

Urban Physics

7S0X0, 2021-2022 Quartile 3

prof.dr.ir. Maarten Hornikx



EINDHOVEN
UNIVERSITY OF
TECHNOLOGY

Urban Acoustics

Week 1

Introduction
Health effects
Noise mapping

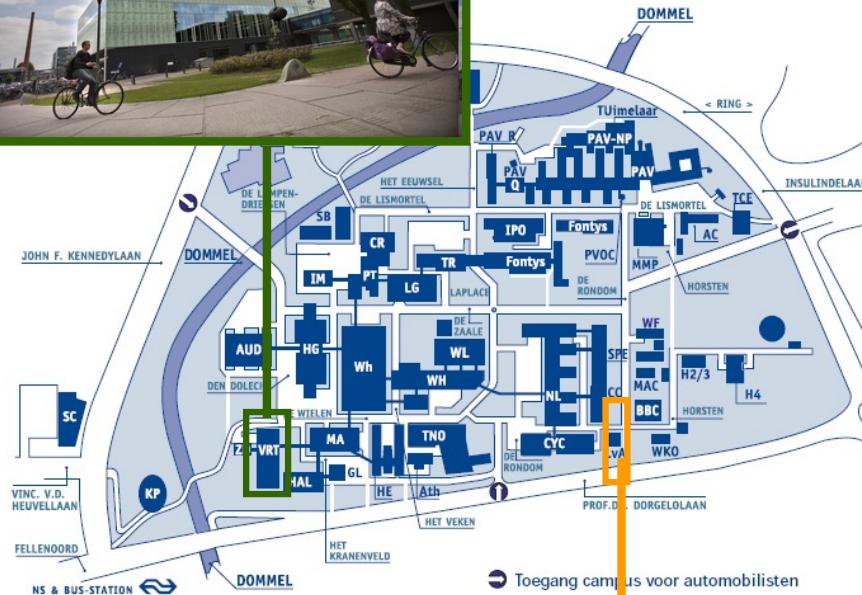
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Unit BPS: Building Acoustics group

Vertigo



Echo Building



Taipei Performing Arts Centre



Royal
HaskoningDHV
Enhancing Society Together



Building Acoustics group

Staff



Maarten Hornikx

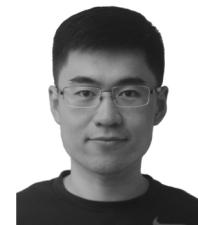


Constant Hak



Jieun Yang

Post-docs



Huiqing Wang



Marc
van Baelen

PhD students



Baltazar
Briere



Tanmayee
Pathre



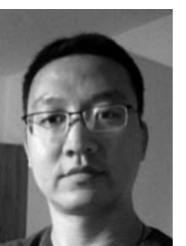
Maud
Dohmen



Michalis
Terzakis



Indra
Sihar



Qin
Yi



Wouter
Wittebol



Dingding
Xie



Xueying
Guan
(start 4/2022)

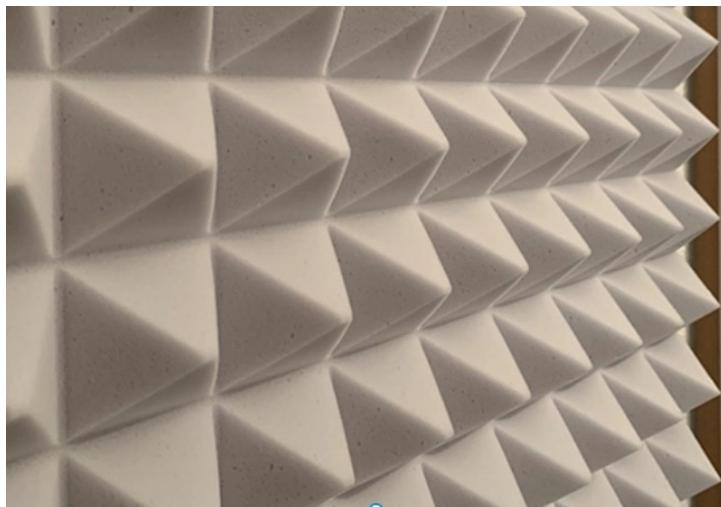
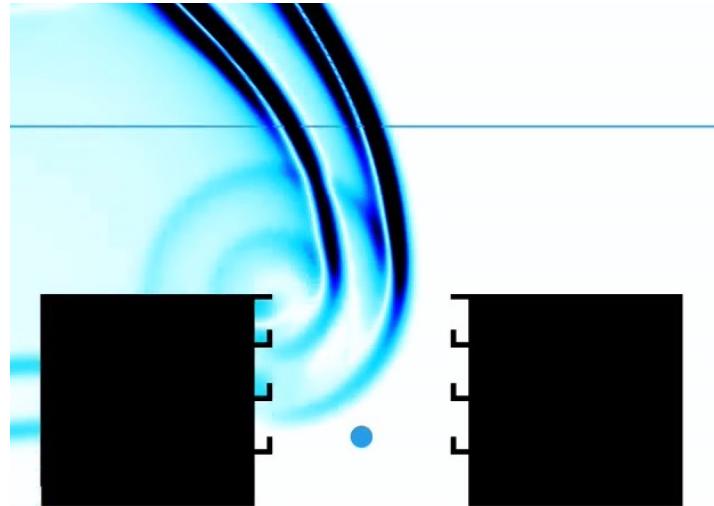


