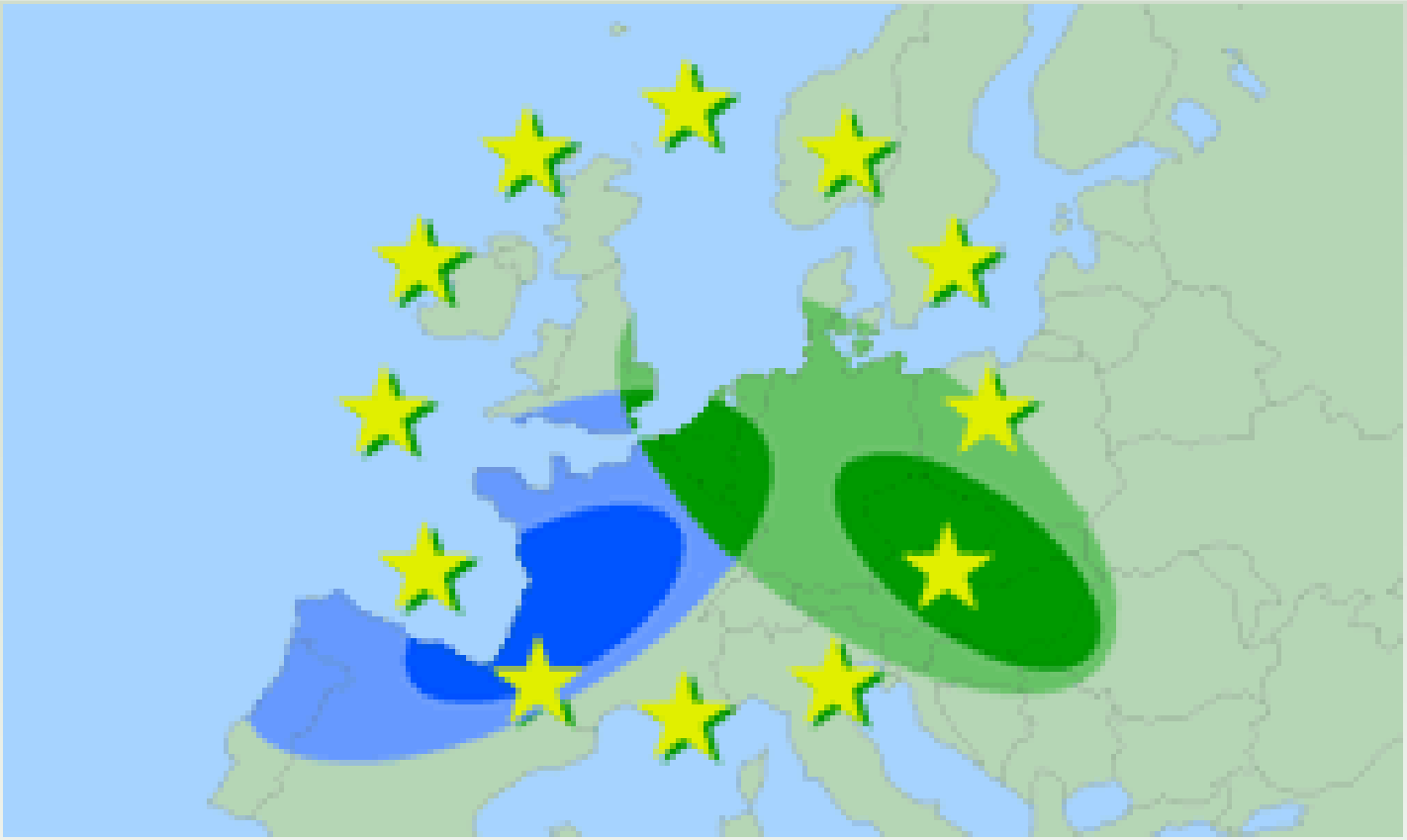


Momir Praščević, PhD

Full professor

University of Niš, Faculty of Occupational Safety of Nis, Noise&Vibration Laboratory

TAIEX Workshop on environmental noise protection
12. - 13. 11. 2015.

UNIVERSITY OF NIŠ

FACULTY OF OCCUPATIONAL SAFETY

Faculty of Occupational Safety, University of Niš is a modern, dynamic academic institution. It is one of the leading educational institutions in Serbia dealing with environmental issues.

Each year, more than 300 students enroll the bachelor (basic academic) studies, and more than 100 students choose one of our master programmes.

All our study programmes are accredited by the Accreditation Body of Serbia and they are in line with Bologna Process model.

50 1965-2015 50 1965-2015

BASIC ACADEMIC STUDIES IN:
- Occupational Safety (240 ECTS)
- Environmental Protection (240 ECTS)

MASTER DEGREE PROGRAMMES IN THE FOLLOWING MODULES:
- Occupational Safety Engineering (60 ECTS)
- Environmental Engineering (60 ECTS)
- Fire Protection Engineering (60 ECTS)
- Emergency Management (60 ECTS)
- Communal System Management (60 ECTS)

PhD STUDY PROGRAMMES:
- Occupational Safety Engineering (180 ECTS)
- Environmental Engineering (180 ECTS)

Our students and academics are doing research in our specialized laboratories:
- Air pollution control laboratory
- Noise and vibration laboratory
- Emergency management laboratory
- Laboratory for electromagnetic radiation

Basic, applied, and developmental research is being performed through cooperation with universities and institutions from Romania, Bulgaria, Slovenia, The Netherlands, Slovak Republic, Czech Republic, etc. Teaching staff from the Faculty of Occupational Safety participated in Erasmus Mundus, Tempus, IPA cross - border cooperation projects and several EU funded programmes.

We aim to educate our students to acquire the academic knowledge offered by study programmes, but also to make our study programmes more attractive for students in line with their needs.

UNIVERSITY OF NIŠ
FACULTY OF OCCUPATIONAL SAFETY
SERBIA, Niš, Čarnojevića 10 A
Phone: (+381 18) 529-701, Fax: (+381 18) 249-962

www.znrfak.ni.ac.rs

CENTER OF TECHNICAL DIAGNOSTICS & NOISE AND VIBRATION LABORATORY

UNIVERSITY OF NIŠ
FACULTY OF OCCUPATIONAL SAFETY
Čarnojevića 10a, 18000 Niš
Tel.: 018 529-747; Fax: 018 529-748

Environmental noise & Occupational noise - measurement and analyis
- Rating noise level;
- Frequency analyis;
- Statistical analysis;

Human vibration
- Hand-arm vibration;
- Whole body vibration;

Room acoustics
- Time reverberation;
- Airborne sound reduction index
- Impact sound reduction index;

Urban noise
- Noise monitoring;
- Noise zoning;
- Strategic noise maps;

Sound power of noise sources
- Sound pressure method;
- Sound intensity method;

Predictive/preventive maintenace of machine
- Vibration condition monitoring;
- Vibrodiagnostics;
- Balancing of rotating machine;

Education
- Workshops;
- Courses;
- Long-term learning;

Design of noise and vibration control systems
- Design of noise insulation and absorption system;
- Design of vibration insulation and absorption system;
- Design of room acoustics;

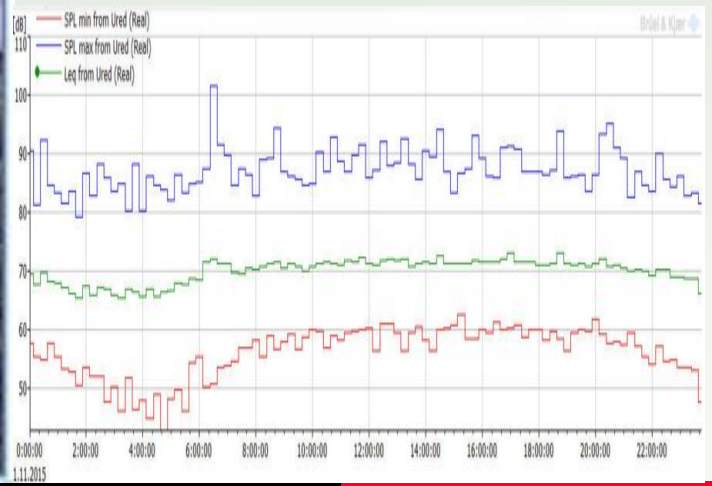
http://www.znrfak.ni.ac.rs/BVLab-KMB/KMB-Home.html

FAKULTET ZAŠTITE NA RADU U NIŠU
LABORATORIJA ZA BUKU I VIBRACIJE
KONTINUIRANI MONITORING BUKE

| HOME | LABORATORIJA | NMT 1 - OPIS LOKACIJE | NMT 1 - DNEVNI IZVEŠTAJ | NMT 2 - OPIS LOKACIJE | NMT 2 - DNEVNI IZVEŠTAJ | MESEČNI IZVEŠTAJ |

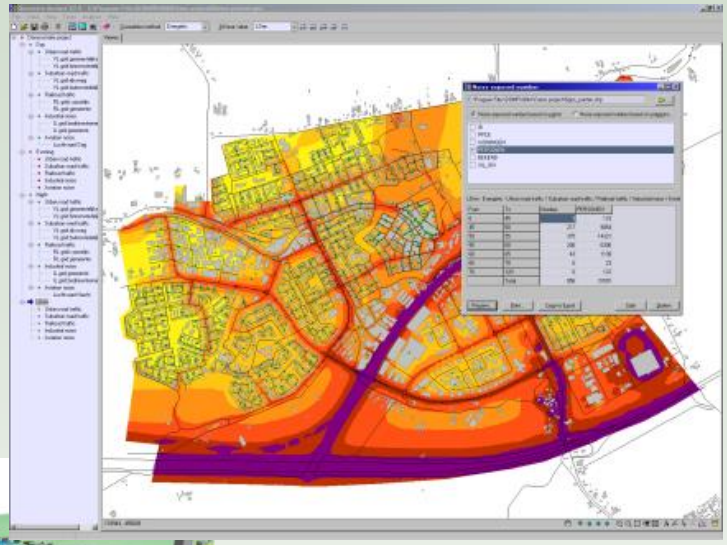
OKTOBAR 2015.

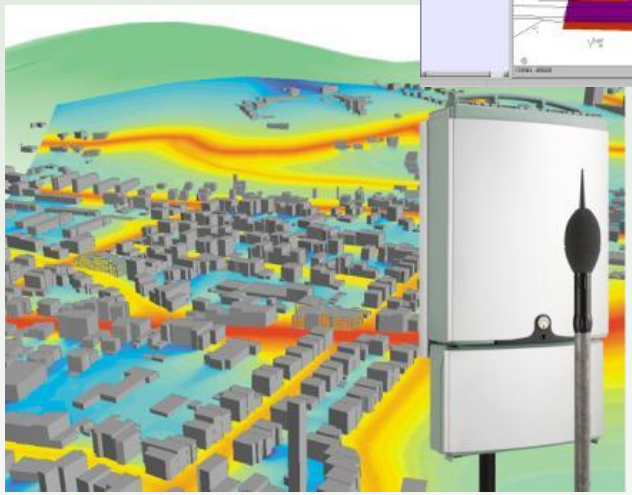
datum	INDIKATORI BUKE				TOP profil buke
	Lday [dB(A)]	Levening [dB(A)]	Lnight [dB(A)]	Lden [dB(A)]	
01.10.15	73.6	72.3	66.8	75.6	GRAFIČKI PRIKAZ
02.10.15	73.3	72.3	67.4	75.8	GRAFIČKI PRIKAZ
03.10.15	72.2	70.5	67.8	75.4	GRAFIČKI PRIKAZ
04.10.15	71.0	71.0	67.6	75.1	GRAFIČKI PRIKAZ
05.10.15	72.8	72.2	67.3	75.6	GRAFIČKI PRIKAZ
06.10.15	73.4	72.4	66.9	75.6	GRAFIČKI PRIKAZ
07.10.15	72.9	73.0	67.5	75.9	GRAFIČKI PRIKAZ
08.10.15	74.0	73.6	68.6	76.9	GRAFIČKI PRIKAZ
09.10.15	73.5	71.9	68.0	76.1	GRAFIČKI PRIKAZ
10.10.15	73.9	72.5	68.5	76.5	GRAFIČKI PRIKAZ
11.10.15	71.9	72.0	69.5	76.6	GRAFIČKI PRIKAZ
12.10.15	73.5	71.8	68.1	76.1	GRAFIČKI PRIKAZ
13.10.15	73.2	71.5	67.6	75.7	GRAFIČKI PRIKAZ
14.10.15	73.2	71.4	67.4	75.5	GRAFIČKI PRIKAZ
15.10.15	73.2	71.8	66.9	75.4	GRAFIČKI PRIKAZ
16.10.15	73.2	74.1	67.9	76.5	GRAFIČKI PRIKAZ
17.10.15	72.6	71.4	67.9	75.7	GRAFIČKI PRIKAZ
18.10.15	71.1	71.2	67.6	75.2	GRAFIČKI PRIKAZ
19.10.15	72.9	71.3	67.0	75.3	GRAFIČKI PRIKAZ
20.10.15	74.5	72.9	68.2	76.6	GRAFIČKI PRIKAZ
21.10.15	73.2	71.9	67.3	75.7	GRAFIČKI PRIKAZ
22.10.15	74.8	73.4	67.9	76.7	GRAFIČKI PRIKAZ
23.10.15	74.1	72.0	68.3	76.4	GRAFIČKI PRIKAZ
24.10.15	72.7	71.6	67.8	75.7	GRAFIČKI PRIKAZ
25.10.15	71.4	71.2	67.4	75.1	GRAFIČKI PRIKAZ
26.10.15	73.8	71.8	67.5	75.9	GRAFIČKI PRIKAZ
27.10.15	71.5	71.6	68.0	75.9	GRAFIČKI PRIKAZ
28.10.15	73.0	71.5	67.2	75.4	GRAFIČKI PRIKAZ
29.10.15	73.0	71.5	68.6	76.2	GRAFIČKI PRIKAZ
30.10.15	73.2	71.9	67.7	75.8	GRAFIČKI PRIKAZ
31.10.15	72.3	71.5	67.9	75.6	GRAFIČKI PRIKAZ



momir.prascevic@znrfak.ni.ac.rs

Industry noise mapping for strategy noise mapping





Action planning

➲ Industrail noise maps

- ➲ Environmental impact assessment
- ➲ Environmental licence (**I**ntegrated **P**ollution **P**revention and **C**ontrol regulations)
- ➲ Complaints from neighbours
- ➲ Certification under ISO 14000
- ➲ Certification under EMAS (Eco-Management and Audit Scheme)
- ➲ Strategic noise mapping (END)

➲ Environmental noise directive

➲ What is industry?

'environmental noise' shall mean unwanted or harmful outdoor sound created by human activities, including noise emitted by means of transport, road traffic, rail traffic, air traffic, and from sites of industrial activity such as those defined in Annex I to Council Directive 96/61/EC of 24 September 1996 concerning integrated pollution prevention and control

➲ Environmental noise directive

➲ What is industry?

Strategic noise maps for agglomerations shall put a special emphasis on the noise emitted by

- **— road traffic,**
- **— rail traffic,**
- **— airports,**
- **— industrial activity sites, including ports.**

➲ Annex I to Council Directive 96/61/EC

➲ Categories of industrial activities

— Energy industries:

Combustion installations with a rated thermal input exceeding 50 MW (1); Mineral oil and gas refineries; Coke ovens; Coal gasification and liquefaction plants

— Production and processing of metals:

Metal ore (including sulphide ore) roasting or sintering installations; Installations for the production of pig iron or steel (primary or secondary fusion) including continuous casting, with a capacity exceeding 2,5 tonnes per hour; Installations for the processing of ferrous metals: Ferrous metal foundries with a production capacity exceeding 20 tonnes per day; Installations; Installations for surface treatment of metals and plastic materials using an electrolytic or chemical process where the volume of the treatment vats exceeds 30 m^3

— Mineral industry:

Installations for the production of cement clinker in rotary kilns with a production capacity exceeding 500 tonnes per day or lime in rotary kilns with a production capacity exceeding 50 tonnes per day or in other furnaces with a production capacity exceeding 50 tonnes per day; Installations for the production of asbestos and the manufacture of asbestos-based products; Installations for the manufacture of glass including glass fibre with a melting capacity exceeding 20 tonnes per day; Installations for melting mineral substances including the production of mineral fibres with a melting capacity exceeding 20 tonnes per day; Installations for the manufacture of ceramic products by firing, in particular roofing tiles, bricks, refractory bricks, tiles, stoneware or porcelain, with a production capacity exceeding 75 tonnes per day, and/or with a kiln capacity exceeding 4 m^3 and with a setting density per kiln exceeding 300 kg/m^3

➲ Annex I to Council Directive 96/61/EC

➲ Categories of industrial activities (+)

— Chemical industry:

Chemical installations for the production of basic organic chemicals; Chemical installations for the production of basic inorganic chemicals; Chemical installations for the production of phosphorous-, nitrogen- or potassium-based fertilizers (simple or compound fertilizers); Chemical installations for the production of basic plant health products and of biocides; Installations using a chemical or biological process for the production of basic pharmaceutical products; Chemical installations for the production of explosives

— Waste management:

Installations for the disposal or recovery of hazardous waste as defined in the list referred to in Article 1 (4) of Directive 91/689/EEC, as defined in Annexes II A and II B (operations R1, R5, R6, R8 and R9) to Directive 75/442/EEC and in Council Directive 75/439/EEC of 16 June 1975 on the disposal of waste oils (3), with a capacity exceeding 10 tonnes per day; Installations for the incineration of municipal waste as defined in Council Directive 89/369/EEC of 8 June 1989 on the prevention of air pollution from new municipal waste incineration plants (4) and Council Directive 89/429/EEC of 21 June 1989 on the reduction of air pollution from existing municipal waste-incineration plants (5) with a capacity exceeding 3 tonnes per hour; Installations for the disposal of non-hazardous waste as defined in Annex II A to Directive 75/442/EEC under headings D8 and D9, with a capacity exceeding 50 tonnes per day; Landfills receiving more than 10 tonnes per day or with a total capacity exceeding 25 000 tonnes, excluding landfills of inert waste

➲ Annex I to Council Directive 96/61/EC

➲ Categories of industrial activities (+)

— Other activities:

Industrial plants for the production of pulp from timber or other fibrous materials and paper and board with a production capacity exceeding 20 tonnes per day; Plants for the pre-treatment (operations such as washing, bleaching, mercerization) or dyeing of fibres or textiles where the treatment capacity exceeds 10 tonnes per day; Plants for the tanning of hides and skins where the treatment capacity exceeds 12 tonnes of finished products per day; Slaughterhouses with a carcase production capacity greater than 50 tonnes per day; Treatment and processing intended for the production of food products from animal raw materials (other than milk) with a finished product production capacity greater than 75 tonnes per day and vegetable raw materials with a finished product production capacity greater than 300 tonnes per day (average value on a quarterly basis); Treatment and processing of milk, the quantity of milk received being greater than 200 tonnes per day (average value on an annual basis); Installations for the disposal or recycling of animal carcases and animal waste with a treatment capacity exceeding 10 tonnes per day; Installations for the intensive rearing of poultry or pigs with more than 40 000 places for poultry, 2 000 places for production pigs (over 30 kg), or 750 places for sows; Installations for the surface treatment of substances, objects or products using organic solvents, in particular for dressing, printing, coating, degreasing, waterproofing, sizing, painting, cleaning or impregnating, with a consumption capacity of more than 150 kg per hour or more than 200 tonnes per year; Installations for the production of carbon (hard-burnt coal) or electrographite by means of incineration or graphitization

➲UREDBA O VRSTAMA AKTIVNOSTI I POSTRO-JENJA ZA KOJE SE IZDAJE INTEGRISANA DOZVOLA ("Sl. glasnik RS", br. 84/2005)

➲Transposition of Annex I to Council Directive 96/61/EC

Law enforcement in the field of industrial pollution control,
prevention of chemical accidents and establishing the EMAS system
EuropeAid/131555/C/SER/RS

LIST OF IPPC INSTALLATIONS

- The list of IPPC installations have been updated by the Special Working Group established by the Minister Decision no. 119-01-00032 / 2014-05 of 10.02.2014.
- The list is made on the basis of the Law on Integrated Pollution Prevention and Control of Environmental Pollution (Fig. Gazette of RS, no. 135/04) and the Regulation on the types of activities and facilities for which integrated permit is issued (Fig. Gazette of RS, no. 84 / 05).

