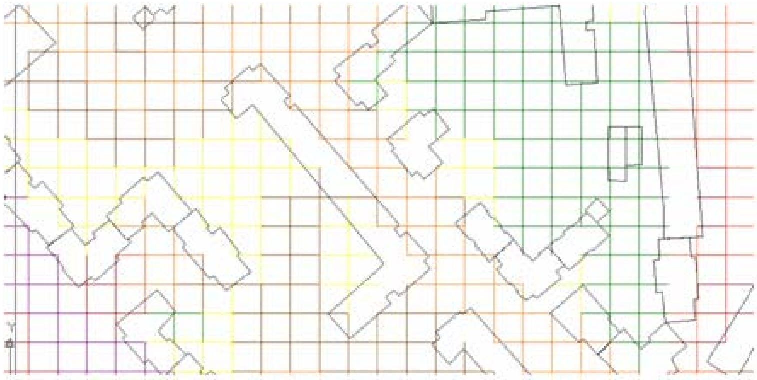


Fig. 11 – Detail view of the noise level grid around buildings.

For the presented study, the assessment of population exposure was done in the CAD environment, using a custom developed software application. The basic functionality of this application is shortly described next. It is considered that for each building it is known the number of inhabitants (stored as metadata attached to each closed polyline that represents a residential building). The grid output from the noise calculation is used to create point entities. The point entities have standard properties that controls the point appearance. Using these properties, the grid points are represented as squares with the size of the grid output (Fig. 11). The grid cells colors are according to the equivalent noise level (intervals of 5 dB), using another standard property of the point entity. The exact noise value is stored as Z coordinate of the point; adding this value as extended data to the point entity is not a good approach because the very high number of grid cells will make the execution of any other command very slow.

The next step is to find all the intersections between the building contour lines and the squares representing the grid cells in the noise map. Only the *x*, *y* coordinates are used to calculate the intersections, because *z* coordinate of the point represents the noise value. For each intersection found, the value of the noise associated to the respective grid cell is added to a list. This list is attached to the building object (polyline entity) in the drawing as extended data (metadata added with custom functions developed in Visual Lisp).

Next, it is calculated the number of inhabitants exposed to each 5 dB interval of noise level, then these values are added to a list of exposed people. That list is then used to prepare the table of the population exposure (see Table 4). The upper limit of each noise interval in the table don’t includes the mentioned value, instead the lower limit includes that value (example: 55–60 means 55–55.99).

Table 4

People exposed to noise levels

	Noise interval [dB(A)]									
	<35	35–40	40–45	45–50	50–55	55–60	60–65	65–70	70–75	>75
People exposed (hundreds), L_{den}	13	22	27	36	45	28	15	5	**1**	–
People exposed (hundreds), L_{night}	55	28	20	13	10	5	**3**	**1**	–	–

In a similar way is determined the noise exposure for dwellings, and for special, sensitive buildings, like hospitals or schools.

The values calculated for each building, and attached as extended data to the drawing object, are exported and then transferred in the GIS layer as attributes.

5. FINAL COMMENTS AND CONCLUSIONS

On the base of noise maps are generated the conflict maps, which highlights the areas with noise levels over the limits established by the national authorities (Environmental Protection Agency). These limits are, for road traffic noise, 70 dB(A) for L_{den} and 60 dB(A) for L_{night}. The conflict maps and the lists of population exposure help the organization that administer the road (that is the noise source) to take measures for noise mitigation. The action plan proposed in the case of this study involves the construction of a new road in East side of the studied area. This new road will help not only to reduce the noise level, but also to reduce the traffic jams at rush hours. However, the length of this paper don't allow further presentation of the conflict maps, action plans and predicted results of their implementation.

Since the main goal of the study was to assess the influence of the noise generated by the major road on the environment, the road traffic on the adjacent streets was ignored, except the road segment B, which is considered to have a high influence on the traffic volumes measured on the main artery.

One can consider that for this study was used data of high quality, as the most important input data was collected on site. No information was available when the project started, so that third party GIS data were used (OpenStreetMap, Google Maps) and on site observations. The traffic volumes were counted manually, in critical points of the road, and the speed was measured using an instrumented vehicle, equipped with a GPS receiver. The grid cell size used in calculation was 5 meters. According to the Good Practice Guide published by European Commission [23], the level of accuracy for different data used in this study are listed in Table 5.

Table 5

Accuracy of data used

Type of data	Accuracy of data used
Road traffic (volumes)	2 dB(A)
Traffic flow speed	<0.5 dB(A)
Traffic categories (light/heavy vehicles)	0.5 dB(A)
Road pavement	1 dB(A)
Speed variation at junctions	<0.5 dB
Road gradient	<0.5 dB
Building height	1 dB
Altitude of field	<0.5 dB
Type of field surface	1 dB
Weather information	1 dB
Demographic data	1 dB

Measuring the accuracy of the results obtained by noise mapping is a difficult task, since, as shown in the table above, each data type used has its own level of accuracy. Globally, on the final maps, the values of the calculated noise level for certain points should be with no more than 3 dB(A) different by the measured noise level in the same points. The noise map of the major road DJ200B was validated with differences between measured and modelled values of 2.5 respectively 2.4 dB, so it was not necessary to adjust the input data and then to model again the noise map.

The lower accuracy given in Table 5 is for the traffic volumes. This is because the counting was done during a single day. The existence of a long term vehicle counting database (years) would allow the determination of seasonal, monthly and daily correction factors, allowing more accurate measurements when using short-term counting (e.g. one hour). Lack of historical data is a premise of increasing uncertainty. The uncertainty of a result is reduced only if all input data are of acceptable accuracy. In case of a high uncertainty of all input data, the total uncertainty will exceed any of the individual values.

The accuracy of results is important in creating conflict maps, when the noise levels are compared with limit values, in order to develop action plans for noise mitigation, that involve public spending.

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