Matthias
Cosnefroy

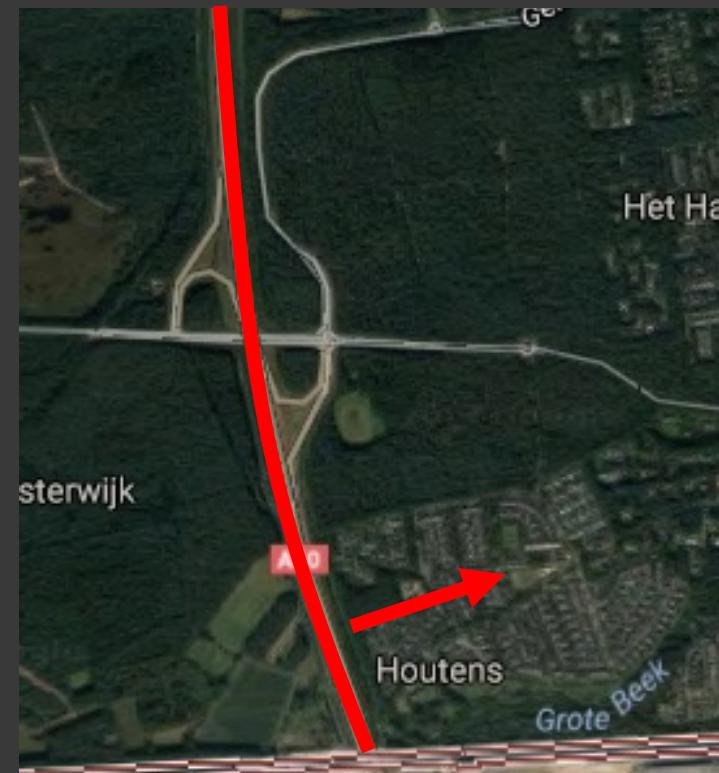
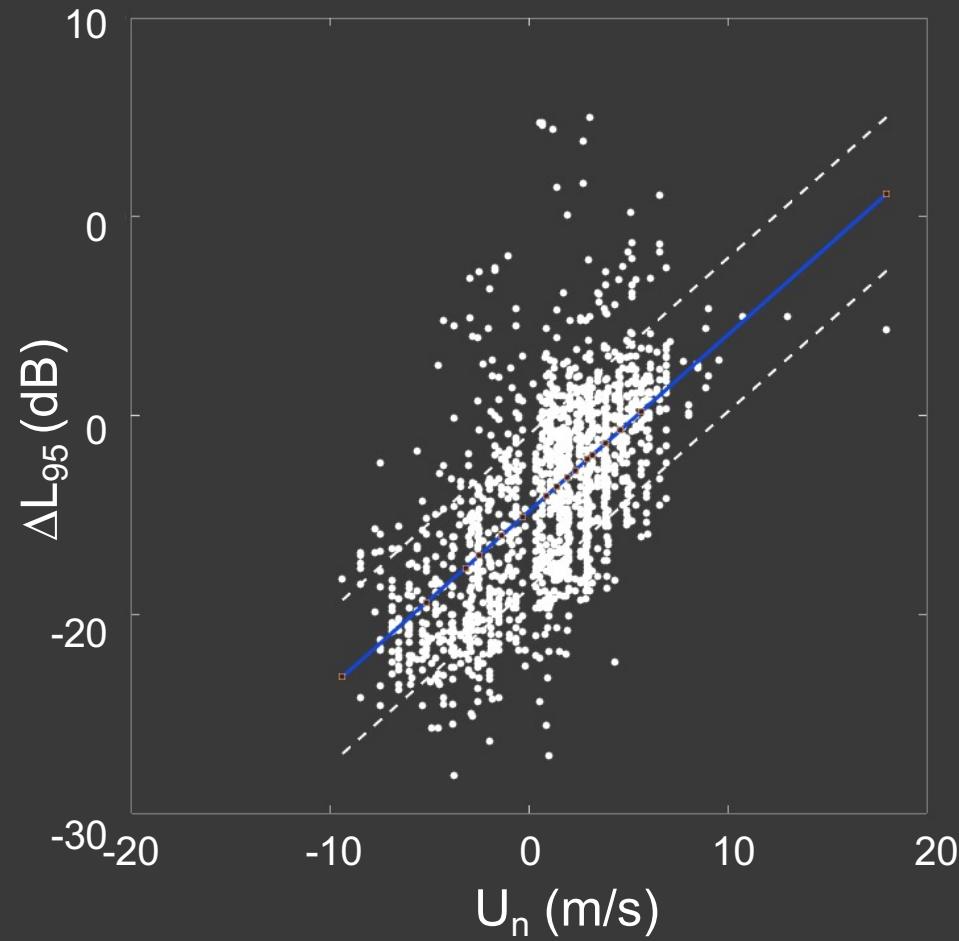


Muhammad
Imran
(start 3/2022)

Research line



Sai Trikootam



Building Acoustics group

Upcoming project: Meetnetwerk vliegtuig Groene Hart (citizen science)



▲ Een vliegtuig vliegt laag over een huis © anp

Groene Hart wil Schiphol om de oren slaan met harde cijfers over vliegtuigherrie: zo gaan ze dat doen

Urban Physics

Mondays: Wind part

Thursdays: Acoustics part (week 2-7 in Atlas 10.330)

Examination:

- Two assignments, wind and acoustics. Both count for 20% towards the final grade (minimum grade = 5)
- Final written exam, counting for 60% (minimum grade = 5)

Overview Urban Acoustics

Week	Subject
1	Effects of noise, acoustics quantities
2	Metrics of urban acoustics
3	Sources of sound
4	Effects on noise propagation
5	Urban noise control
6	Computing urban acoustics, I
7	Computing urban acoustics, II
8	Presentation of assignment

Overview Urban Acoustics

Le = Lecture, Tu = tutorial, Pr = presentation

Week		
1	Lectures	
2	Lecture + Tutorial exercises week 1&2	
3	Lecture + Tutorial exercises week 3	Assignment explanation
4	Lecture + Tutorial exercises week 4	
5	Lecture + Tutorial exercises week 5	
6	Lecture + Tutorial exercises week 6	
7	Lecture + Tutorial exercises week 7	
8	Presentations	

Overview Urban Acoustics

- Lecturers

Maarten Hornikx

m.c.j.hornikx@tue.nl

- Course Material

Book: Environmental Noise Pollution (TU/e digital library)

Report: Burden of disease from environmental noise (web download)

Report: 'Cnossos' (web download)

Booklet: Novel solutions for quieter and greener cities (web download)