ippcserbia.org/dokumenta/172/IPPC%20Serbia_36877034.pdf

Law enforcement in the field of industrial pollution control,
prevention of chemical accidents and establishing the EMAS system
EuropeAid/131555/C/SER/RS

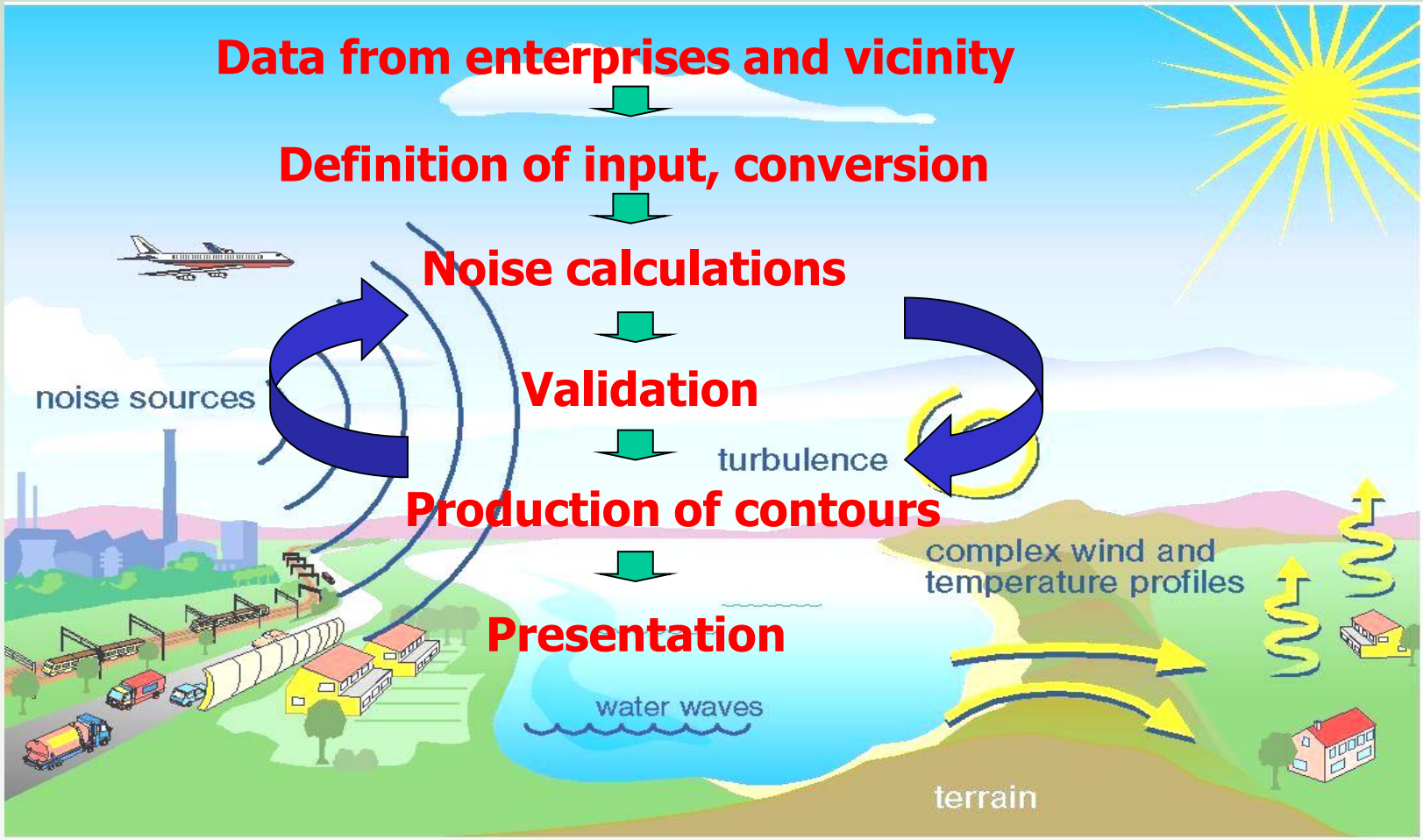
LIST OF IPPC INSTALLATIONS

28.	Toplana Krivi Vir JP "Gradska toplana" Niš	Adresa objekta: Ul.Blagoja Parovića 3, Niš Tel:018/4530413 Faks:018/4533927	1.1	128 MW
29.	Toplana Jug JP "Gradska toplana" Niš	Adresa objekta: Ul. Branka Radićevića, Niš Tel:018/4530413 Faks:018/4533927 nebojsa.rajkovic@nitoplana.rs popov.tatjana@nitoplana.rs	1.1	66,75 MW
15.	"NISSAL" a.d. preduzeće za preradu aluminijuma	Bulevar Svetog Cara Konstantina bb, 18110 Niš Tel: 018/541-501; 502-510 office@nissal.co.rs gordaya.stamenkovic@nissal.co.rs	2.6	Zapremine kada za površinsku obradu aluminijuma preko 30 m^3
17.	AD "Holcim Srbija", Popovac, fabrika cementa	35254 Popovac Tel.035/572-264 Fax 035/572-576 hristina.stojkovic@holcim.com	3.1.	2.000 t /dnevno cementnog klinkera

Град Ниш
City of Niš

Holcim

➲ Noise mapping methodology



Noise calculations vs Immision measurements

- Direct measurement at the dwellings are problematic, because of other sources (e.g. traffic noise) and representativity
- One can only check one point each time you measure, so measuring is time consuming and costly
- Better is to measure the emission of the sources nearby and to calculate noise at all surrounding dwellings (although this also requires some effort)
- For industry: Less standardized emission data (like for road traffic) are available
- Industrial noise sources consist of many completely different objects (machinery, fans, blowers, furnaces, pumps, shovels etc) large variation in types and noise power
- Immision measurements most accurate

➲ Noise calculations according to END

➲ ISO 9613-2: „Acoustics — Attenuation of sound propagation outdoors, Part 2; General method of calculation”

Formula: $L_f = L_W + D_c - A$

$$A = A_{div} + A_{atm} + A_{gr} + A_{bar} + A_{misc}$$

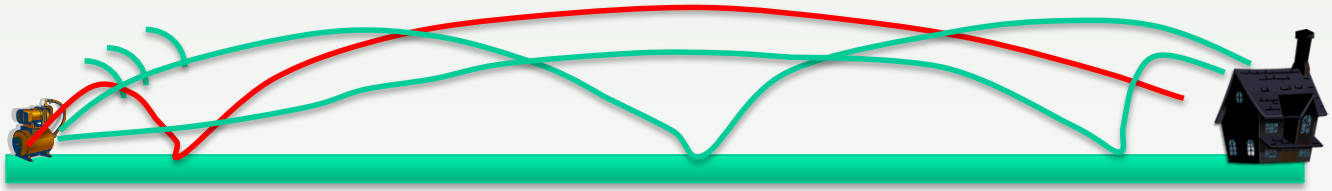
L_f – immission octave-band sound pressure level
L_w – octave-band sound power level
D_c – directivity correction
A - octave-band attenuation

➲ Noise calculations according to END

➲ ISO 9613-2 (+)

- ➲ Divergence (distance reduction)
- ➲ Atmospheric absorption
- ➲ Ground effect (absorption/reflection)
- ➲ Screening by barriers/objects, etc
- ➲ Miscellaneous effects, like:
  - Reductions in residential areas/installations
  - Propagation through forests

$$A = A_{div} + A_{atm} + A_{gr} + A_{bar} + A_{misc}$$



➲ Noise calculations according to END

➲CNOSSOS-EU (from 31. 12. 2018.)

- ➲ Frequency range from 63 Hz to 8 kHz
- ➲ Classification of source types (point, line, area)
- ➲ Sound source information
  - Emitted sound power level spectrum (L_w, $L_{w/m}$, $L_{w/m2}$)
  - Working hours (day, evening, night, on a yearly averaged basis)
  - Location (x, y) and elevation (z) of the noise source
  - Type of source (point, line, area)
  - Dimensions and orientation
  - Operating conditions of the source
  - Directivity of the source.

$$C_W = 10 \times \lg\left(\frac{T}{T_{ref}}\right)$$

➲ Noise calculations according to END

➲CNOSSOS-EU (+)

➲ Sound propagation model

- calculation of the attenuation in favourable conditions
- calculation of the attenuation in homogeneous conditions
- calculation of the long-term sound level for each path
- accumulation of the long-term sound levels for all paths affecting a specific receiver, therefore allowing the total sound level to be calculated at the receiver point

$$L_{LT} = 10 \times \lg\left(p \cdot 10^{\frac{L_F}{10}} + (1-p) \cdot 10^{\frac{L_H}{10}}\right)$$

➲ Noise calculations according to END

➲CNOSSOS-EU (+)

➲ Attenuation

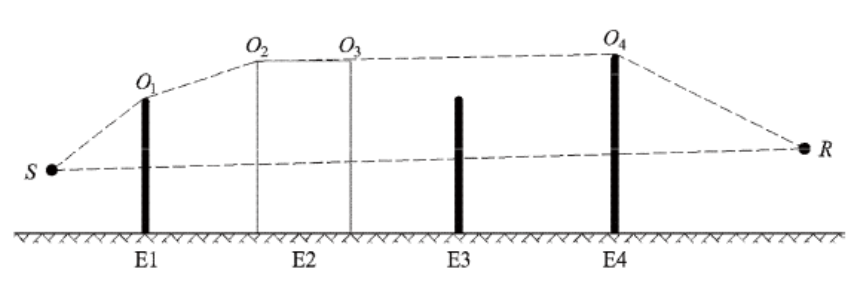
- the attenuation due to geometrical divergence

$$A_{div} = 20 \times \lg(d) + 11$$

- the attenuation due to atmospheric absorption

$$A_{atm} = \alpha_{atm} \cdot d/1\,000$$

- the attenuation due to the boundary of the propagation medium
- the attenuation due to the ground or the attenuation due to diffraction



➲ Emitted sound power level determination

- ➲ Measurements
- ➲ Databases
- ➲ Literature/reports/previous surveys, etc.
- ➲ 'Kentallen' which are dB(A)/m2
- ➲ Data delivered by manufacturers

➲ Emitted sound power level determination

➲ Measurements regarding annex II END

- ISO 8297: 1994 „Acoustics — Determination of sound power levels of multisource industrial plants for evaluation of sound pressure levels in the environment — Engineering method";
- EN ISO 3744: 1995 „Acoustics — Determination of sound power levels of noise sources using sound pressure — Engineering method in an essentially free field over a reflecting plane";
- EN ISO 3744: 2010 „Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Engineering method in an essentially free field over a reflecting plane";
- EN ISO 3746: 1995 „Acoustics — Determination of sound power levels of noise sources — Survey method using an enveloping measurement surface over a reflecting plane"
- EN ISO 3746: 2010 „Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure - Survey method using an enveloping measurement surface over a reflecting plane"

➲ Emitted sound power level determination

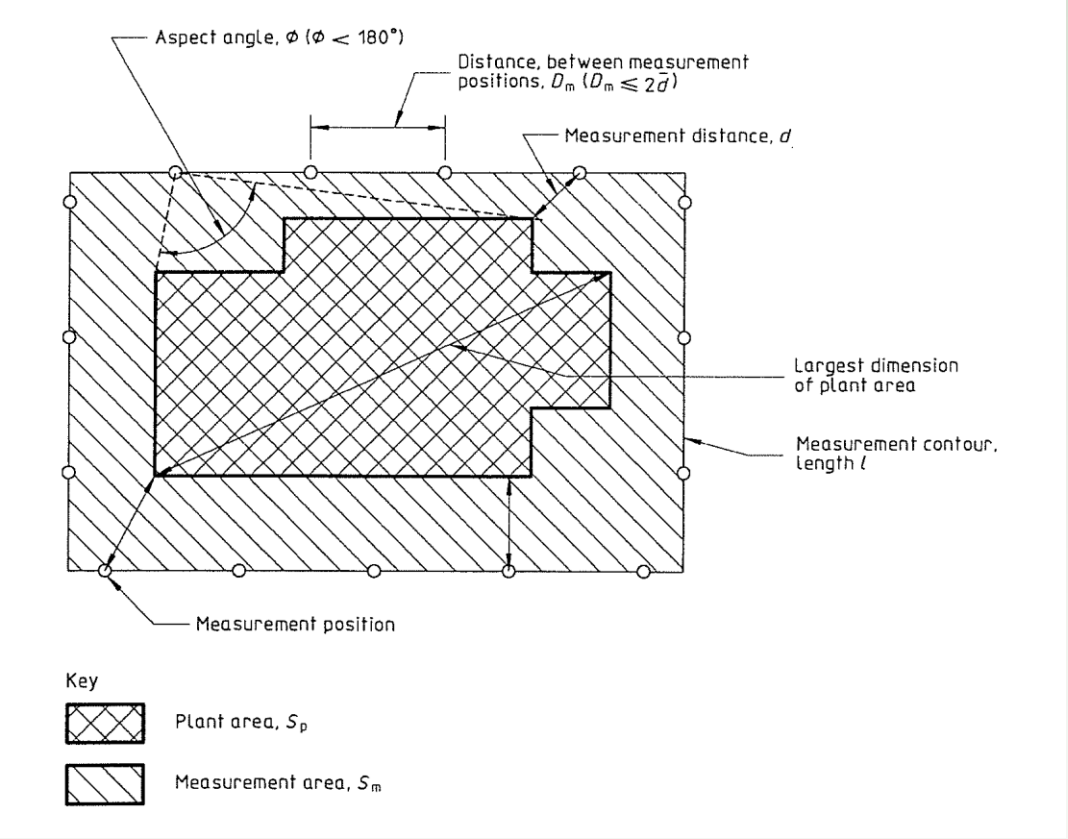
➲ HMRI II.7 Netherlands

- Noise emitting buildings
- Sound pressure level inside building + sound insulation of façade elements -> SPL surface source

➲ Emitted sound power level determination

➲ Measurements regarding annex II END

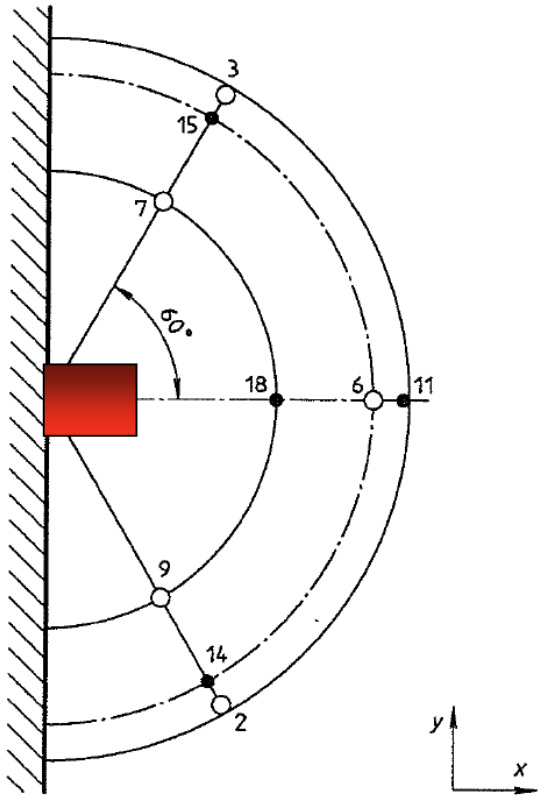
➲ ISO 8297: 1994

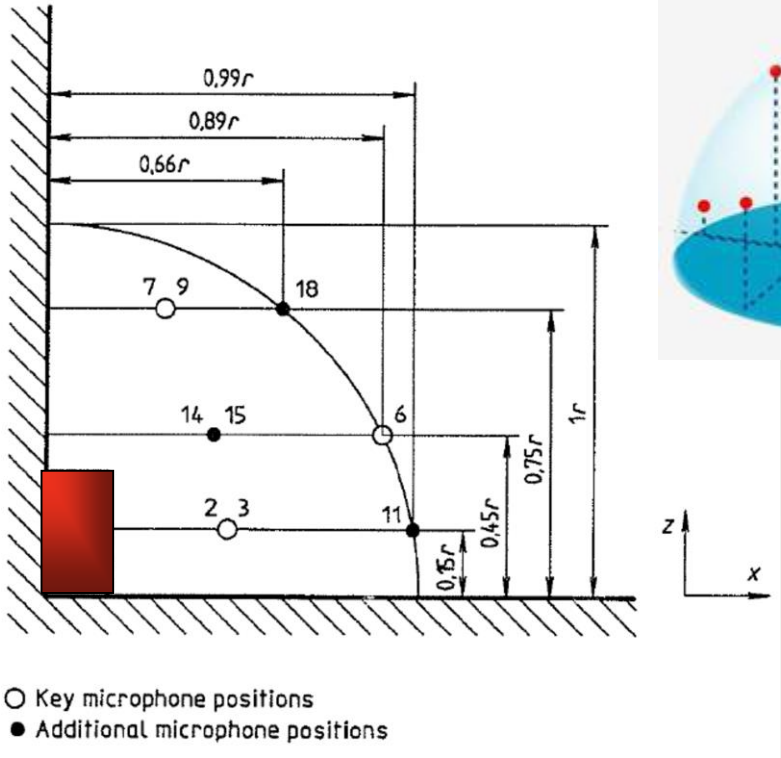


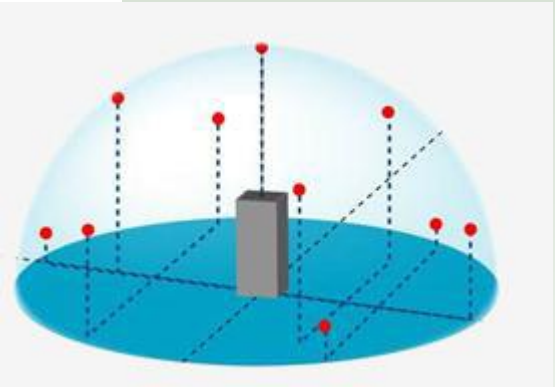
➲ Emitted sound power level determination

➲ Measurements regarding annex II END

➲ ISO 3744 / ISO 3746







➲ Emitted sound power level determination

➲ Measurements regarding annex II END

➲ Emitted sound power level determination

➲ Databases

➲ SourceDB, linked in Predictor - LimA

SourceDB+ - Licensed to: DGMR Software B.V.

File Edit Extra Help

Sources | Spectra

Description	Sound power [dB(A)]	Drive type	Industry type	Source type	Quality	Data input	Height [m]	Height variation
Container repair	69,9	other	container repair	area (dBA/m2)	poor	Standard	5	2
Container repair	67,9	other	container repair	area (dBA/m2)	avarage	Standard	5	2
Container repair	65,9	other	container repair	area (dBA/m2)	good	Standard	5	2
Metal construction works (outside	98	other	container repair	point (dBA)	avarage	Standard	1,5	1
Metal construction works (outside	98	other	ship yards	point (dBA)	avarage	Standard	1,5	1
Lifting truck - 16 ton - diesel	106,1	internal combustion	container repair	point (dBA)	poor	Standard	1	0,5
Lifting truck - 16 ton - diesel	105,1	internal combustion	container repair	point (dBA)	avarage	Standard	1	0,5
Lifting truck - 16 ton - diesel	104,1	internal combustion	container repair	point (dBA)	good	Standard	1	0,5
Mobile crane - 100kW<>200kW	109,1	internal combustion	construction and building	point (dBA)	poor	Standard	1,5	0,5
Mobile crane - 100kW<>200kW	109,1	internal combustion	container repair	point (dBA)	poor	Standard	1,5	0,5
Mobile crane - 100kW<>200kW	109,1	internal combustion	contractor companies	point (dBA)	poor	Standard	1,5	0,5
Mobile crane - 100kW<>200kW	109,1	internal combustion	ship yards	point (dBA)	poor	Standard	1,5	0,5
Mobile crane - 100kW<>200kW	105,1	internal combustion	construction and building	point (dBA)	avarage	Standard	1,5	0,5
Mobile crane - 100kW<>200kW	105,1	internal combustion	container repair	point (dBA)	avarage	Standard	1,5	0,5
Mobile crane - 100kW<>200kW	105,1	internal combustion	contractor companies	point (dBA)	avarage	Standard	1,5	0,5
Mobile crane - 100kW<>200kW	105,1	internal combustion	ship yards	point (dBA)	avarage	Standard	1,5	0,5
Mobile crane - 100kW<>200kW	103,1	internal combustion	contractor companies	point (dBA)	good	Standard	1,5	0,5
Mobile crane - 100kW<>200kW	103,1	internal combustion	container repair	point (dBA)	good	Standard	1,5	0,5
Mobile crane - 100kW<>200kW	103,1	internal combustion	construction and building	point (dBA)	good	Standard	1,5	0,5
Mobile crane - 100kW<>200kW	103,1	internal combustion	ship yards	point (dBA)	good	Standard	1,5	0,5
Yard stacking cranes	107	electric	container repair	point (dBA)	poor	Standard	15	5
Yard stacking cranes	102	electric	container repair	point (dBA)	avarage	Standard	15	5
Yard stacking cranes	97	electric	container repair	point (dBA)	good	Standard	15	5
Reefers - pretrippen - diesel	90,6	internal combustion	container terminals	point (dBA)	avarage	Standard	2	0,5
Reefers - pretrippen - diesel	90,6	internal combustion	container repair	point (dBA)	avarage	Standard	2	0,5

C:\Proj32\SDBplus\Out\imagine.mdb [number of sources: 1128] Database version: 1.0

FREE

http://www.imagine-project.org/

http://www.dgmr.nl/

imagine

➲ Emitted sound power level determination

➲ Databases

➲ SourceDB, linked in Predictor – LimA (+)

SourceDB+ - Licensed to: DGMR Software B.V.