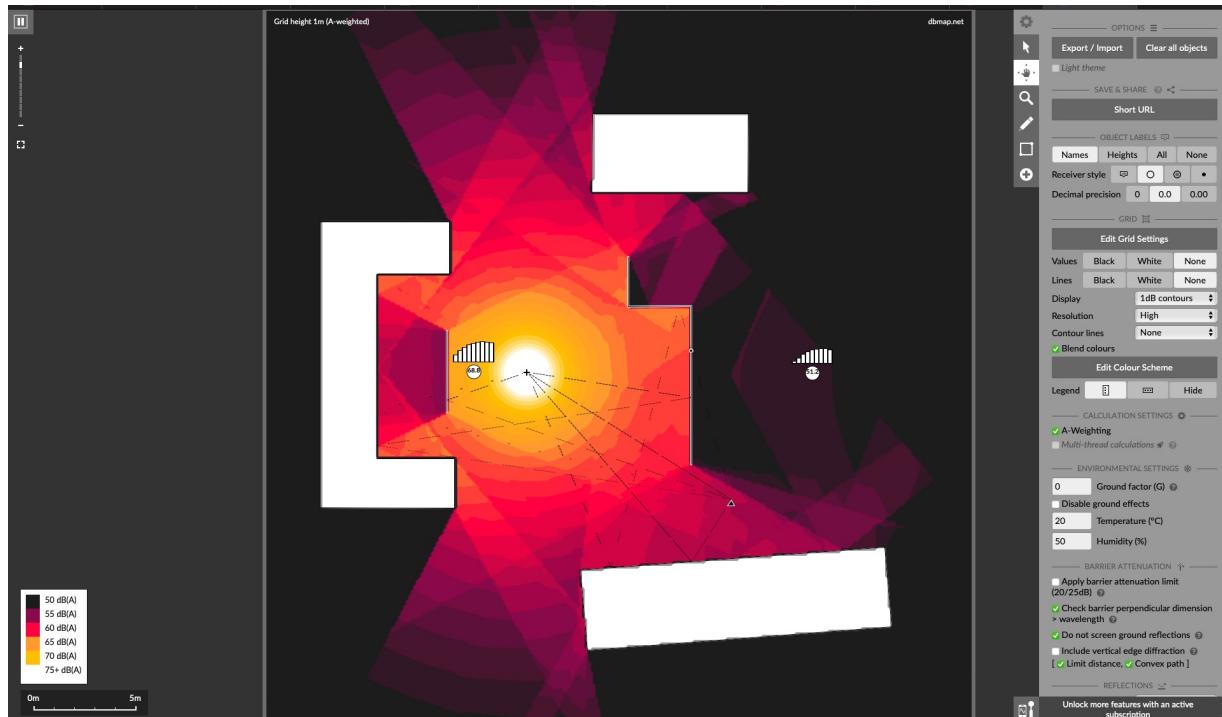
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Lecture notes

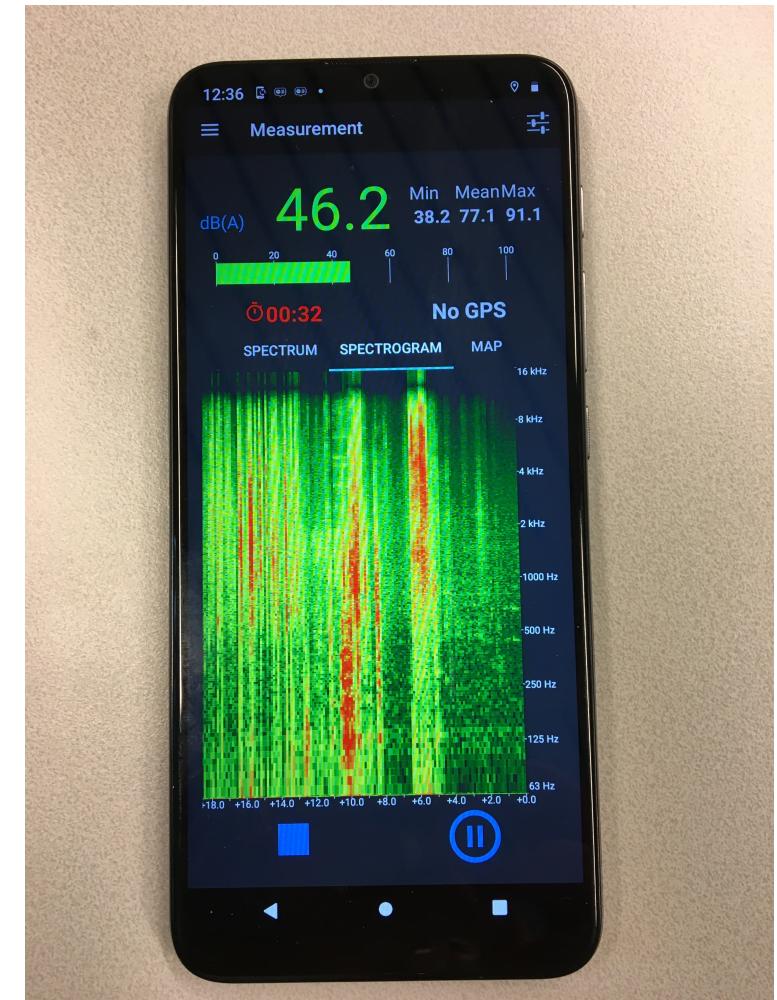
- Recordings last year will be shared online as well

Software

dBmap.net



NoiseCapture app



Overview Urban Acoustics

Week 1, Acoustics: Effects of noise, acoustics quantities

Course Material

- Lecture slides will be posted at Canvas
- Document 'Environmental noise pollution' Chapters 2-2.3, 3, 4-4.4.1, Box 4.1
- Document 'Burden of disease from environmental noise', p. viii-xvii

Background material:

- Document 'Environmental noise pollution' Chapters 1.1-1.3, 4.5
- Document 'Burden of disease from environmental noise', full document

Thursday 10 February Hour 5, Helix west 3.91

Lecture A.1 (Maarten Hornikx), Contents: Introduction, health effects of environmental noise, European noise mapping regulations.

Lecture A.2 (Maarten Hornikx), Contents: Acoustics quantities, acoustic pressure and velocity, sound pressure level, A-weighting, octave bands.

Overview Urban Acoustics

- To describe the health impact of environmental noise and the EU approach to monitor and manage it
- To qualitatively describe the aspects that influence the urban sound environment, by using acoustic expressions
- To be able to identify and analyze urban sound environments of low quality, as well as to propose quantitative solutions
- To be able to calculate the sound level due to road traffic noise for simple urban situations



Sounds in the outdoor environment



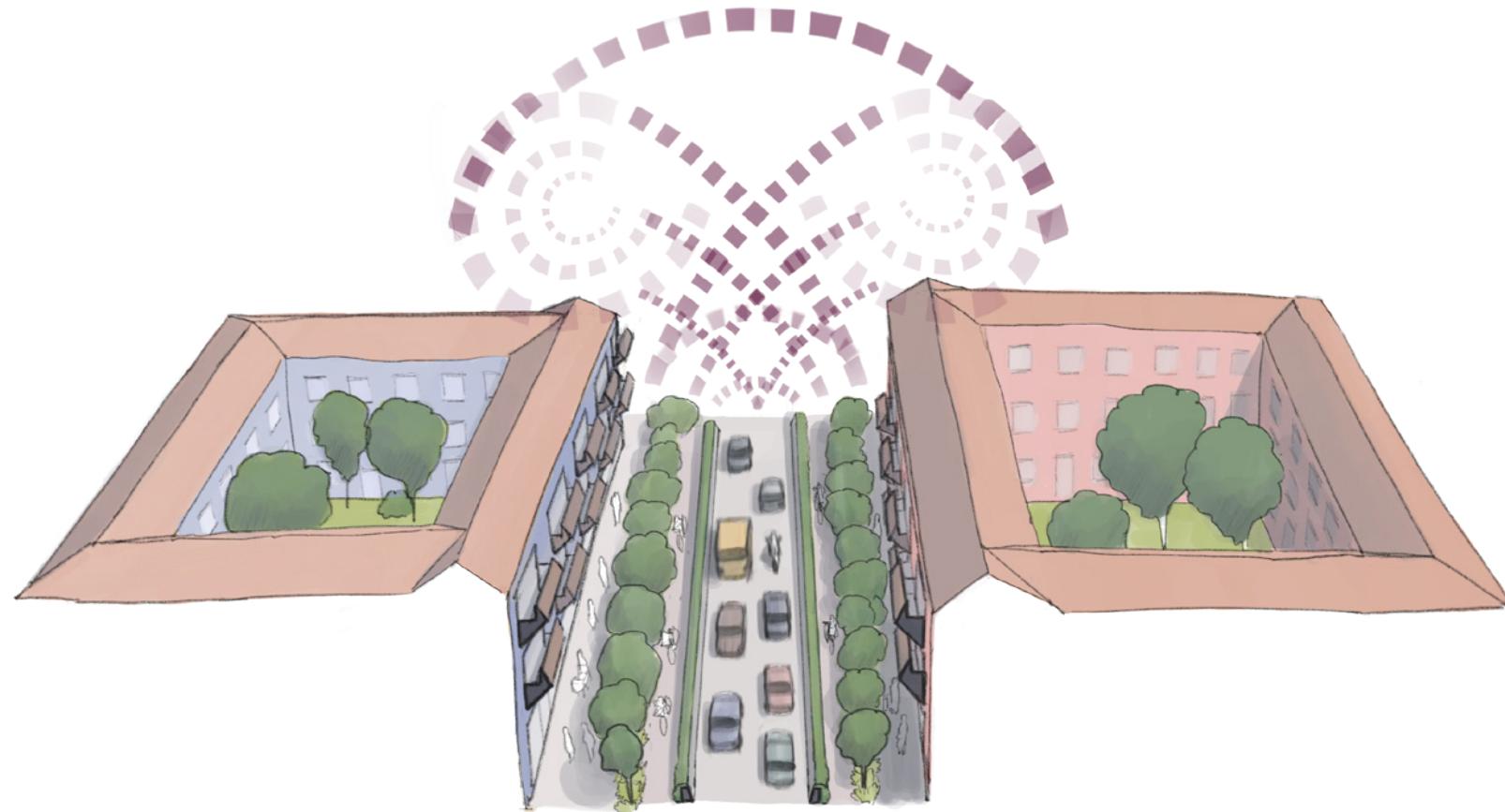
Sounds in the outdoor environment

Environmental noise: unwanted sound created by human activities that is considered harmful or detrimental to human health and quality of life
(Murphy et al., 2009)