File Edit Extra Help

Sources | Spectra

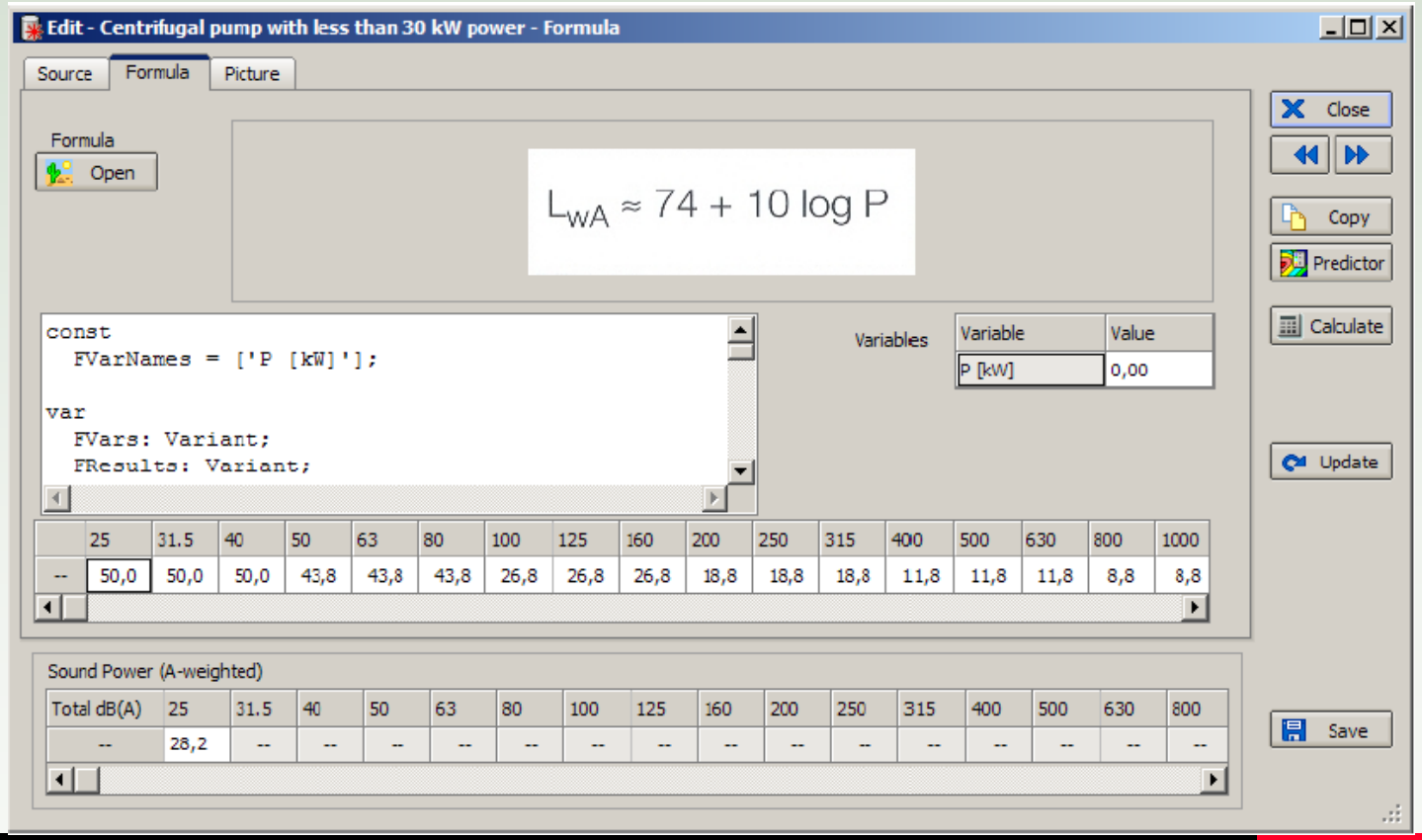
Description	Sound power [dB(A)]	25	31.5	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2
Container repair	69,9	28,2	28,2	28,2	40,2	40,2	40,2	47,2	47,2	47,2	53,2	53,2	53,2	57,2	57,2	57,2	62,2	62,2	62,2	58,2	
Container repair	67,9	26,2	26,2	26,2	38,2	38,2	38,2	45,2	45,2	45,2	51,2	51,2	51,2	55,2	55,2	55,2	60,2	60,2	60,2	56,2	
Container repair	65,9	24,2	24,2	24,2	36,2	36,2	36,2	43,2	43,2	43,2	49,2	49,2	49,2	53,2	53,2	53,2	58,2	58,2	58,2	54,2	
Metal construction works (outside	98	65,2	65,2	65,2	75,2	75,2	75,2	81,2	81,2	81,2	86,2	86,2	86,2	90,2	90,2	90,2	78,2	78,2	78,2	85,2	
Metal construction works (outside	98	65,2	65,2	65,2	75,2	75,2	75,2	81,2	81,2	81,2	86,2	86,2	86,2	90,2	90,2	90,2	78,2	78,2	78,2	85,2	
Lifting truck - 16 ton - diesel	106,1	61,2	61,2	61,2	75,2	75,2	75,2	80,2	80,2	80,2	90,2	90,2	90,2	94,2	94,2	94,2	97,2	97,2	97,2	95,2	
Lifting truck - 16 ton - diesel	105,1	60,2	60,2	60,2	74,2	74,2	74,2	79,2	79,2	79,2	89,2	89,2	89,2	93,2	93,2	93,2	96,2	96,2	96,2	94,2	
Lifting truck - 16 ton - diesel	104,1	59,2	59,2	59,2	73,2	73,2	73,2	78,2	78,2	78,2	88,2	88,2	88,2	92,2	92,2	92,2	95,2	95,2	95,2	93,2	
Mobile crane - 100kW<>200kW	109,1	64,2	64,2	64,2	78,2	78,2	78,2	83,2	83,2	83,2	93,2	93,2	93,2	97,2	97,2	97,2	100,2	100,2	100,2	98,2	
Mobile crane - 100kW<>200kW	109,1	64,2	64,2	64,2	78,2	78,2	78,2	83,2	83,2	83,2	93,2	93,2	93,2	97,2	97,2	97,2	100,2	100,2	100,2	98,2	
Mobile crane - 100kW<>200kW	109,1	64,2	64,2	64,2	78,2	78,2	78,2	83,2	83,2	83,2	93,2	93,2	93,2	97,2	97,2	97,2	100,2	100,2	100,2	98,2	
Mobile crane - 100kW<>200kW	109,1	64,2	64,2	64,2	78,2	78,2	78,2	83,2	83,2	83,2	93,2	93,2	93,2	97,2	97,2	97,2	100,2	100,2	100,2	98,2	
Mobile crane - 100kW<>200kW	105,1	60,2	60,2	60,2	74,2	74,2	74,2	79,2	79,2	79,2	89,2	89,2	89,2	93,2	93,2	93,2	96,2	96,2	96,2	94,2	
Mobile crane - 100kW<>200kW	105,1	60,2	60,2	60,2	74,2	74,2	74,2	79,2	79,2	79,2	89,2	89,2	89,2	93,2	93,2	93,2	96,2	96,2	96,2	94,2	
Mobile crane - 100kW<>200kW	105,1	60,2	60,2	60,2	74,2	74,2	74,2	79,2	79,2	79,2	89,2	89,2	89,2	93,2	93,2	93,2	96,2	96,2	96,2	94,2	
Mobile crane - 100kW<>200kW	105,1	60,2	60,2	60,2	74,2	74,2	74,2	79,2	79,2	79,2	89,2	89,2	89,2	93,2	93,2	93,2	96,2	96,2	96,2	94,2	
Mobile crane - 100kW<>200kW	103,1	58,2	58,2	58,2	72,2	72,2	72,2	77,2	77,2	77,2	87,2	87,2	87,2	91,2	91,2	91,2	94,2	94,2	94,2	92,2	
Mobile crane - 100kW<>200kW	103,1	58,2	58,2	58,2	72,2	72,2	72,2	77,2	77,2	77,2	87,2	87,2	87,2	91,2	91,2	91,2	94,2	94,2	94,2	92,2	

C:\Proj32\SDBplus\Out\Imagine.mdb [number of sources: 1128] Database version: 1.0

➲ Emitted sound power level determination

➲ Databases

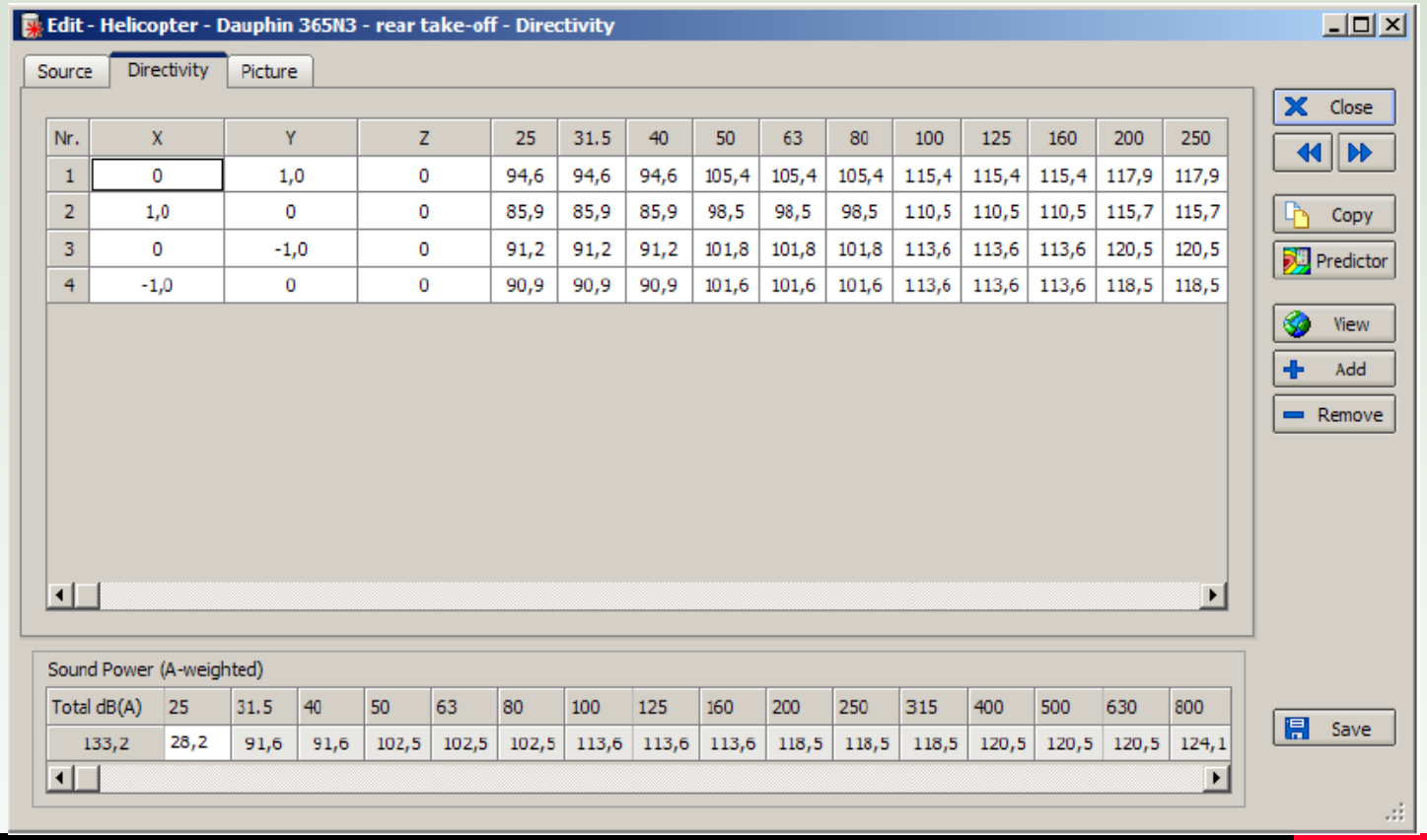
➲ SourceDB, linked in Predictor – LimA (+)



➲ Emitted sound power level determination

➲ Databases

➲ SourceDB, linked in Predictor – LimA (+)



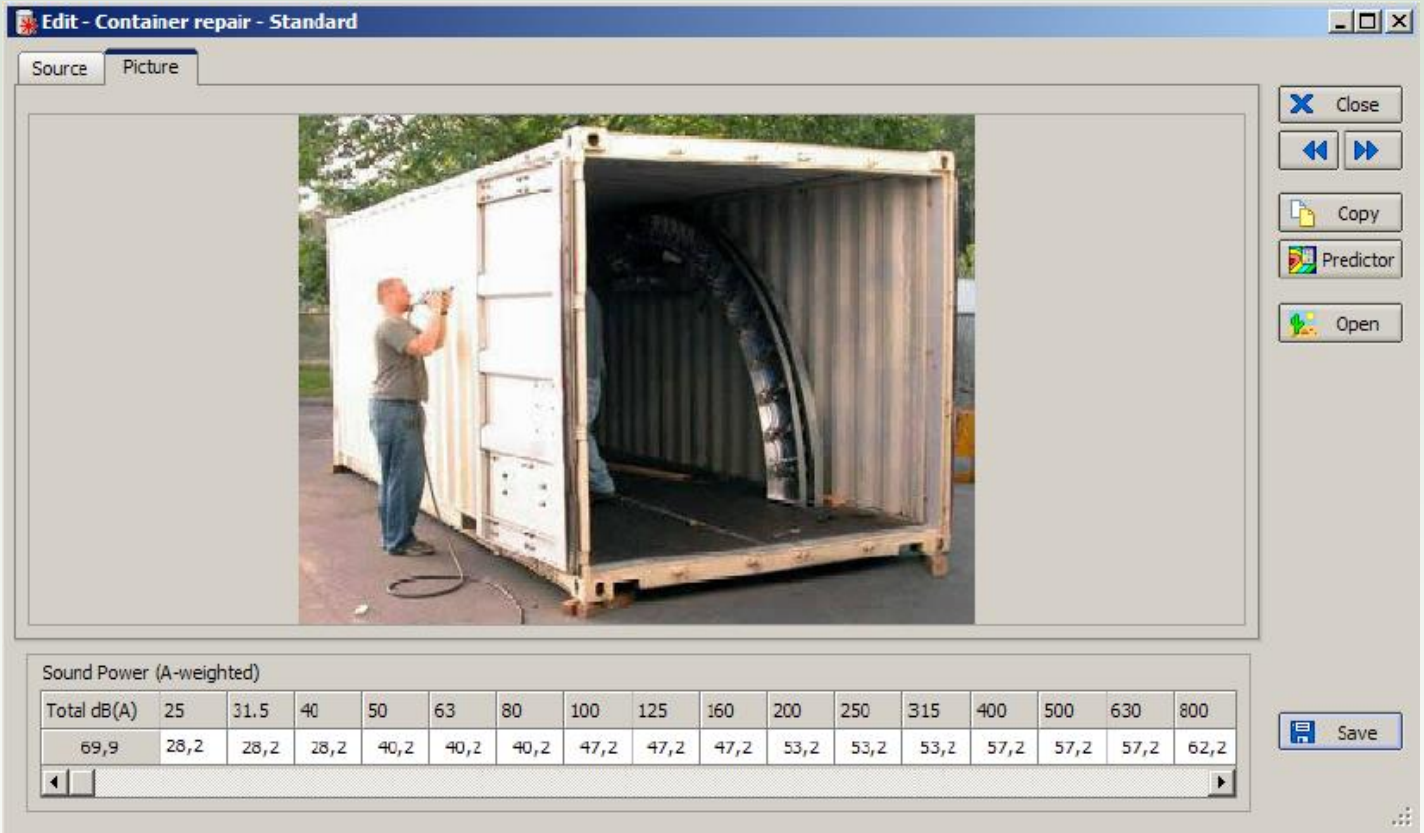
Nr.	X	Y	Z	25	31.5	40	50	63	80	100	125	160	200	250
1	0	1,0	0	94,6	94,6	94,6	105,4	105,4	105,4	115,4	115,4	115,4	117,9	117,9
2	1,0	0	0	85,9	85,9	85,9	98,5	98,5	98,5	110,5	110,5	110,5	115,7	115,7
3	0	-1,0	0	91,2	91,2	91,2	101,8	101,8	101,8	113,6	113,6	113,6	120,5	120,5
4	-1,0	0	0	90,9	90,9	90,9	101,6	101,6	101,6	113,6	113,6	113,6	118,5	118,5

Total dB(A)	25	31.5	40	50	63	80	100	125	160	200	250	315	400	500	630	800
133,2	28,2	91,6	91,6	102,5	102,5	102,5	113,6	113,6	113,6	118,5	118,5	118,5	120,5	120,5	120,5	124,1

➲ Emitted sound power level determination

➲ Databases

➲ SourceDB, linked in Predictor – LimA (+)



➲ Emitted sound power level determination

➲ Databases

➲ Other databases (source: Henk Wolfert)

Table 1: Sample databases for individual industrial sound sources with sound power levels for entire companies.

Database	Description	Address
Directive 2000/14/EC	Sound power levels of equipment used outdoors: Art 12, limiting values for different types of machines.	http://europa.eu.int/comm/environment/noise
Report UBA-94-102	Noise emission Measurement – Limit values – State of the art Chapter 2.2.1	Umweltbundesamt (Federal Environmental Agency) Austria
Lärm Bekampfung 88	Tendenzen – Probleme – Lösungen	Umweltbundesamt (Federal Environmental Agency) Germany
British Standard 5228 part 1 – 1997	Noise and vibration control on construction and open sites.	British Standards Institution UK
Eurovent Directory of Certified products	Certified Lw for Air Conditioners and Cooling Equipment.	Eurovent Certification Company France

➲ Emitted sound power level determination

➲ Databases

➲ Other databases (source: Good Practice Guide)

Table 2: Non-comprehensive list of available databases with sound power levels for entire companies.		
Database	**Description**	**Address**
Kentallen Industrie	Mean value of Lw" on the basis of a large number of situations	i-kwadraat c/o DCMR Milieudienst Rijnmond The Netherlands E-mail : si2@DCMR.nl http://www.xs4all.nl/~rigolett
DGMK Project 209	Specific A-weighted Sound Power Level of Refineries and Petrochemical Works	DGMK Deutsche Wissenschaftliche Gesellschaft für Erdöl, Erdgas und Kohle e.V Germany
DGMK Project 308	Evaluation of the immission-relevant A-weighted sound power level of an open plant from sound measurements inside the plant.	
DGMK Project 446	Community noise levels of existing refineries and petrochemical plants.	
Report UBA-94-102	Noise emission Measurement – Limit values – State of the art Chapter 2.2.2	Umweltbundesamt (Federal Environmental Agency) Austria
Monographien Band 154	Schallemission von Betriebstypen und Flächenwidmung	
DIN18005 Part 1	Noise abatement in town planning; calculation methods	http://www2.din.de/
AV-Ecosafer	L_W measured on site for different types of open chemical and petrochemical installations	AV-Ecosafer nv Belgium
Defra	Update of noise database for prediction of noise on construction and open sites (HMSO 2005)	http://www.defra.gov.uk/

➲ Emitted sound power level determination

➲ Literature

- ➲ Schalltechnischen Taschen Buch
- ➲ Integrated low-noise design in process industry
- ➲ Lärmminderung in Petro-Chemie
- ➲ VDI publications
- ➲ BREFS belonging to IPPC (reference documents)
- ➲ Websites
- ➲ Good Practice Guide on Port Area Noise Mapping and Management (NOMEPorts)
- ➲ Articles or papers
- ➲ Previous reports/surveys

➲ Emitted sound power level determination

➲ 'Kentallen' method

➲ Emission value per m2 production surface
➲ Document:

https://www.rijksoverheid.nl/documenten/brochures/2011/03/22/handleiding-meten-en-rekenen-industrielawaai

Activity	dB(A) per m^2
Process industry	65
Refineries	70
Container Terminal	65
Production hall	50
Shipyard	70
Oil Terminal	45
Warehousing	55

➲ Emitted sound power level determination

➲ 'Kentallen' method

➲ Calculation

http://rigolett.home.xs4all.nl/ENGELS/lwacalc.htm

Sound power per m2 (LWA in dB(A)/m2)
process-industry.....65 Refineries .....70 chemicals 68
68 Other value if known...
Number of m2
100

data on geometry			
Heigth of source (meter)	2		
Horizontal distance between source and receiver (meter)	50		
Fraction sound absorbing soil (0=all reflecting(sand, concrete, water); 1= all absorbing(arable land, forest floor)	0.5		
Heigth of house or observer (meter)	5		
Operational time (hrs)	8	in a total period of (hrs)	16
Operational time during NIGHT (hrs; max=8)	0		
Calculated Noise Level (LAeq in dB(A)) Here			

Click Here to Reset | Click Here to Compute

➲ Emitted sound power level determination

➲ Data obtained from manufacturers

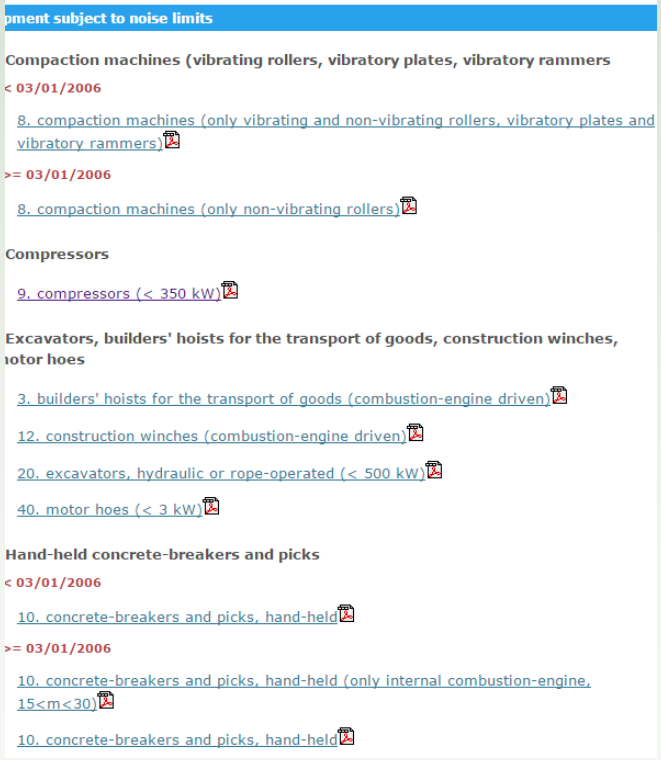
➲ It's often determined according to test methods Directive 2000/14/EC:

- ⇨ Emission Limit Values
- ⇨ Noise Labelling

➲ Noise emissions for outdoor equipment – Database:

http://ec.europa.eu/growth/tools-databases/noise-emissions-outdoor-equipment/index_en.htm

CAREFULLY!!!



➲ Representative operations for noise emmission

- ➲ Determine relevant noise sources for noise emission
- ➲ Determine representative operations
  - ➲ Depends on the evaluation parameter
    - ⇨ Lden or Lday and Lnight: averaging over 1 year
    - ⇨ NL: 12 days with incidental operations are excluded -> 13th busiest day is determinative

For example: unloading chemical tankers with deepwell pumps 1 day per week

- ⇨ Averaging over 1 year -> -8 dB (1/7)
- ⇨ NL: -0 dB

➲ Representative operations for noise emmission

- ➲ How to do?
  - ➲ Visit the company
  - ➲ Interview an operations manager
  - ➲ Determine:
    - ⇨ Relevant noise sources for Sound Power Level

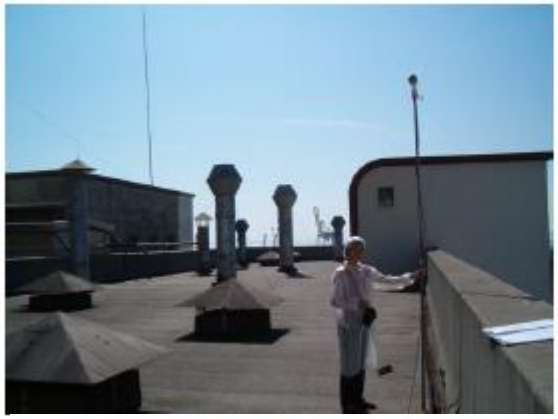
      The noisiest ones first...
    - ⇨ Relevant noise sources for operating time

      A lot of little ones makes a big one

- **Input data of surroundings and objects**
  - Topographical maps
  - Altitude data of the terrain and buildings
- **Input data of calculation points or grids**
  - Calculation points at dwellings
  - Grid for calculation of contours

➲ Immission noise measurements

- ➲ Validation of noise map
- ➲ Near the source and in surrounding






Case study 1: The cement factory "Holcim" Serbia

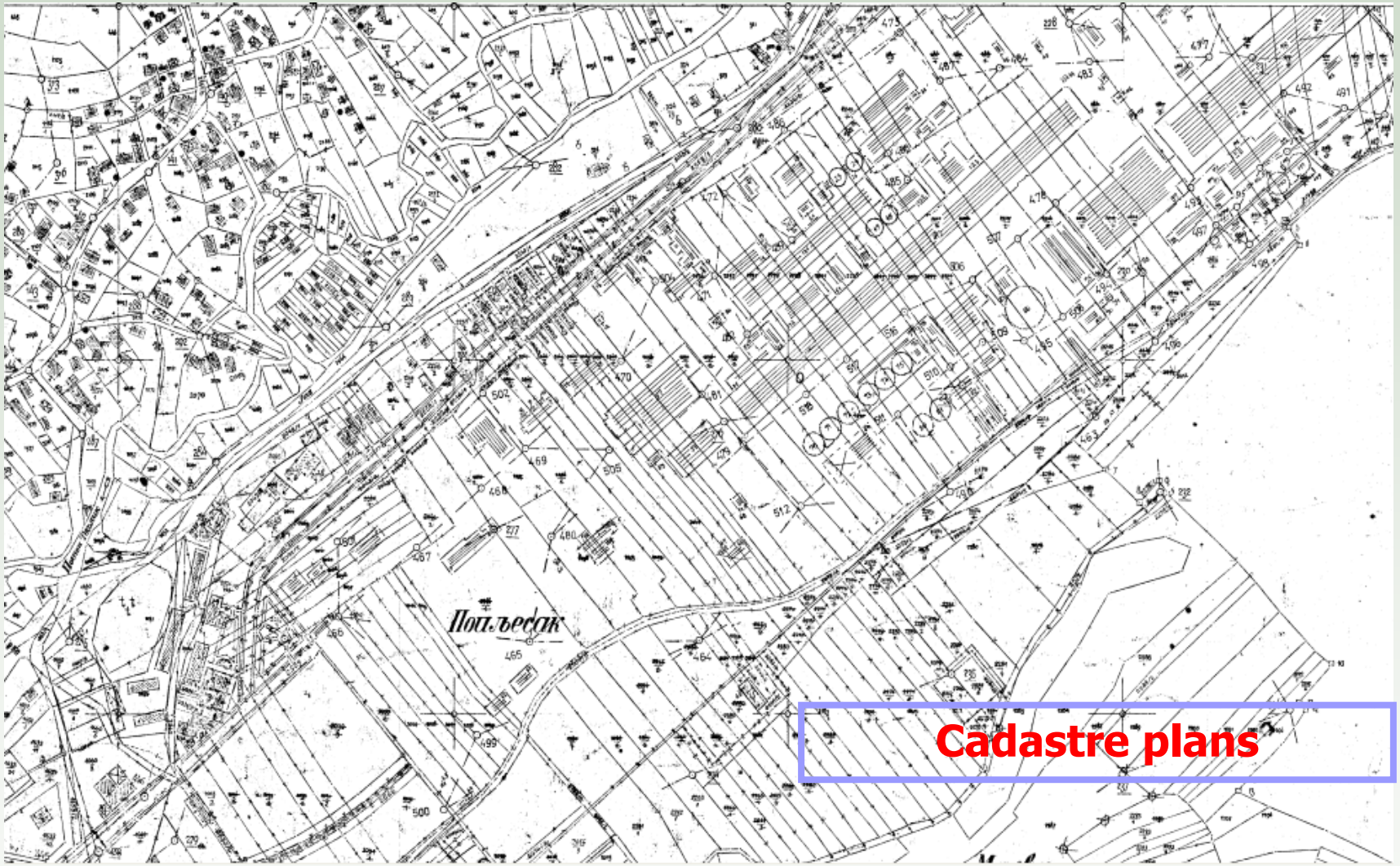
- Noise map for day period (06:00-22:00)
- Noise map for night period (22:00-06:00)
- Noise indicator – LAeq
- Receiver height – 1.5m
- ISO 9613-2

Input - terrain and building data (1)

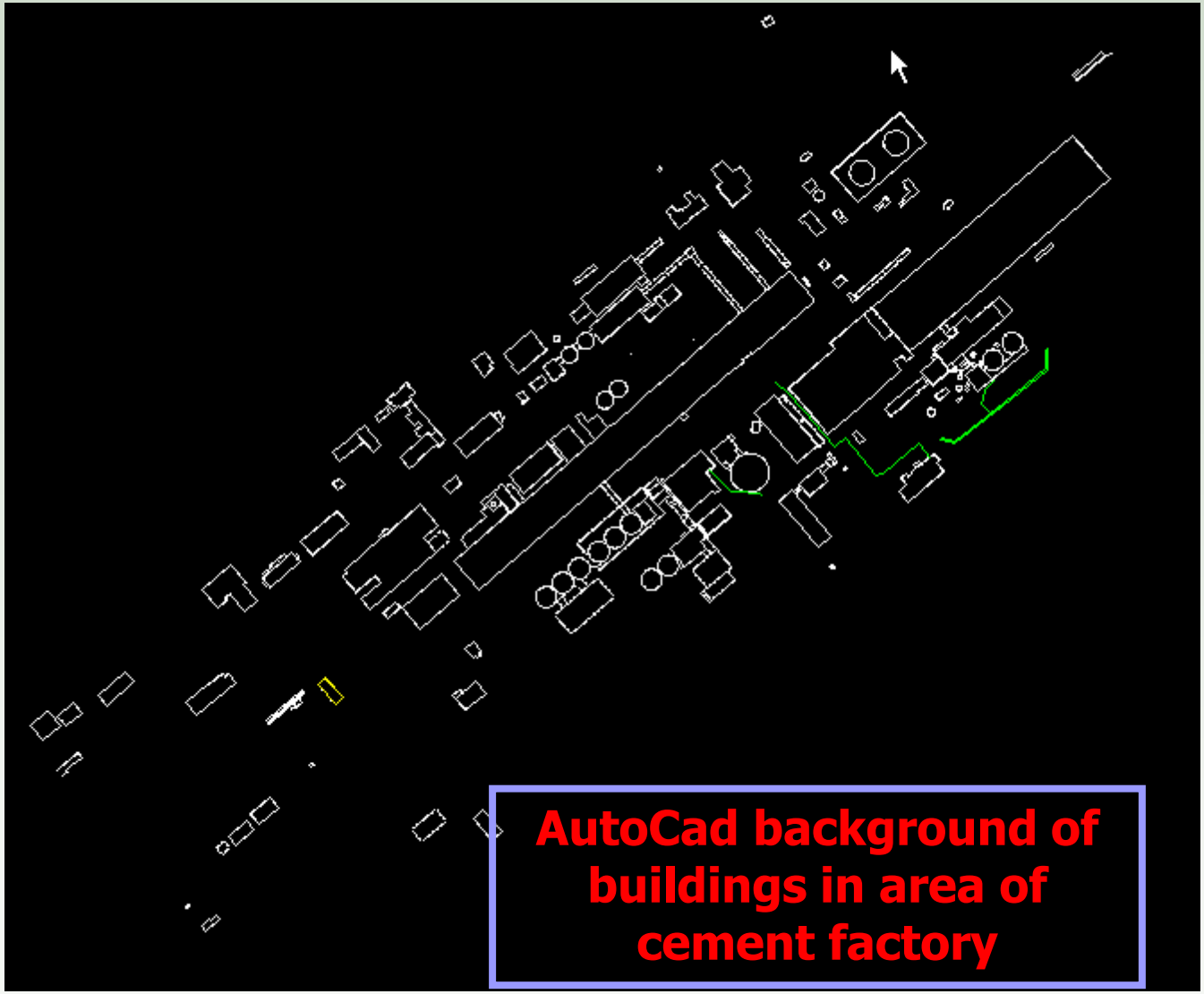
7.542.742
4.864.500

7.539.700
4.861.855

Input - terrain and building data (2)



Input - terrain and building data (3)

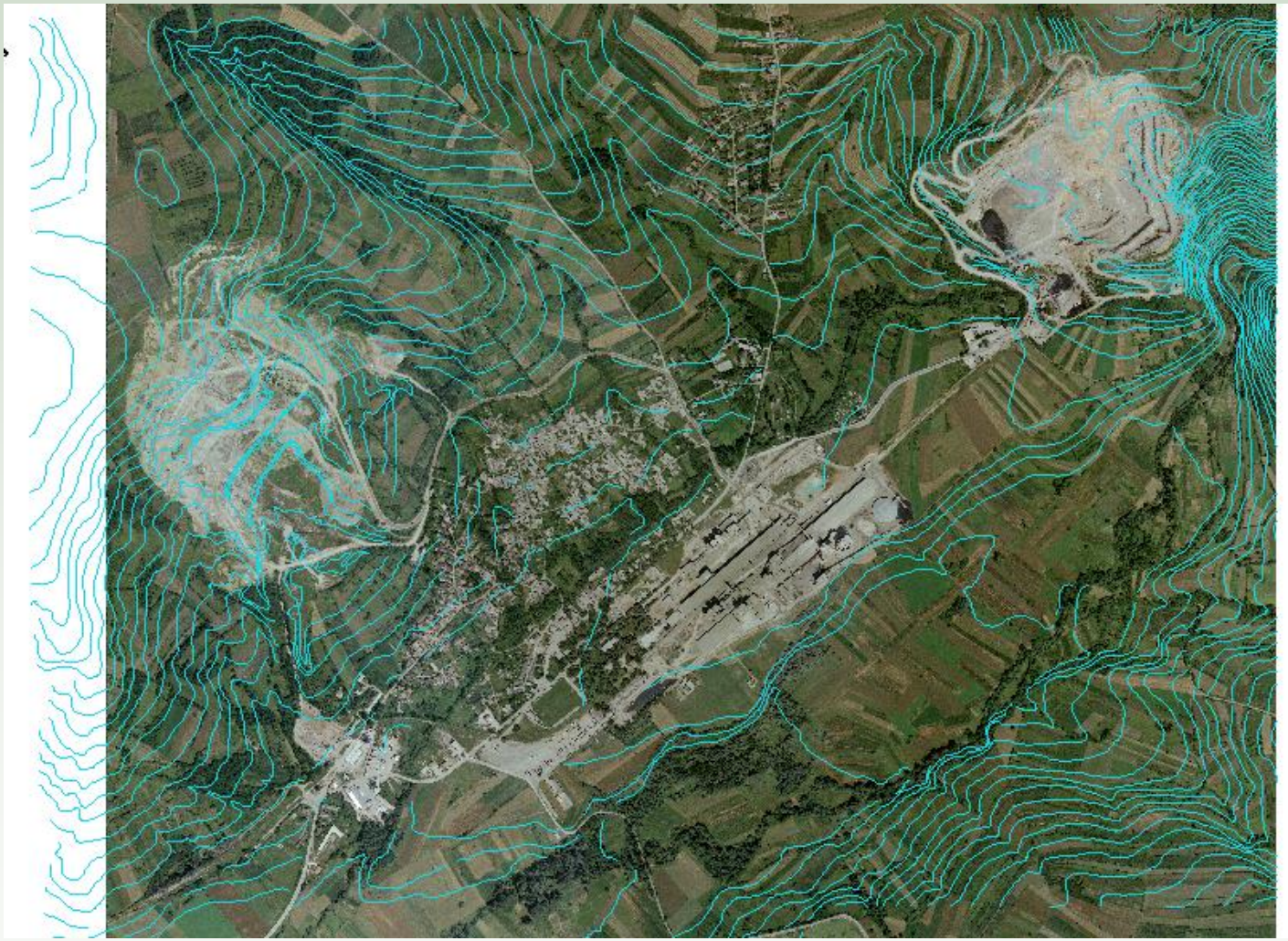


The model of terrain and buildings - procedure

- Importing the orthophoto clip, the cadastre plots and AutoCAD background
- Overlaping maps
- Calibration overall map using three well-defined points
- Digitization of the terrain on the basis of contour line and data about the altitude in the form of points
- Digitization of topographic terrain by entering the data on the green and concrete surfaces
- Digitalization of facilities by setting the reflective feature of facades and the height of buildings

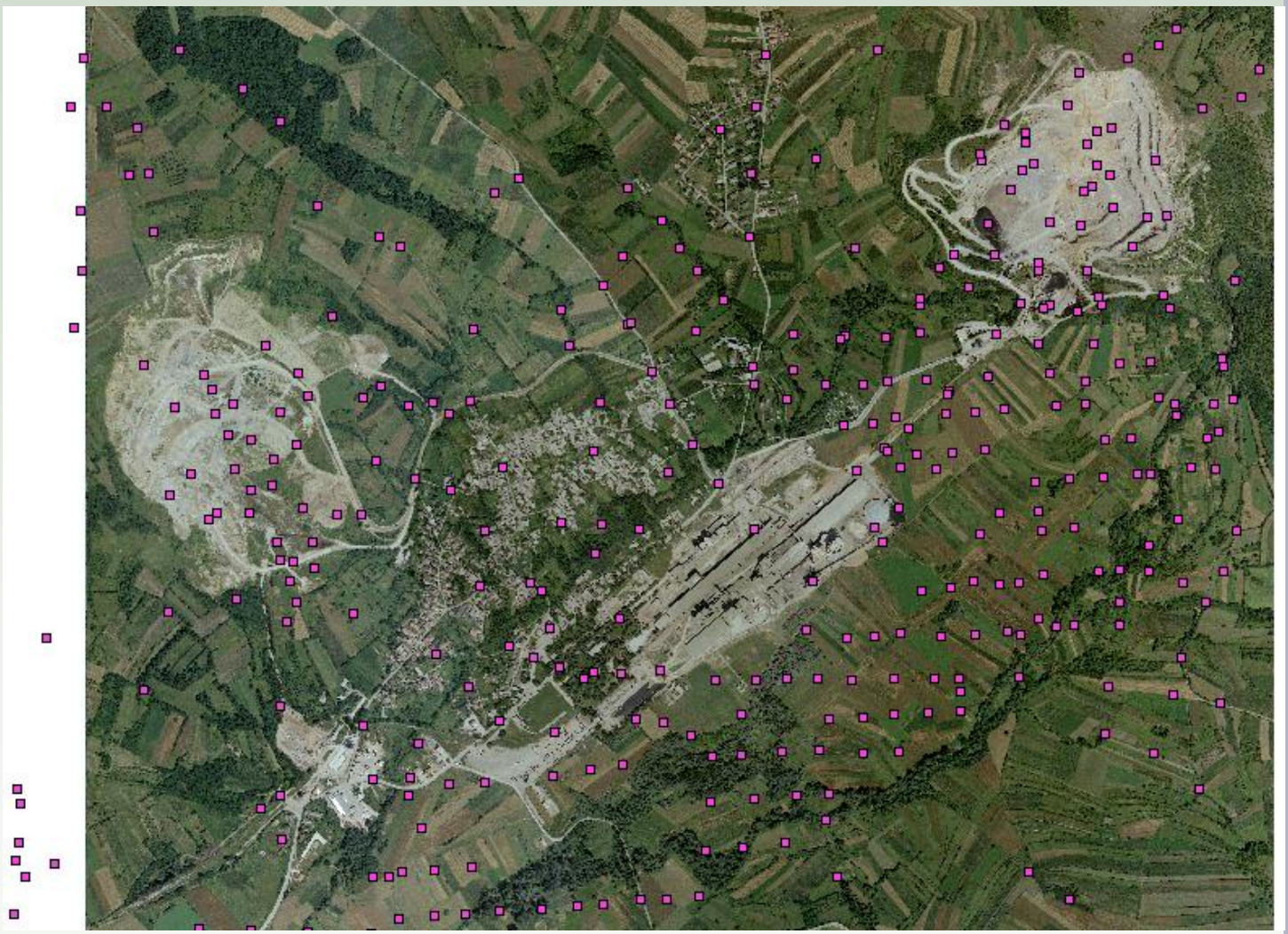
The model of terrain and buildings – results