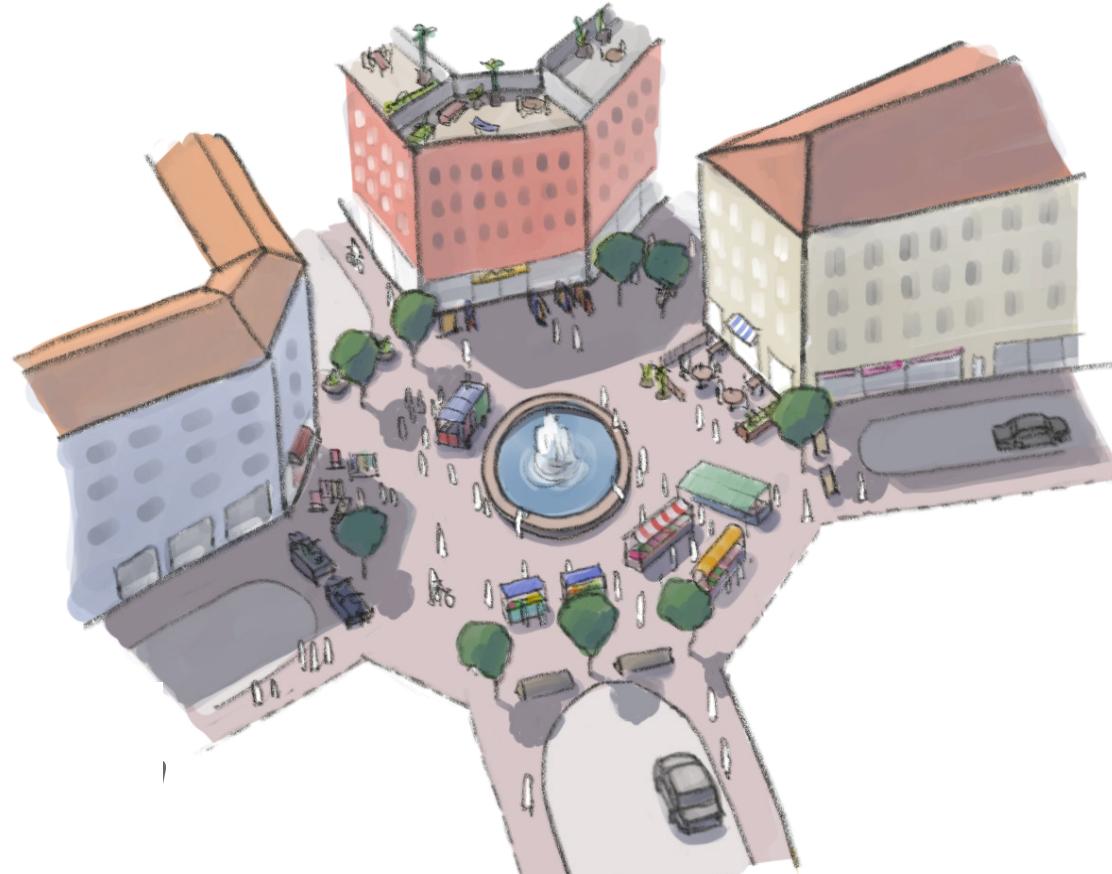
http://www.vartgoteborg.se/prod/sk/vargotnu.nsf/1/trafik,rekordokning_for_kollektivresandet

Urban Acoustics

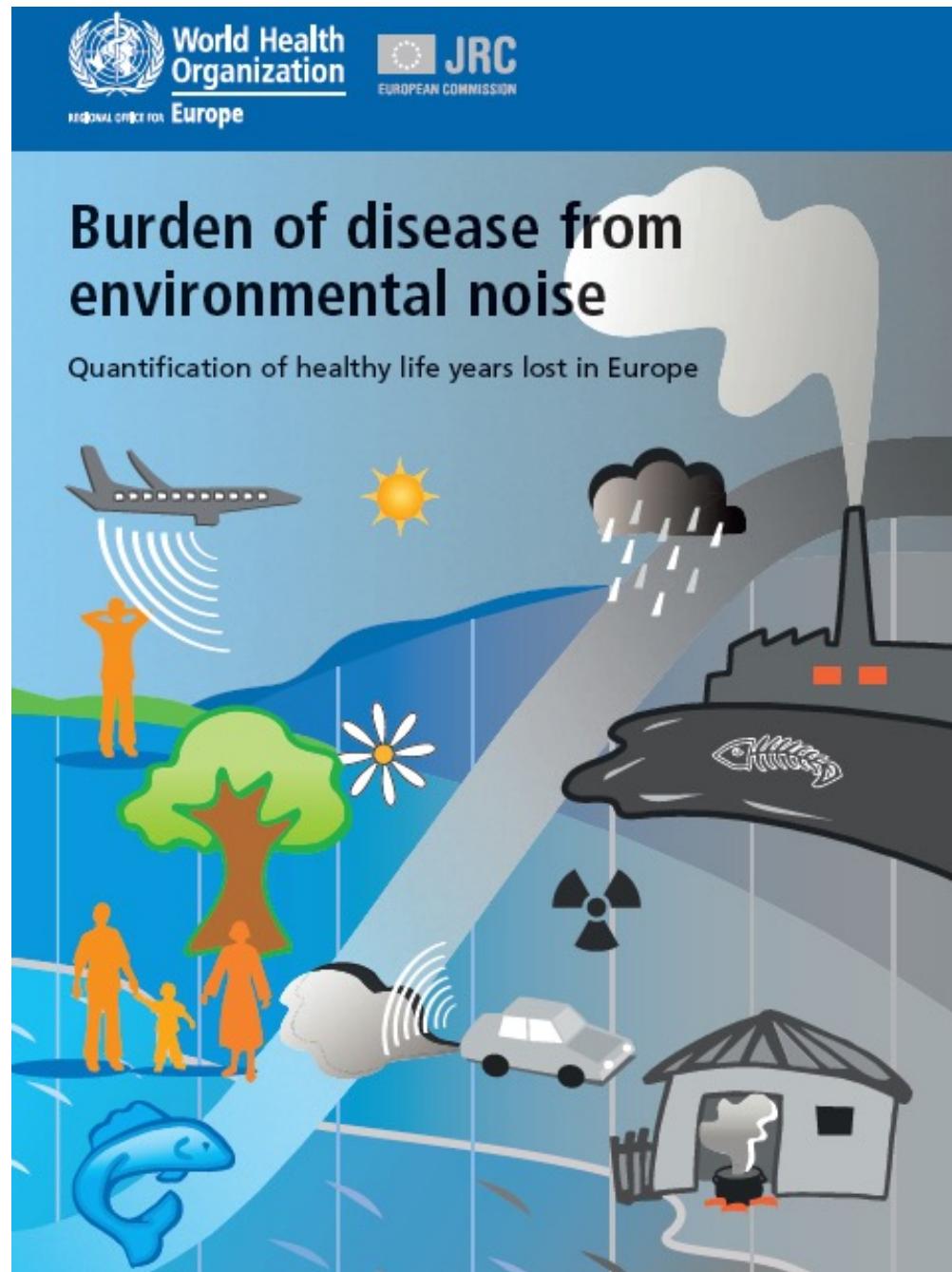


Soundscaping

- (Design of) the acoustic environment accounting for all sounds (positive and negative) present