The contour line



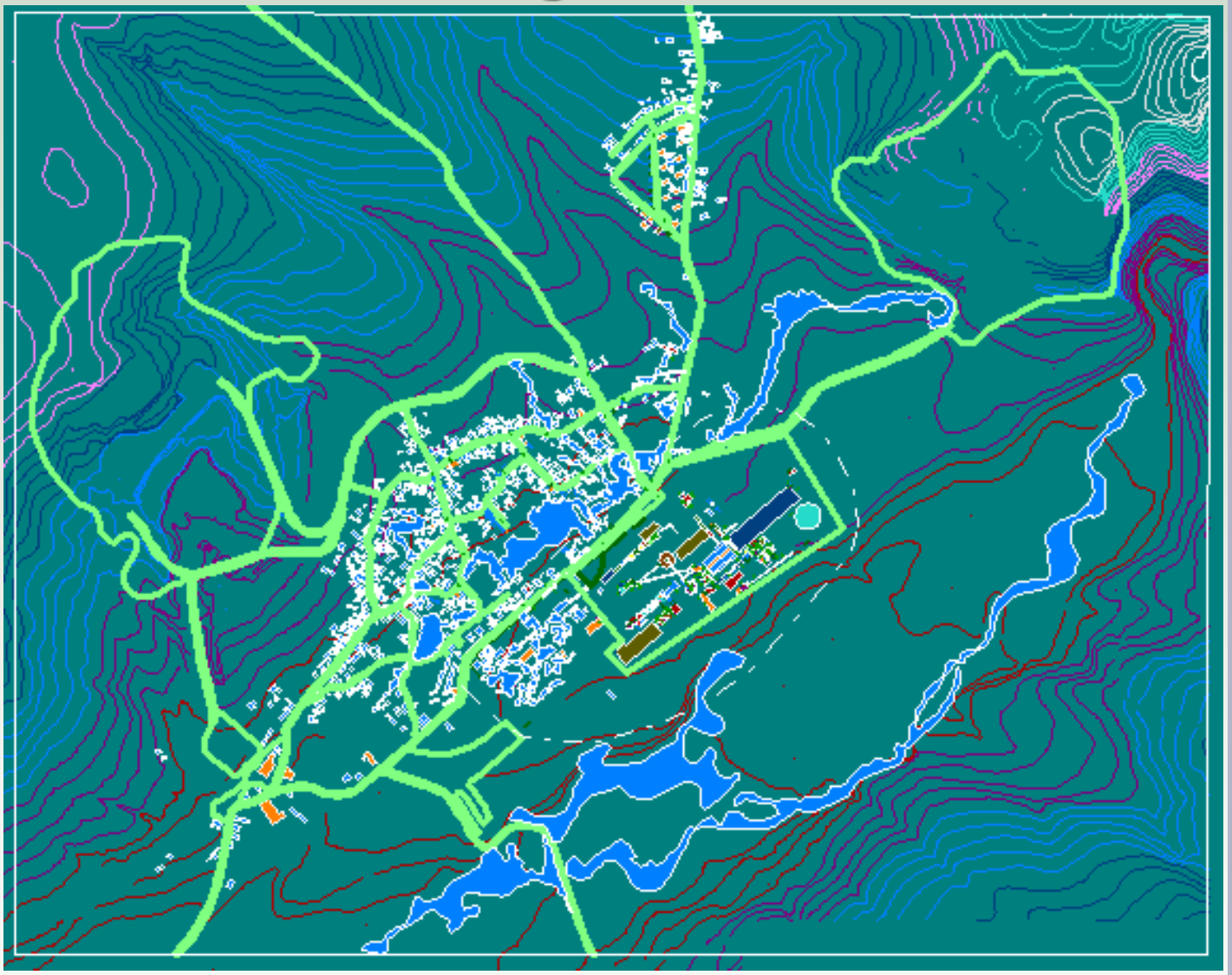
The model of terrain and buildings – results

Point altitude



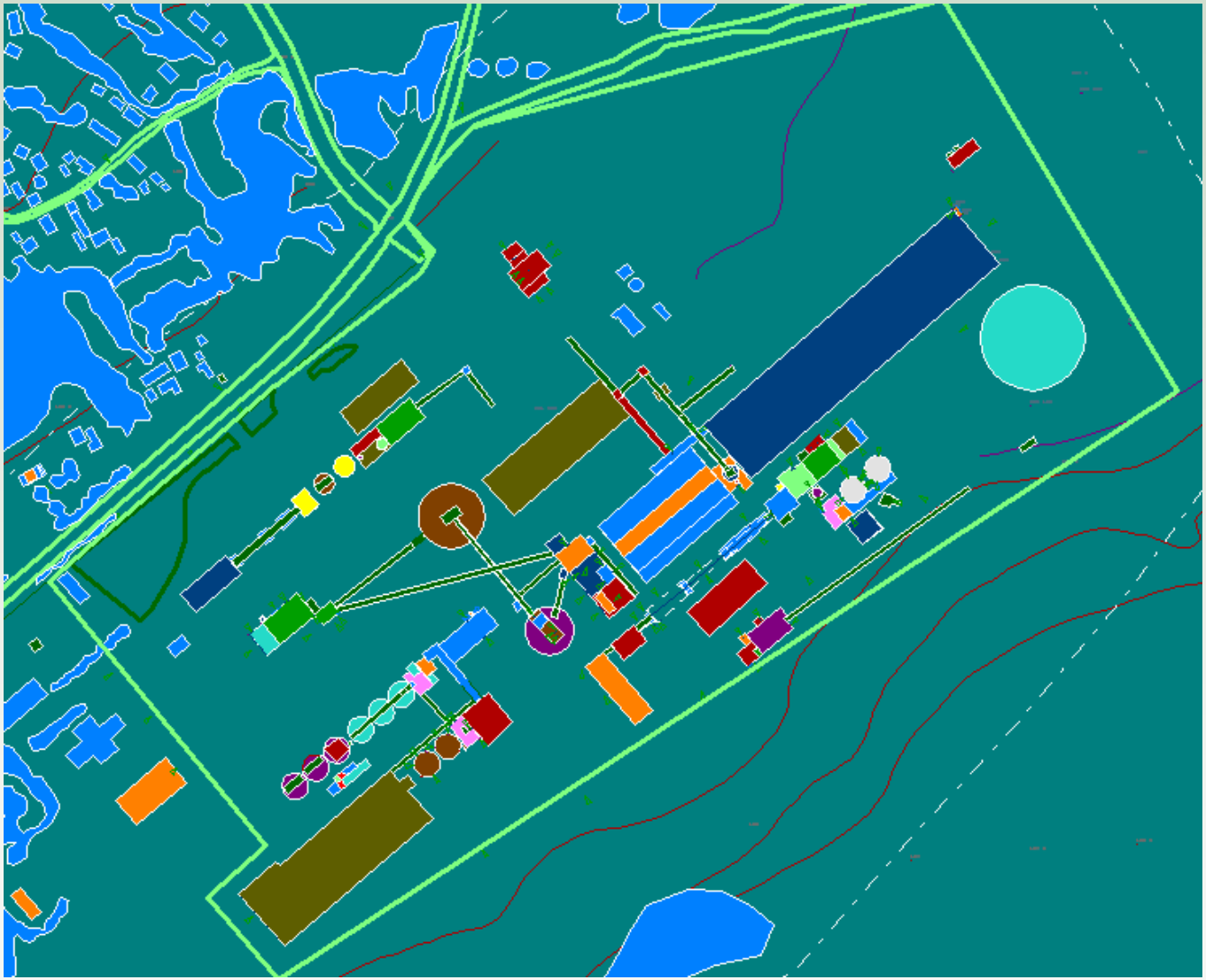
The model of terrain and buildings – results

2D total model



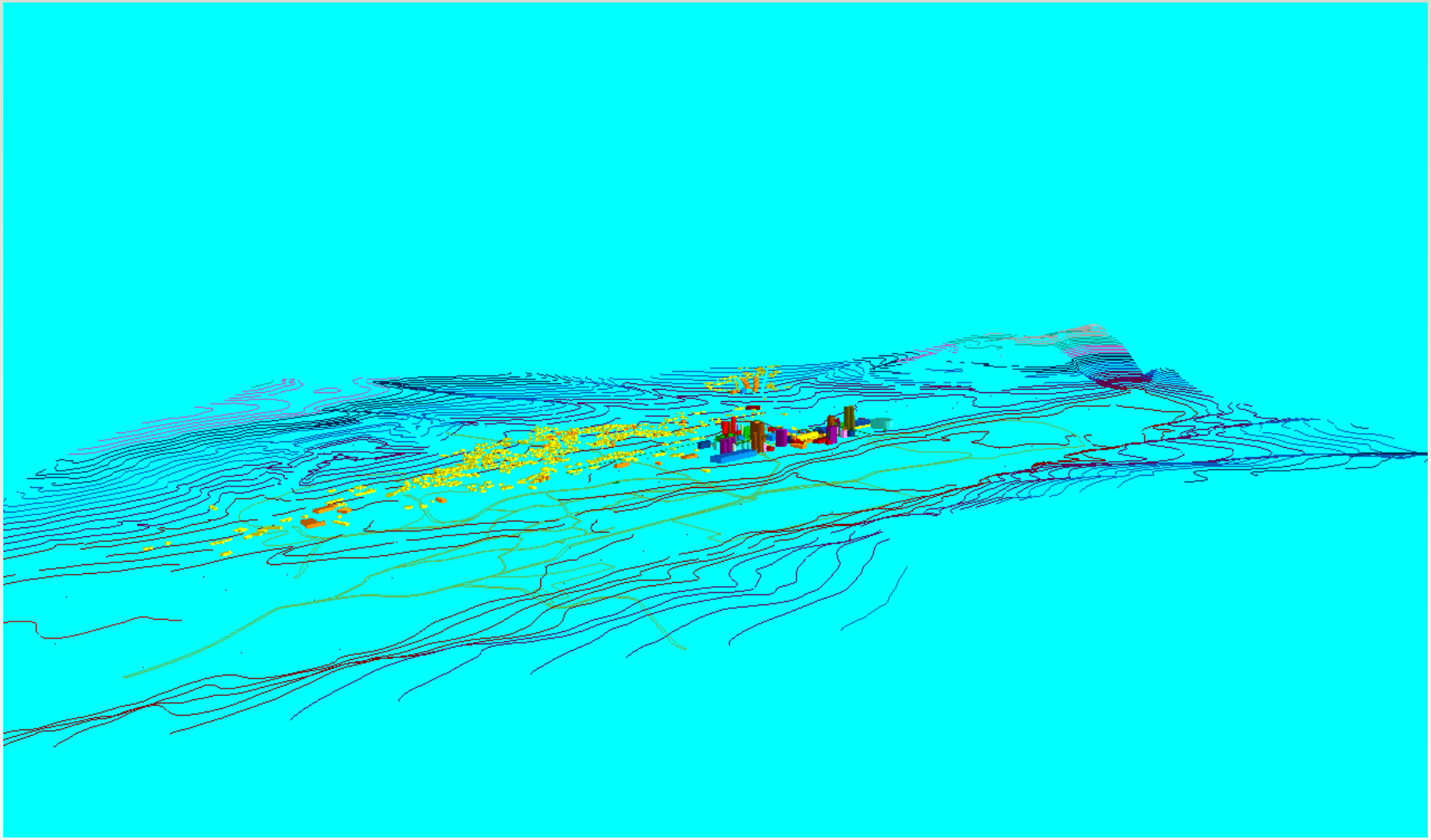
The model of terrain and buildings – results

2D factory model



The model of terrain and buildings – results

3D total model



Noise source

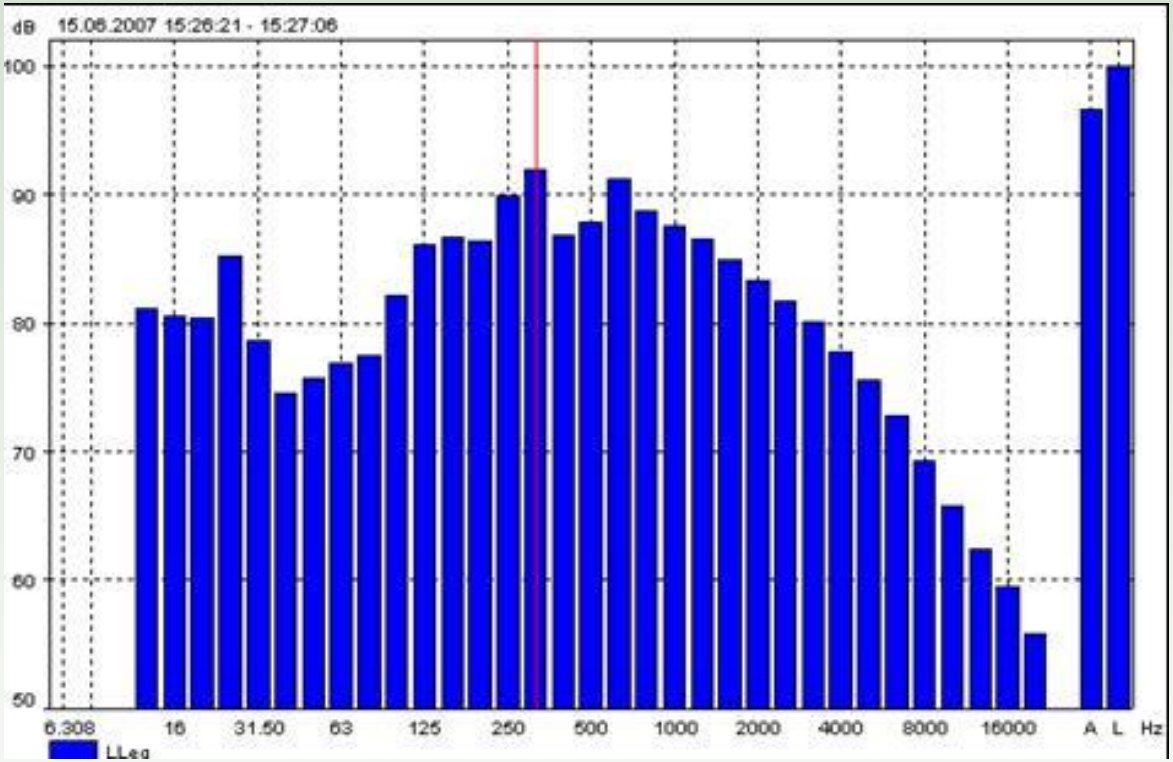
- Point sources (pumps, motors, fans, etc)
- Line sources (conveyor belts, etc)
- Area sources (windows and doors on buildings where noise sources are located)

➡ NO NOISE EMISSION DATA

➡ NO SOUND INSULATION DATA

Noise source - measurements

- Emission sound pressure level near noise source at defined distance



Rotating kiln

Noise measurements in environment

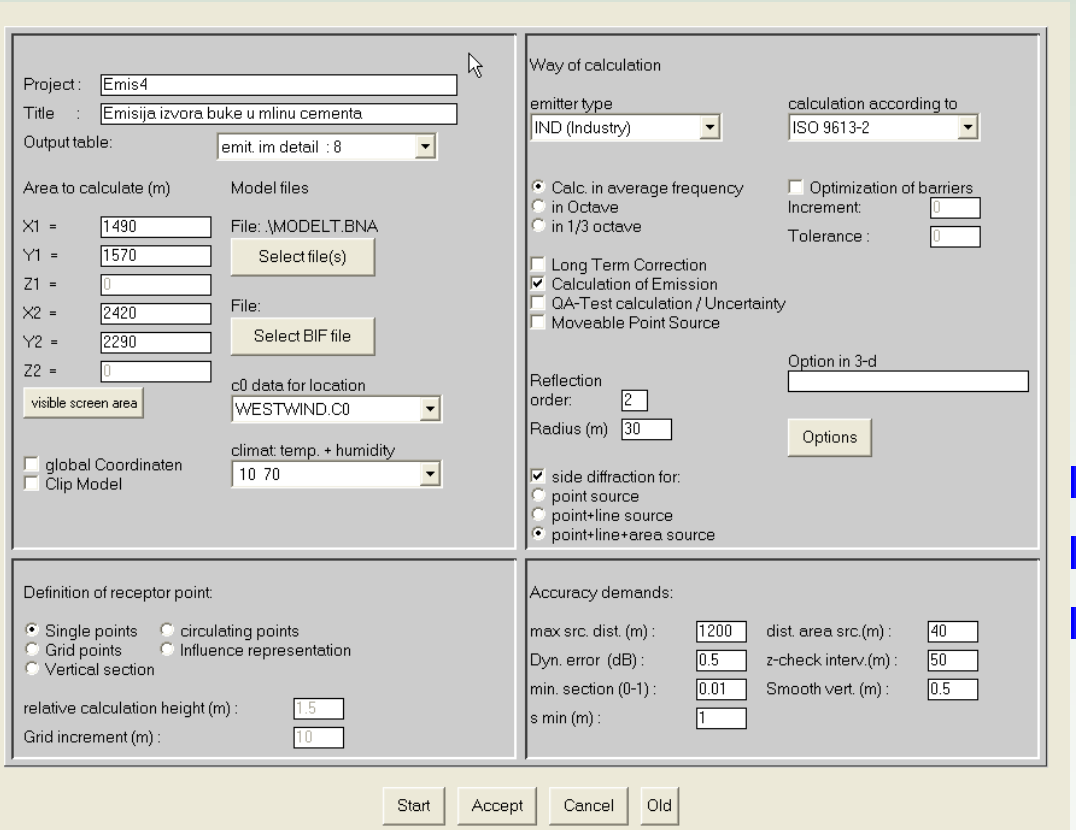
momir.prascevic@znrfak.ni.ac.rs

Faculty of Occupational Safety, Noise&Vibration Laboratory

Sound power od noise source

Determination of the sound power level for the selected noise sources, based on the noise level in the defined points which are in their vicinity.

Calculation of emissions is a method of "calculating backwards" i.e. the receptors have a known measured values, whils some or all of emitters have unknown noise emission levels.



Defining noise source

- IND1 /EMG 01
- IND2 /EMG 02
- IND3 /EMG 02

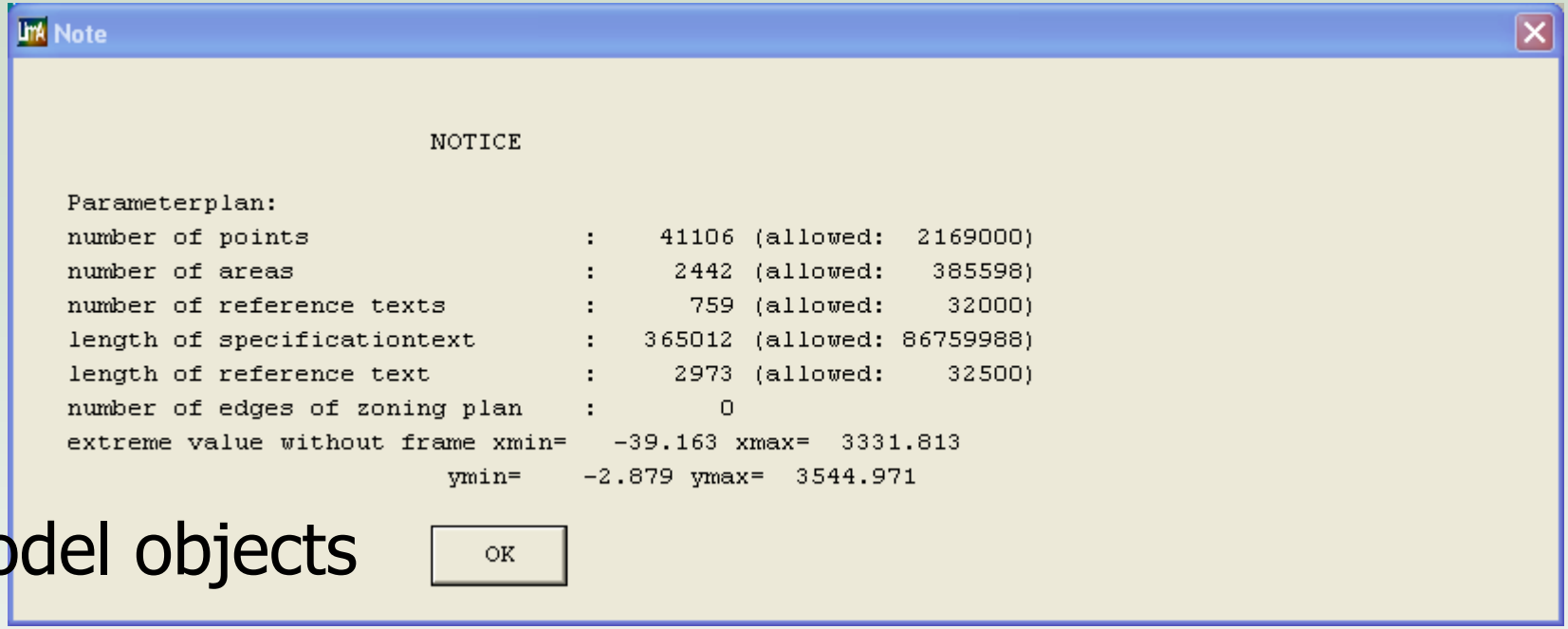
Defining receving points

- AUF1 /MEP1 LDAY1 LNIGHT1
- AUF2 /MEP2 LDAY2 LNIGHT2
- AUF3 /MEP3 LDAY3 LNIGHT3

Results

- ProjectNameKON.BNA

Calculation

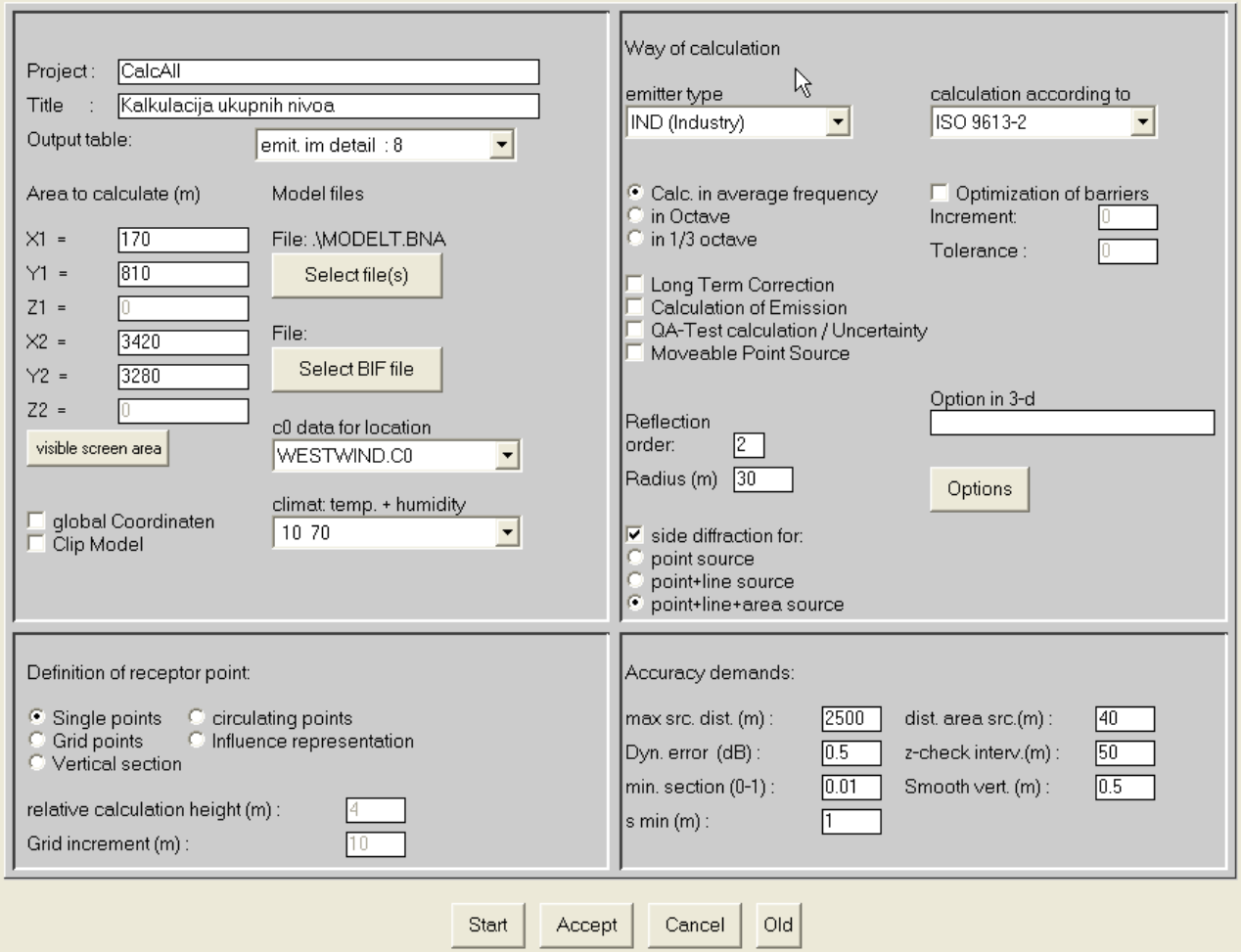


- Model objects
  - building - 147
  - noise source - 97
  - point receiver - 130
  - contour line - 345
  - point altitude - 407

Single points calculation

AUF – 130
Calc. Time: 250s

Settings



Single points results

LD	LN	Z	AUF
47.05	46.94	222.59	- GEB.: M128 50.8
42.95	42.83	235.83	- GEB.: M127 41.5
48.15	47.69	208.08	- GEB.: M129 43
48.79	48.47	207.40	- GEB.: M130 46.3
49.98	49.78	204.20	- GEB.: M131 46.9
47.96	47.68	210.59	- GEB.: M132 47.1
46.08	44.55	204.81	- GEB.: M133 41.2
46.09	42.68	207.17	- GEB.: M134 41.2
42.79	38.87	209.20	- GEB.: M135 40.8
45.08	43.84	208.40	- GEB.: M136 38.6
46.12	43.72	201.57	- GEB.: M137 50
46.65	45.54	196.40	- GEB.: M139 46.6
45.04	43.29	195.46	- GEB.: M140 46.1
48.08	45.29	199.01	- GEB.: M141 50.4
43.46	41.51	204.76	- GEB.: M142 39.8
47.18	43.65	205.01	- GEB.: M146 46.8
48.65	43.34	201.28	- GEB.: M143 47.3
47.03	46.36	200.90	- GEB.: M144 48.8
48.80	46.20	200.99	- GEB.: M145 49.2
52.30	47.02	201.75	- GEB.: M126 41.5
51.62	50.05	202.33	- GEB.: M125 52.4
51.76	51.03	201.91	- GEB.: M124 49.4
49.63	48.78	201.21	- GEB.: M123 53.8

Single points results - details

Calculated according to ISO 9613, Downwind

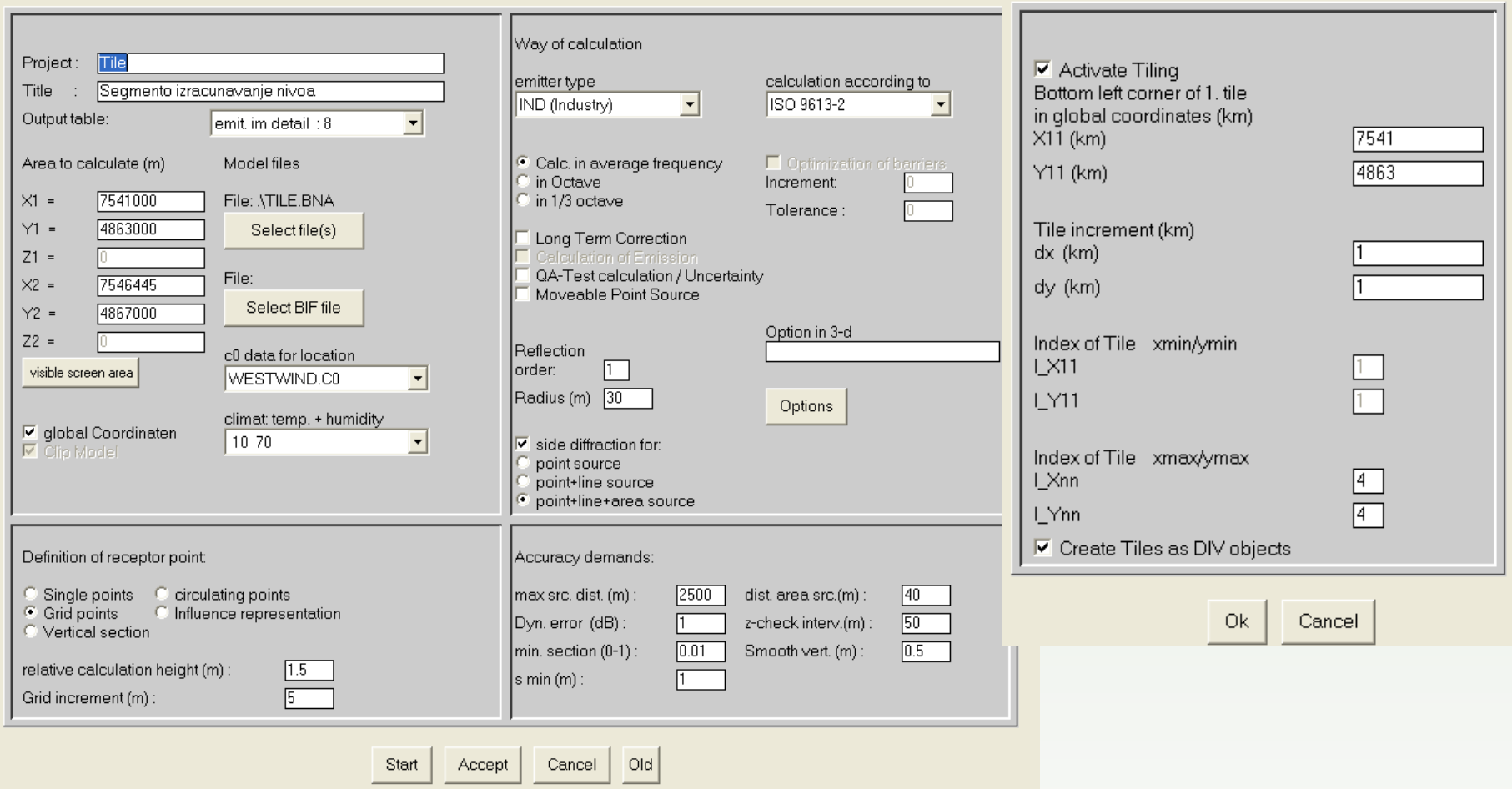
receptor point description : - GEB.: M145 49.2 <ID>-
position of receptor point : Xi= 7542.7021 km Yi= 4865.1123 km Zi= 200.99 m

	day	night
Immission :	48.8 dB(A)	46.2 dB(A)

Emitter position of emitter	Ident	Element	Main Freq. emis.(Lw) immission	i	Length emit.	D Lng length	DI -C met	Dc	ds	Adiv	Aatm	Details of calculati Afol	Ahous	hm	Agr	dsr	e	ds
km	km	m	day night		m	dB	dB	dB	m	dB	dB	dB	dB	m	dB	m	m	m
10 Cev	-	77	500 Hz	1	1.0	0.00	0.00	3.00	388.94	-62.80	-0.74	0.00	0.00	30.67	-2.00	306.4	6.3	7
Xa= 7542.9150 Ya= 4864.7925 Za= 260.88			93.5 93.5															
Xe= 7542.9150 Ye= 4864.7925 Ze= 260.88			17.7 17.7															
10 Grebac 1	-	74	500 Hz	1	1.0	0.00	0.00	3.00	402.16	-63.09	-0.76	0.00	0.00	23.96	-2.69	292.6	32.3	8
Xa= 7542.9326 Ya= 4864.7856 Za= 247.80			103.0 103.0															
Xe= 7542.9326 Ye= 4864.7856 Ze= 247.80			25.6 25.6															
10 Grebac 2	-	76	500 Hz	1	1.0	0.00	0.00	3.00	402.55	-63.10	-0.76	0.00	0.00	26.94	-2.42	291.6	104.9	
Xa= 7542.9307 Ya= 4864.7852 Za= 253.67			97.9 97.9															
Xe= 7542.9307 Ye= 4864.7852 Ze= 253.67			19.1 19.1															
10 Motor 2	-	75	500 Hz	1	1.0	0.00	0.00	3.00	405.47	-63.16	-0.77	0.00	0.00	26.95	-2.44	291.8	104.6	1
Xa= 7542.9326 Ya= 4864.7832 Za= 253.80			92.8 92.8															
Xe= 7542.9326 Ye= 4864.7832 Ze= 253.80			14.8 14.8															
10 Motor1	-	73	500 Hz	1	1.0	0.00	0.00	3.00	387.71	-62.77	-0.74	0.00	0.00	26.92	-2.33	290.0	37.8	6
Xa= 7542.9189 Ya= 4864.7949 Za= 253.39			96.3 96.3															
Xe= 7542.9189 Ye= 4864.7949 Ze= 253.39			19.2 19.2															
10 Motor1	-	73	500 Hz	1	1.0	0.00	0.00	3.00	390.69	-62.84	-0.74	0.00	0.00	26.91	-2.35	290.2	37.4	6
Xa= 7542.9204 Ya= 4864.7930 Za= 253.39			96.3 96.3															
Xe= 7542.9204 Ye= 4864.7930 Ze= 253.39			16.5 16.5															
reflected by : 1223																		
11 Pog motor	-	12	500 Hz	1	1.0	0.00	0.00	3.00	377.21	-62.53	-0.72	-2.95	0.00	1.35	-4.67	371.4	13.9	
Xa= 7543.0195 Ya= 4864.9082 Za= 204.88			88.2 88.2															
Xe= 7543.0195 Ye= 4864.9082 Ze= 204.88			3.0 3.0															
11 Pog trans	-	13	500 Hz	1	1.0	0.00	0.00	3.00	371.67	-62.40	-0.71	-2.91	0.00	2.87	-4.53	305.1	69.1	