Health effects due to environmental noise



Health effects due to environmental noise

DALYs are the sum of the potential years of life lost due to premature death and the equivalent years of 'healthy' life lost by virtue of being in states of poor health or disability (WHO2011)

DALY

Disability Adjusted Life Years is a measure of overall disease burden, expressed as the cumulative number of years lost due to ill-health, disability or early death

$$= \text{YLD} + \text{YLL}$$

Years lived with disability
Years of life lost



DALYs due to environmental noise

- Results for European Union

Adverse health effect	DALYs
Cardiovascular diseases	61 000
Cognitive impairment in children	45 000
Sleep disturbance	903 000
Tinnitus	22 000
Annoyance	587 000

WHO 2011

Environmental noise exposure

Road traffic noise exposure for the European countries reporting noise maps

Road traffic noise within agglomeration L_{den} (dB(A))	Percentage exposed ^a	Relative risk ^b	Attributable fraction
< 55	50	1.000	0.00
55–59	17	1.000	0.00
60–64	19	1.015	1.48
65–69	9	1.067	6.29
70–74	4	1.161	13.87

Source: Noise Observation and Information Service for Europe

Health effects: Annoyance

- Individuals annoyed by noise tend to experience anger, disappointment, unhappiness, withdrawal, distraction, anxiety, exhaustion and even depression
- 55 dB(A) is the WHO guideline corresponding to serious annoyance
- 57 million people (12% of the EU population) are annoyed by road traffic
- 5.5 million people (1% of the EU population), are annoyed by rail traffic (den Boer and Schroten, 2007).



<http://www.salon.com>

Health effects: Annoyance

- Noise annoyance is subjective as individuals vary in their sensitivity to noise. Raw and Griffiths (1988) found that self-reported sensitivity to noise is the most important variable for predicting ratings of annoyance.
- The standard approach by which noise annoyance is assessed at the population level is through an attitudinal questionnaire.



<http://www.lboro.ac.uk/>

Health effects: Sleep disturbance

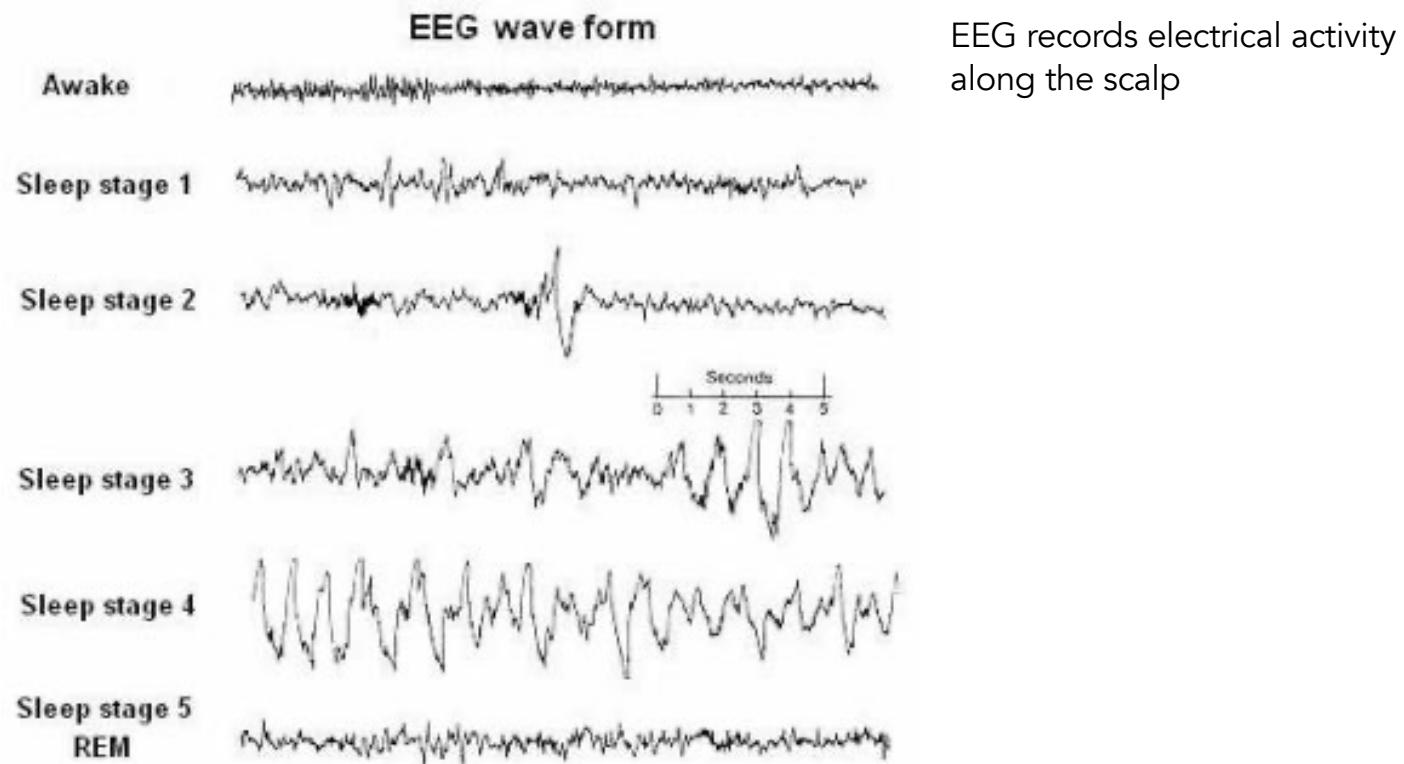
- Sleep disturbance occurs already for levels between $L_{night} = 30-40 \text{ dB(A)}$
- Reduction in sleep quality is associated with 'after-effects' such as fatigue, low work capacity and reduced cognitive performance
- Human subjects are disturbed more by intermittent noise than by continuous noise
- Intermittent noises with peak noise levels above 45 dB(A) can increase the time taken to fall asleep by up to 20 min



<http://www.ergoflex.co.uk>

Health effects: Sleep disturbance

- Sleep disturbance can be quantified objectively by
 - The number and duration of nocturnal awakenings,
 - The number of sleep stage changes and modifications in their amounts.
- Sleep disturbance can be quantified subjectively by
 - Questionnaires distributed to subjects on the morning after a night's sleep.