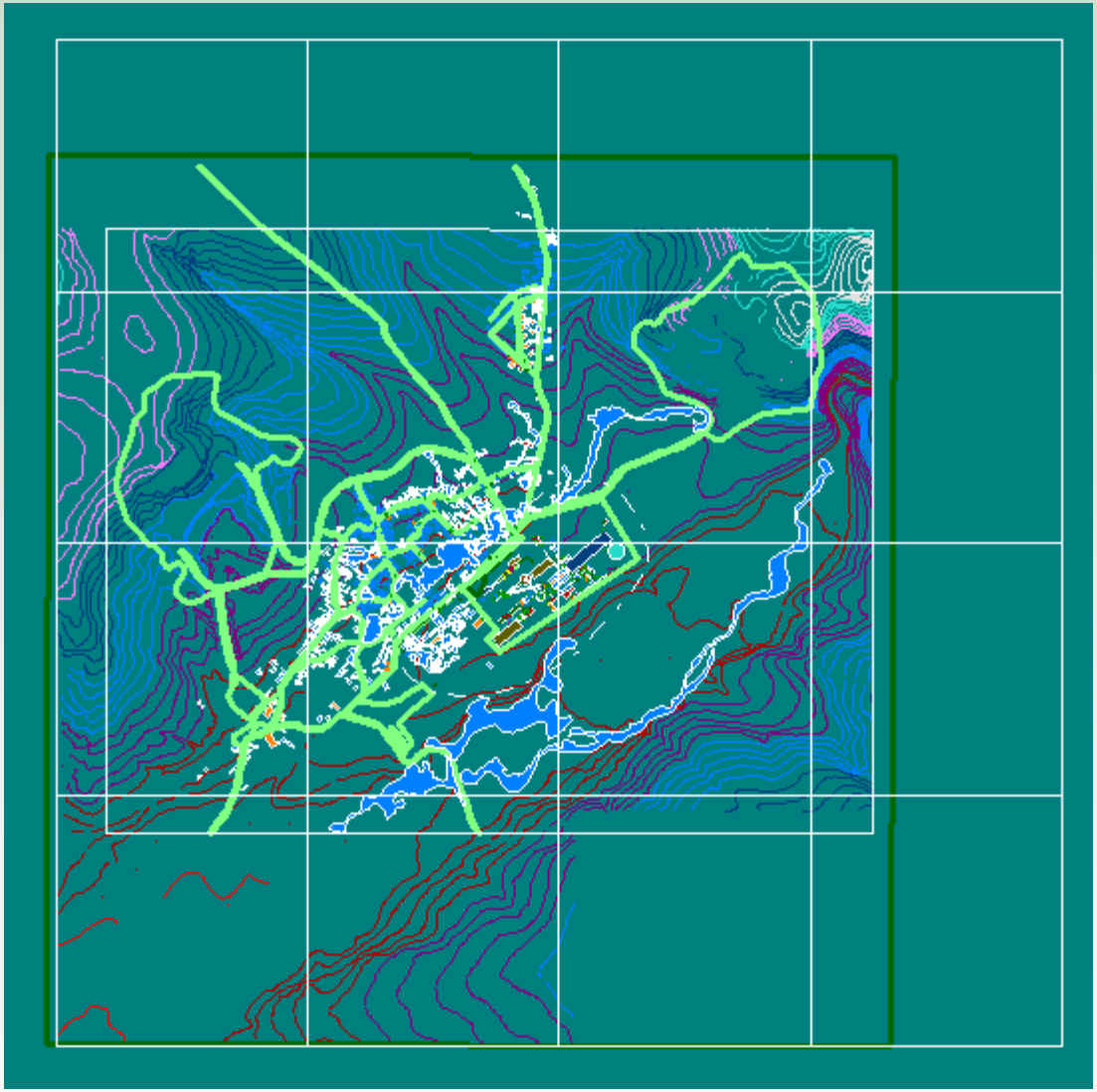
Grid points calculation

Settings



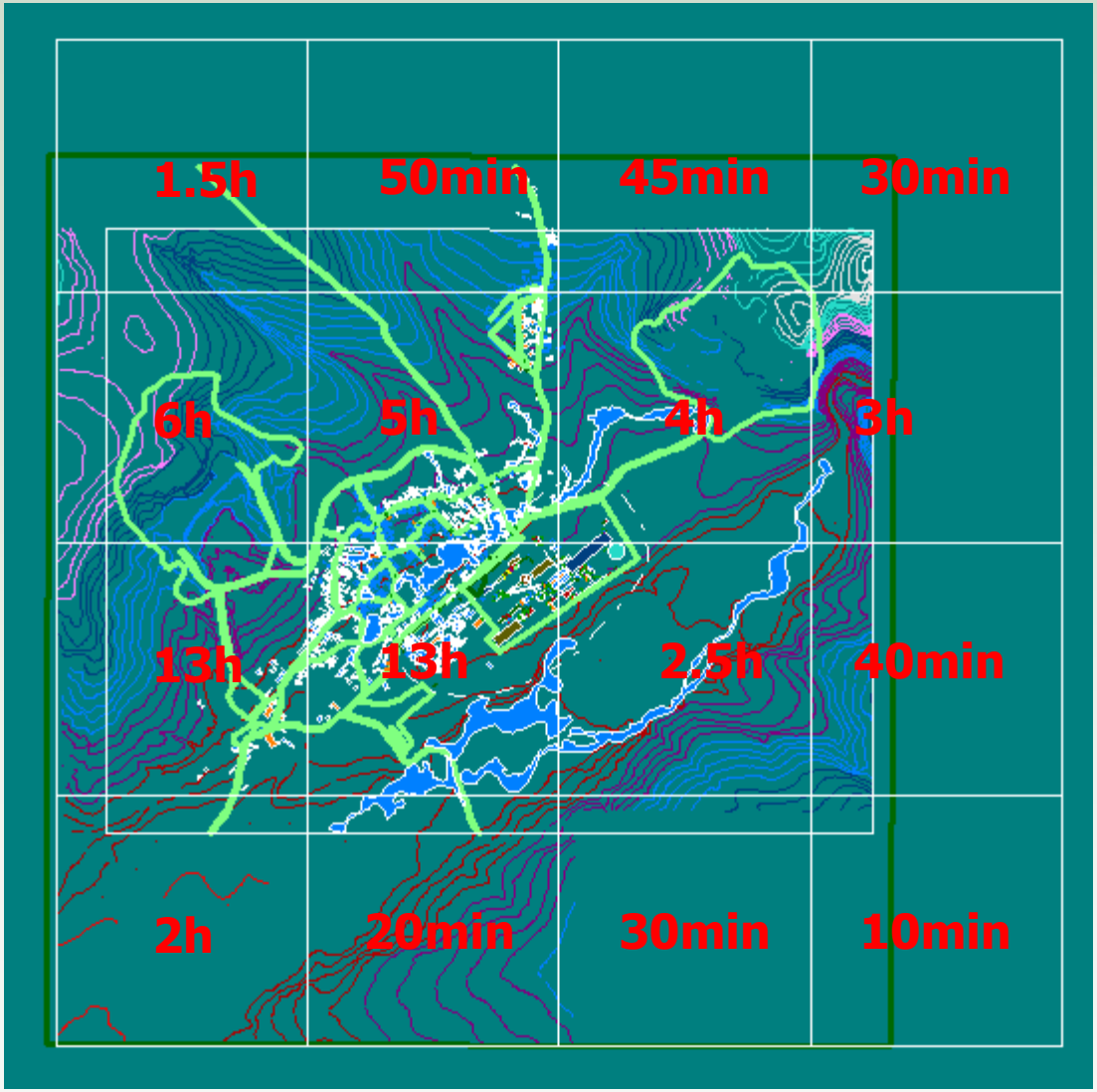
Grid points calculation

Tilig of calculation area

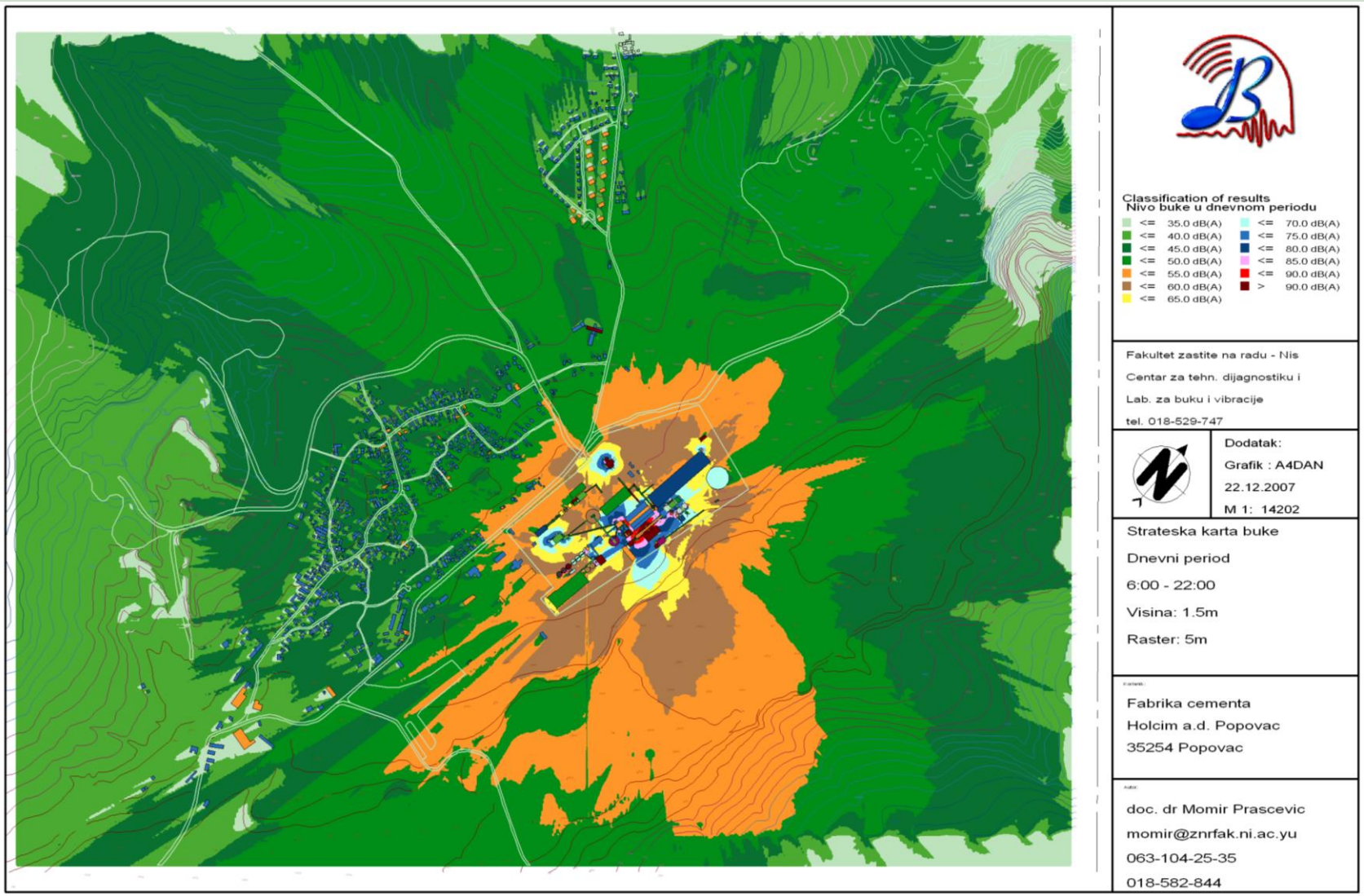


Grid points calculation

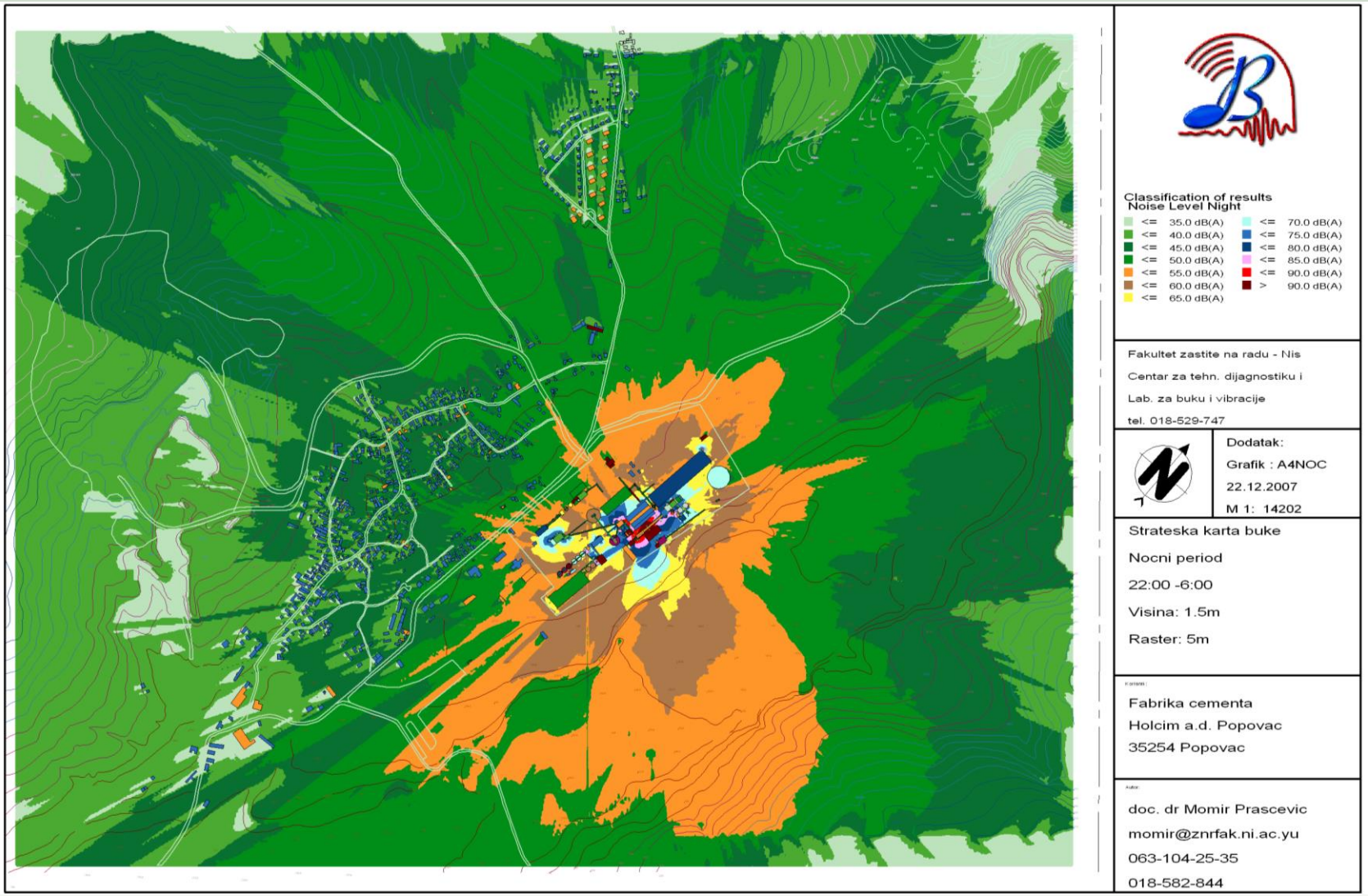
Calculation time ≈53h

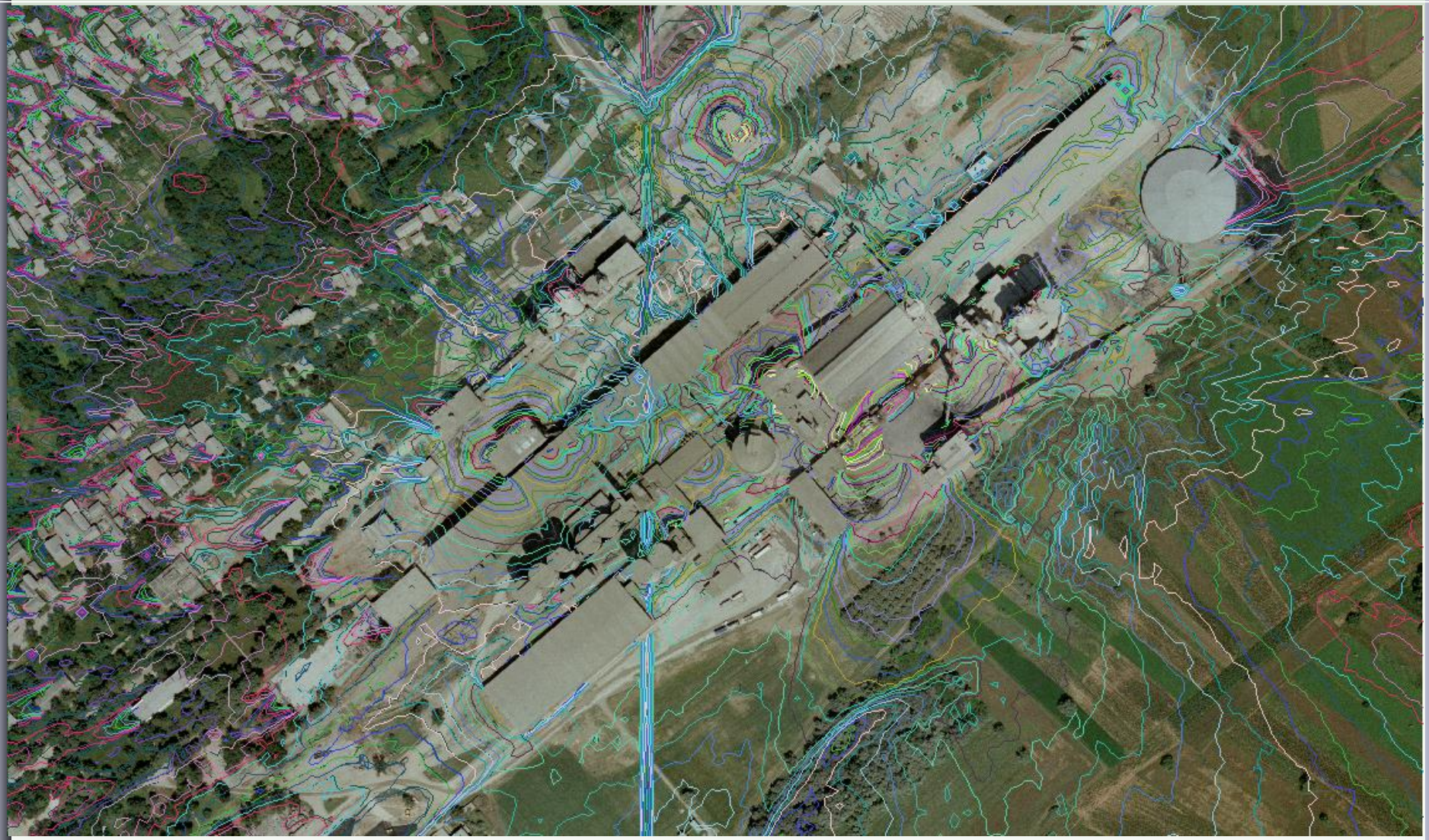


Noise map of cement factory - day



Noise map of cement factory - night





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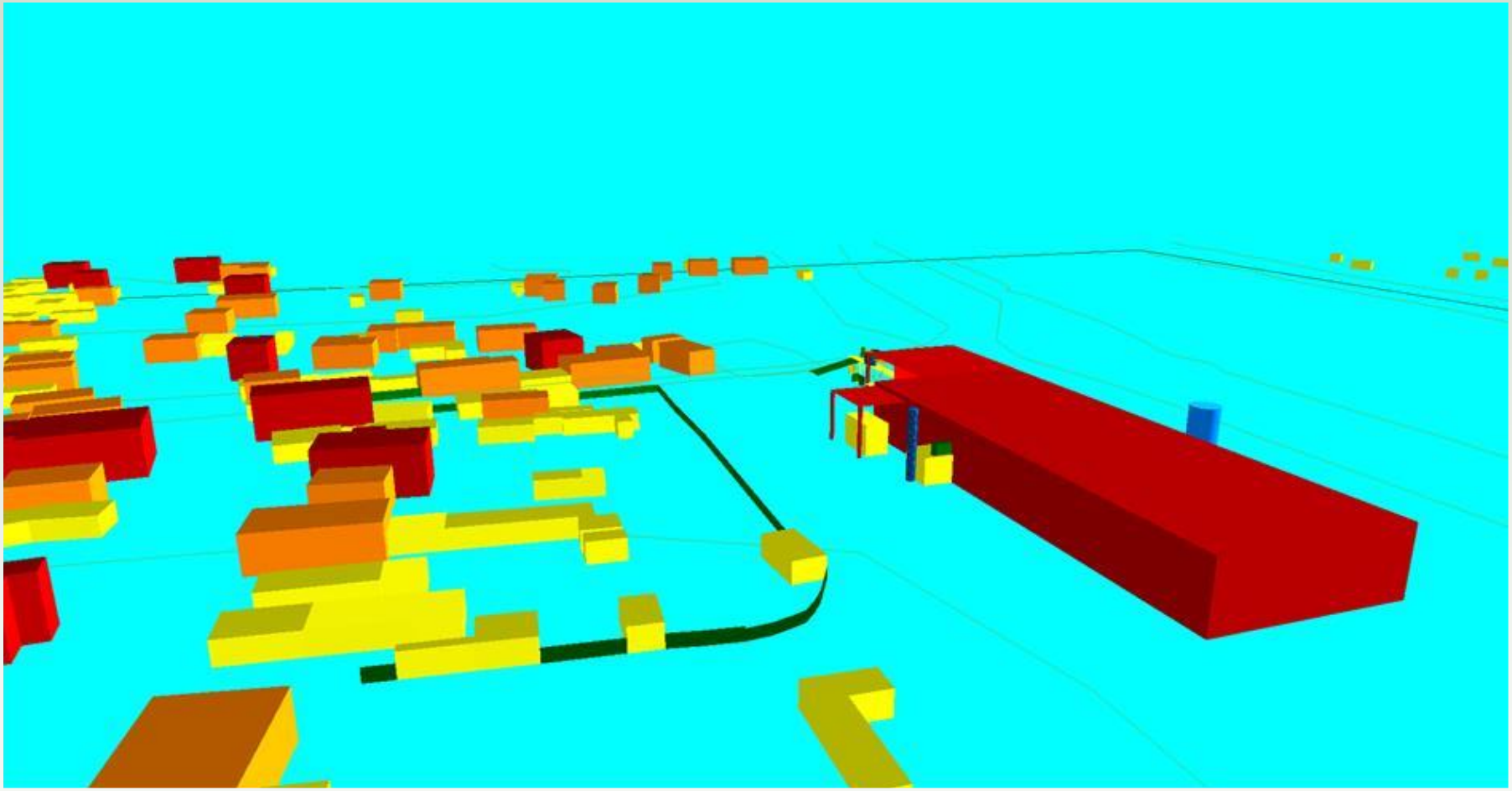
Case study 2: Pelet factory "Sparrow" Varvarin

- Noise map for day period (06:00-18:00)
- Noise map for evening period (18:00-22:00)
- Noise map for night period (22:00-06:00)
- Noise indicator – Lday, Levening, Lnight
- Receiver height – 1.5m
- ISO 9613-2

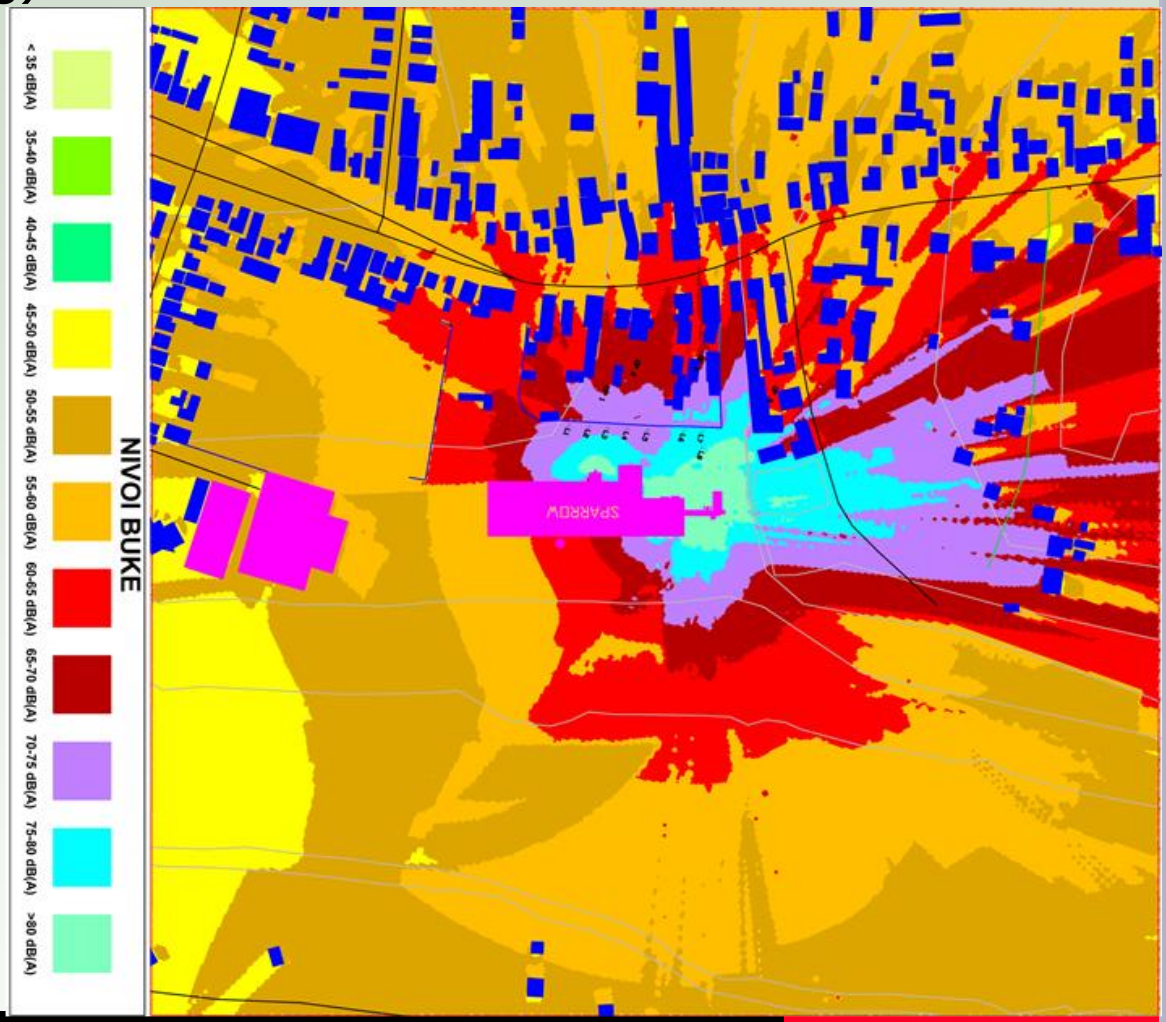
Case study 2: Pelet factory "Sparrow" Varvarin

- Model



Case study 2: Pelet factory "Sparrow" Varvarin

- Noise map (day&evening)



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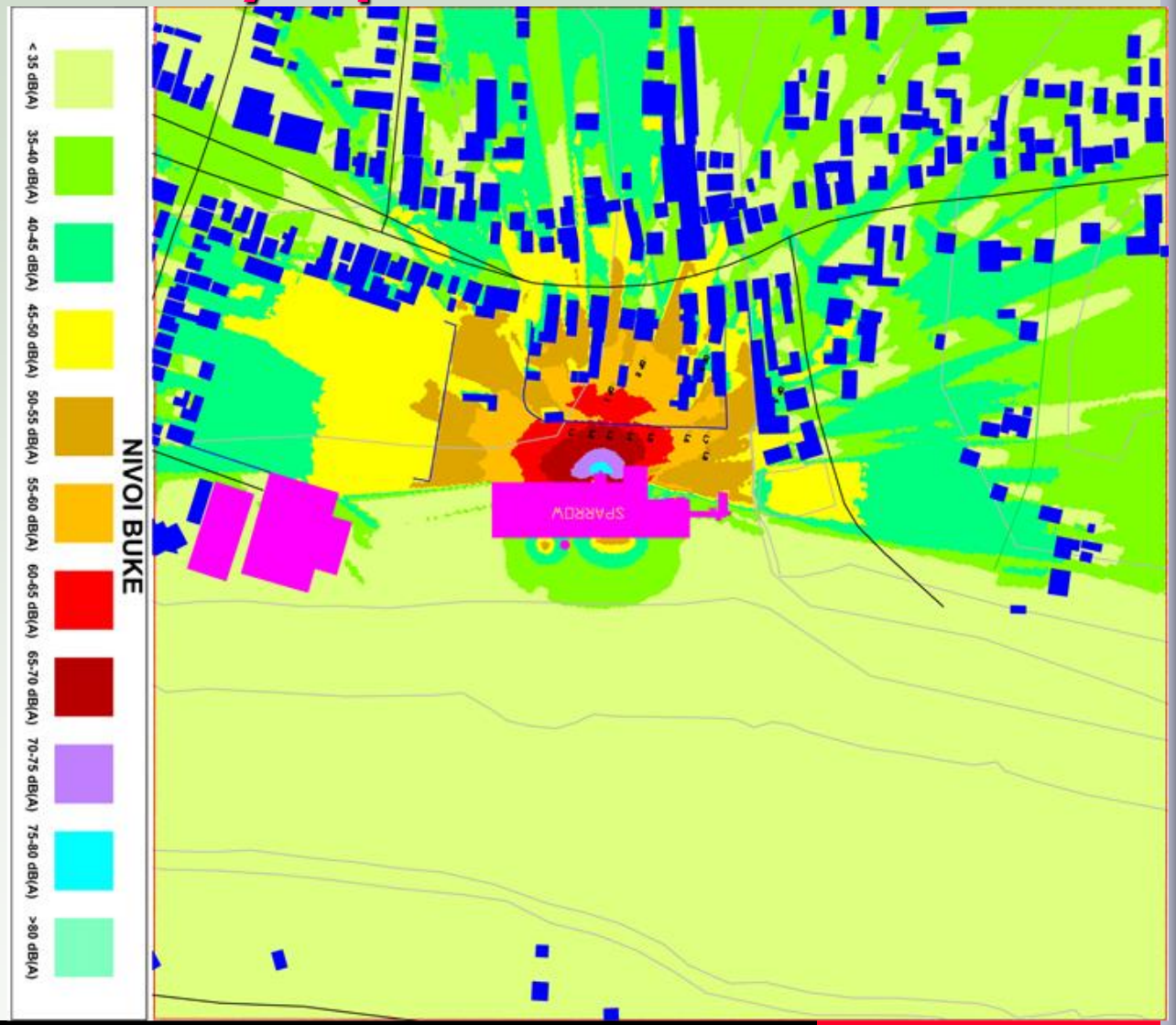
Case study 2: Pelet factory "Sparrow" Varvarin

- Noise map (night)



Case study 2: Pelet factory "Sparrow" Varvarin

- Calculations vs Measurements (day&evening)

Measurement points	Measurements	Calculation	Difference
	[dB(A)]	[dB(A)]	[dB(A)]
L4	73,6	72,7	0,9
L5	73,1	72,3	0,8
L6	78,4	77,2	1,2
L7	79,8	78,0	1,8
L8	79,9	79,0	0,9
OP1	68,1	68,9	-0,8
OP2	67,8	69,1	-1,3
OP3	68,5	68,5	0,0
OP4	57,8	63,2	-5,4

Case study 2: Pelet factory "Sparrow" Varvarin

- Calculations vs Measurements (day&evening)

Measurement points	Measurements	Calculation	Difference
	[dB(A)]	[dB(A)]	[dB(A)]
L1	64,7	64,0	0,7
L2	67,4	65,6	1,8
L3	66,2	65,8	0,1
L4	63,1	64,9	-1,8
OP1	57,2	58,8	-1,6
OP2	56,6	56,9	-0,3

Action planning - introduction

- First: END does not require you to take noise measures
- END only requires member states to map noise levels and report action plans
- Only you decide what action plan and measures are to be taken.
- In practice reducing noise levels from road traffic is expensive and relatively few dwellings can be protected.
- Means are limited;
- Best available: noise barriers, low-noise pavements , insulation, improve traffic logistics&behavior

AP: END demands

- Noise maps repeat every 5 year:
  - Agglomerations: >100.000 Inhabitants
  - Roads: >3.000.000 Vehicles/Year
  - Railways: >30.000 Trains/Year
  - Main airoport
- Action Plans
- Obligatory for all, also Serbia

➲ AP: END Annex V – minimum requirements

- ➲ Description of: agglomeration, major roads, major railways, major airports and other noise sources taken into account, the authority responsible, the legal context, any limit values in place.
- ➲ Summary of the results of the noise mapping,
- ➲ Evaluation of the estimated number of people exposed to noise, identification of problems and situations that need to be improved,
- ➲ Record of the public consultations .
- ➲ Noise-reduction measures already in force or in preparation

➲ AP: END Annex V – minimum requirements (+)

- ➲ Actions which the competent authorities intend to take in the next five years (including any measures to preserve quiet areas, long-term strategy, financial information (if available): budgets, cost-effectiveness assessment, cost-benefit assessment, provisions envisaged for evaluating the implementation and the results of the action plan).

Actions which the competent authorities intend to take in the fields within their competence may for example include: traffic/land-use planning, measures at noise sources, selection of quieter sources, reduction of sound transmission, regulatory or economic measures or incentives

- ➲ Each action plan should contain estimates in terms of the reduction of the number of people affected (annoyed, sleep disturbed or other).

AP: Questions and answers

- How to maintain/manage the current quality?
- How to preserve from worsening?
- How to improve the sound quality (sound scape)
- How to make people more aware of the presence of quiet (urban) areas?
- How to make residents and politicians aware of the added value of quiet areas?
- Which parties/policies need to be involved?

AP: Questions and answers

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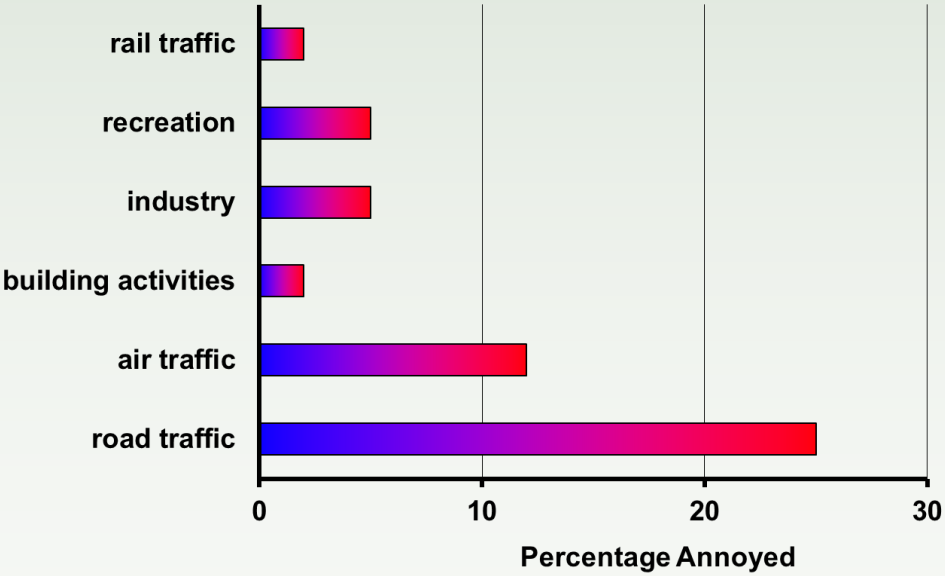
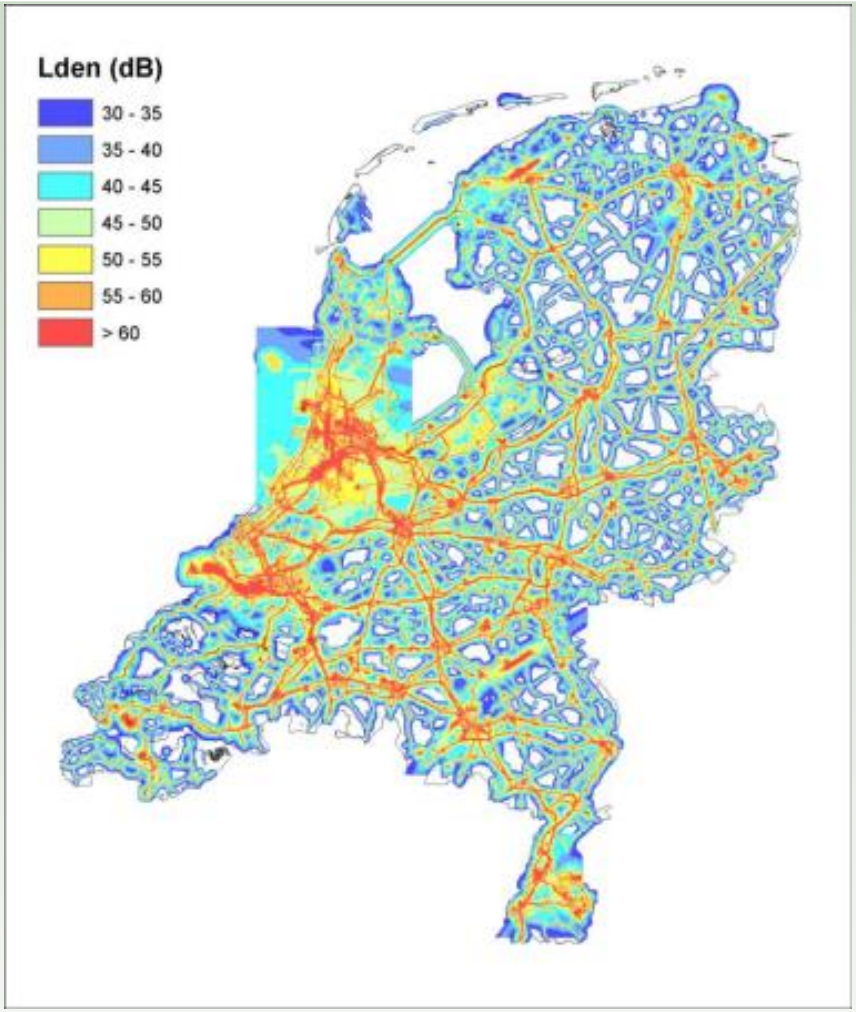
➲ AP: Steps

1. Make and publish Noise Maps
2. Define hotspots and determine problem situations
3. Choose which to attack
    - Efficiency
    - Effectiveness
4. Determine noise-reduction measures
    - Civil engineering aspects
    - Costs (“Price of Silence”)
5. Implement measures
6. Determine objectively effect of these measures
7. Go to 1.

➲ AP: Hotspots detection

1. Simpe methods
2. Weighted methods
3. Complex methods





➲ AP: Hotspots detection

- ➲ Simple method 1
  - ➲ Based on the noise exposure in an area with sensitive objects like houses, hospital, schools, nursing homes, psychiatric institutes, etc. Counting the numbers of exposed people or dwellings that are exposed.

Noise class:	Number exposed:
55-59 dB	1000
60-64 dB	700
65-69 dB	400
70-75 dB	150
> 75 dB	50
Total:	2200

➲ AP: Hotspots detection

- ➲ Simple method 2
  - ➲ Based on the noise annoyance in an areas with sensitive objects like houses, hospital, schools, nursing homes, psychiatric institutes, etc. Counting the numbers of people that are annoyed/sleep disturbed.

Noise class:	Percentage Annoyed/SD:
55-59 dB	2
60-64 dB	18
65-69 dB	30
70-75 dB	45
> 75 dB	5
Total:	100

➲ AP: Hotspots detection

- ➲ Simple method 3
  - ➲ Based on conflict map which shows the differences between the current/future situation and limit values. Government could decide ▪ >10dB is hotspot

➲ AP: Hotspots detection

➲ Weighted method 1 - Italian Prioritisation Index

Formula:

- → $P = k.R\ (L-L_z)$
- → P = Prioritisation Index
- → k = factor for sensitivity
  - →k = 4 for hospitals/nursing homes
  - →k = 3 for schools
  - →k = 1 for other buildings
- → R = number of residents/building
- → L = noise level most exposed façade (L_{DEN}/L_{NIGHT})
- → L_z = limit value

➲ AP: Hotspots detection

- ➲ Weighted method 2 - Scottish Building Prioritisation Score
- → *Formula:*
  - → $BPS = L + 10 \log N_A$
  - → $N_A = NPA_{\%}/100$
  - → N = number of addresses per building
  - → P = population per address
  - → A% = percentage of people annoyed per source
  - → L = noise level most exposed façade (L_{DEN}/L_{NIGHT})

➲ AP: Hotspots detection

➲ Weighted method 3 - MABPS Multi Annoyance Building Prioritisation Score

Formula:

→ $MABPS = L_{TOT} + 10 \log N_A$

→ L_{TOT} = cumulative noise level at most exposed façade (L_{DEN})

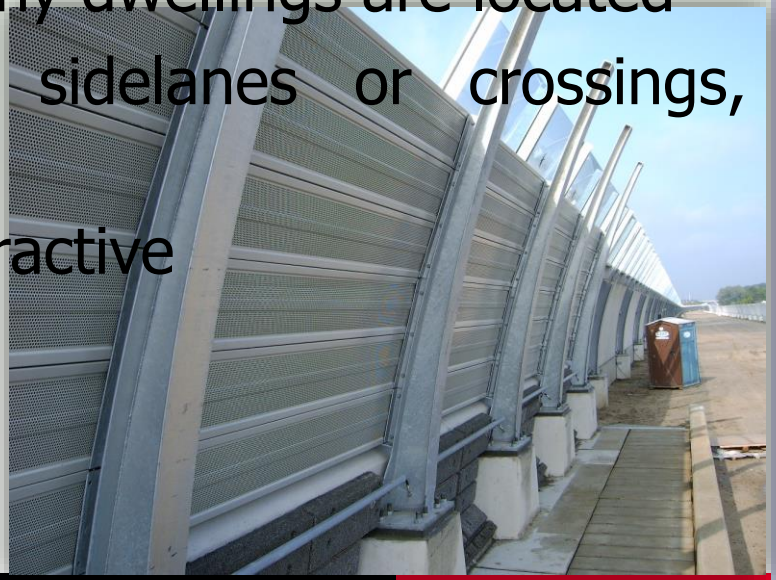
→ N_A = number of annoyed people to be determined as defined in Italian Prioritisation Index

➲ AP: Benefits

➲ Benefits depend on what is protected

➲ AP: Barriers

- ➲ Effect in the order of 10 dB(A) reduction
- ➲ High costs, think of 150 Euro/m2
  - ➲ So complete shielding over 1 km with 4 m barriers costs 2 x 0,6 = 1,2 million Euro's (both sides)
- ➲ In order to be cost effective barriers should only be applied at 'hot spots' where many dwellings are located
- ➲ In urban areas with many sidelanes or crossings, application is often impossible
- ➲ Visual aspects are often not attractive

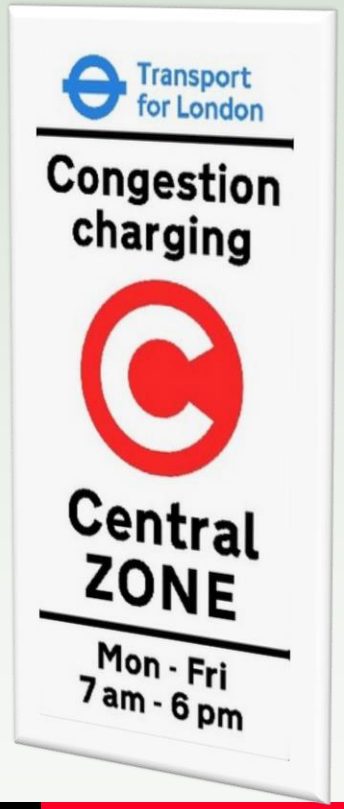


AP: Low-Noise Pavements

- Effect maximum 5 dB(A) reduction
- Extra Costs 100 000 €/km
- Requires high level of Road Engineering
- Shorter lifetime than normal Dense Asphalt Concrete (DAC)
  - Estimated at 7 years

AP: Traffic management

- Stimulate use of new modern vehicles (phasing out older noisiest types, particularly trucks)
- Where possible steady calm flow (50 km/h) instead of many crossings and stops
- Maintain speed limit in evening and night
- Stimulate use of public transportation



AP: Other measures

- Compensation in cases the noise is too high (e.g. landscape, green, cleanness, openness etc.)
- Make existing QUA more attractive (green, provisions,..)
- Improve accessibility, especially for elderly people and along hiking/biking tracks
- Introduce temporary QUA Areas (weekend/season)
- Information panels at main entrance
- Signposts to QUA
- Legal measures (local regulations that comprise limit values for city districts or parking limitations, etc.)

➲ AP: Attention

- ➲ Measures planned at hotspots should not lead to increase of noise levels in the so called grey areas. e.g. curbing cars from to city centre could lead to more cars in districts adjacent to the inner city.

Thank you for your attention!