Health effects: Cardiovascular diseases

- Hypertension (high blood pressure) and ischaemic heart disease
- Increased cardiovascular risk for daytime average sound pressure level above 60 dB(A) (Hurtley ed., 2009)
- Other researchers (Babisch et al. 2005) found evidence of a link between traffic noise exposure greater than 60 dB(A) and increased risk of MI (Myocardial Infarction) – commonly known as heart attack



<http://www.who.int>

Health effects: Cognitive impairment in children

- Definition: The Reduction in cognitive ability in school-age children that occurs while the noise exposure persists and will persist for some time after the termination of the noise exposure
- Tasks involving central processing and language comprehension, such as reading, attention span, problem solving and memory, appear to be most affected by exposure to noise (Evans and Maxwell, 1997; Stansfeld and Matheson, 2003).



<http://www.wisegeek.org>

Health effects: Tinnitus

- Definition: sensation of sound in the absence of an external sound source, often associated with partial hearing loss.
- It can cause sleep disturbance, cognitive effects, anxiety, psychological distress, depression communication problems, frustration, irritability, tension, inability to work, reduced efficiency and restricted participation in social life.
- Excessive exposure to noise is generally what causes tinnitus. Environmental noise from social/leisure noise such as personal music players, gun shooting events, music concerts, sporting events and events using firecrackers is associated with tinnitus



<http://www.complete-hearing.com>

WHO noise guidelines (2018)



ENVIRONMENTAL **NOISE** GUIDELINES

for the European Region



WHO noise guidelines (2018)



Leisure noise

Recommendation

For average noise exposure, the GDG conditionally recommends reducing the yearly average from all leisure noise sources combined to **70 dB $L_{Aeq,24h}$** as leisure noise above this level is associated with adverse health effects. The equal energy principle³ can be used to derive exposure limits for other time averages, which might be more practical in regulatory processes.

For single-event and impulse noise exposures, the GDG conditionally recommends following existing guidelines and legal regulations to limit the risk of increases in hearing impairment from leisure noise in both children and adults.

Following a precautionary approach, to reduce possible health effects, the GDG strongly recommends that policy-makers take action to prevent exposure above the guideline values for average noise and single-event and impulse noise exposures. This is particularly relevant as a large number of people may be exposed to and at risk of hearing impairment through the use of personal listening devices. There is insufficient evidence, however, to recommend one type of intervention over another.

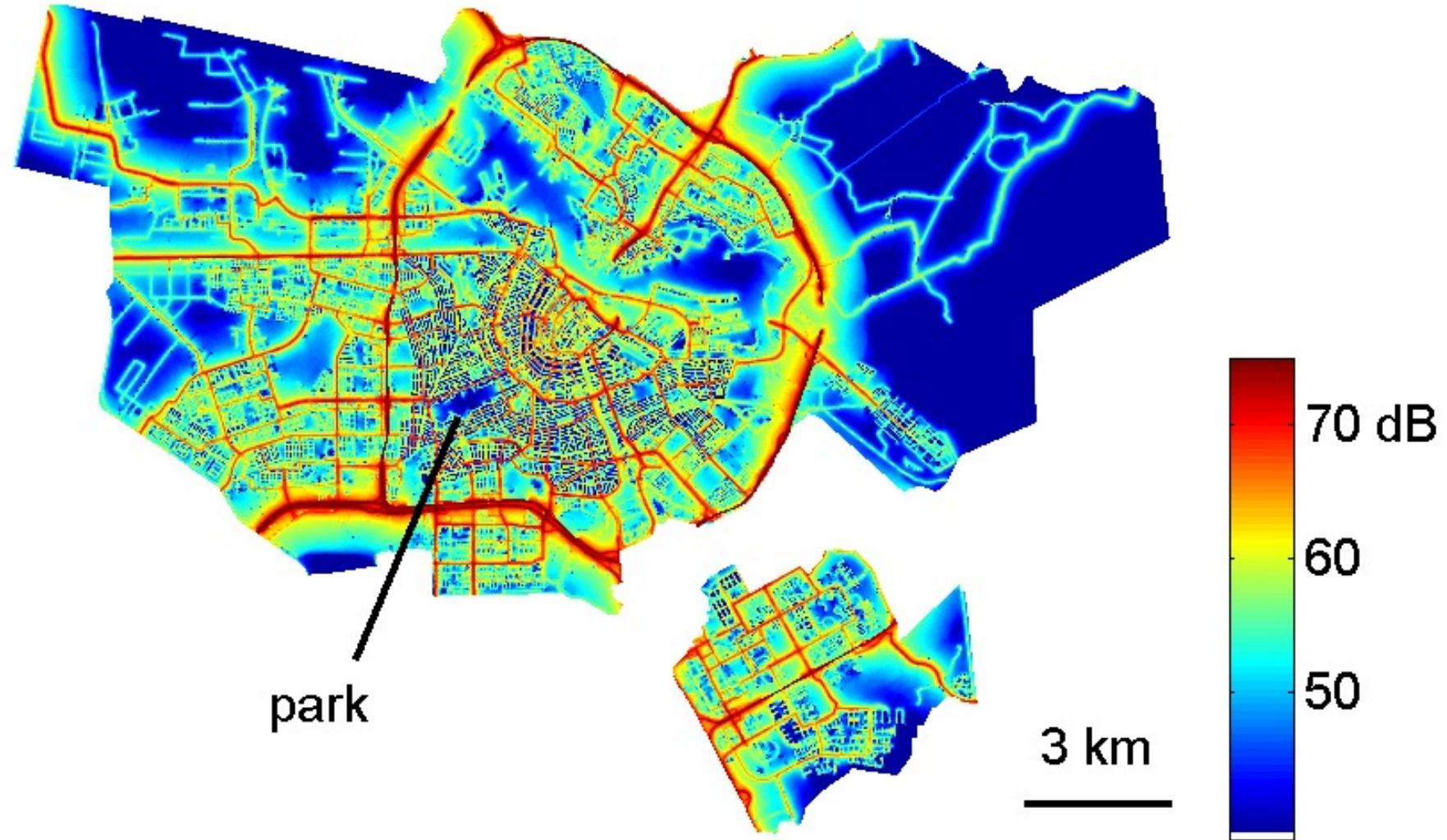
Strength

Conditional

Conditional

Strong

Noise mapping



Noise mapping: description

- Noise mapping is a means of presenting calculated and/or measured noise levels in a representative manner over a particular geographic area
- It allows researchers and policymakers to identify locations that are subject to excessive noise levels and if there are individuals residing in those areas affected by excessive pollution
- Thereafter, steps can be taken to reduce noise levels so that public health is protected
- The mapping process also allows for the identification of areas of good sound quality – often referred to as quiet areas – so that these can be protected into the future as amenity areas for rest or recreation that are free from noise disturbance

Noise mapping: Environmental Noise Directive

- Environmental Noise Directive (END): common EU approach aimed at avoiding, preventing or reducing the negative and harmful effects caused by environmental noise.

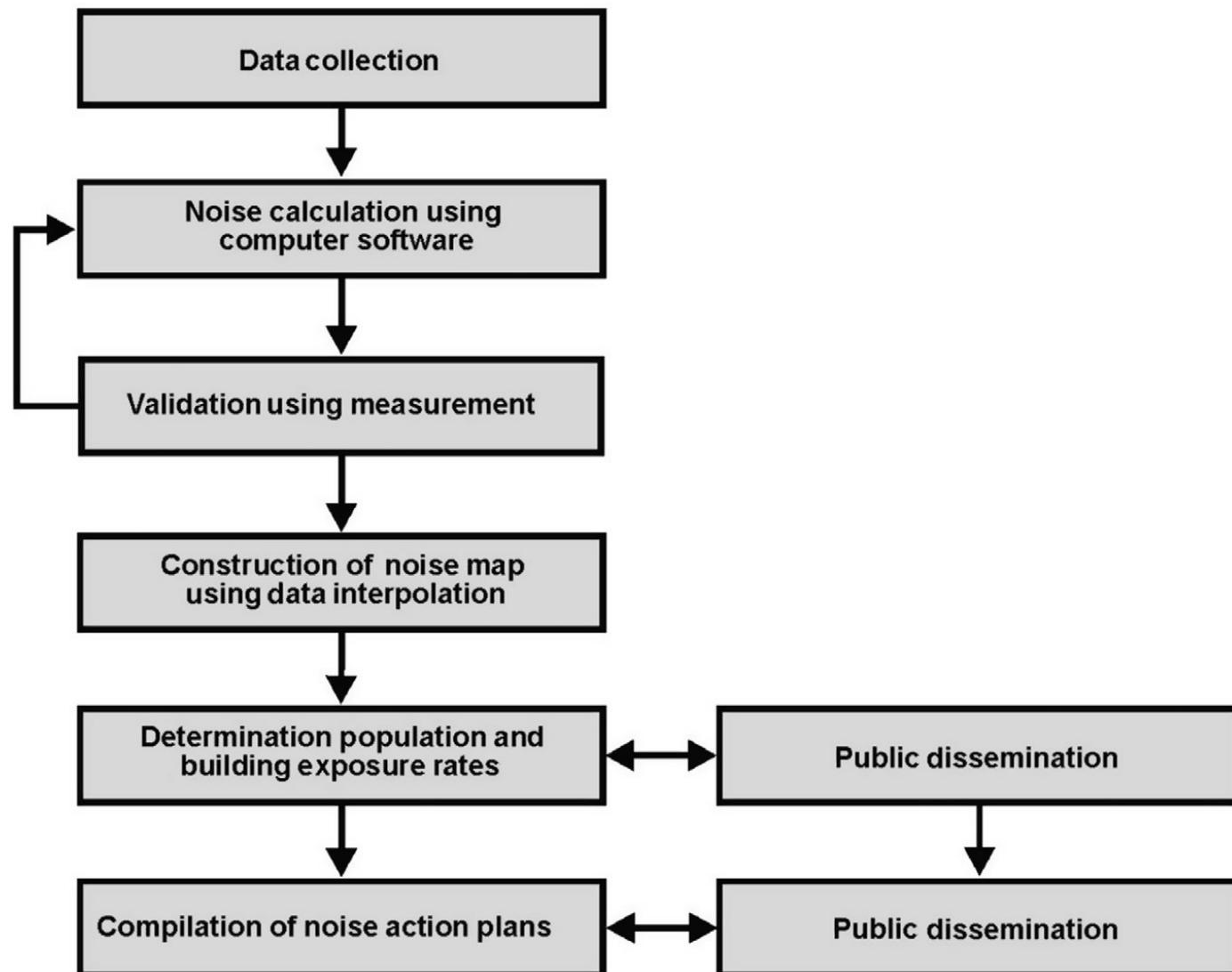


<http://ec.europa.eu/environment/noise/>

Noise mapping: Environmental Noise Directive

- A series of actions need to be implemented Member States to achieve the objectives of the END.
 - Monitoring of environmental noise (noise mapping)
 - Managing environmental noise issues (action plans: plans designed to manage noise issues and effects, including noise reduction if necessary)
 - Public information and consultation
 - Development of a long-term EU strategy (cooperation of members states)
- Noise mapping rounds every 5 years
 - 2007 (first round): agglomerations > 250 000 inhabitants
 - 2012 and 2017 (second/third round): agglomerations > 100 000 inhabitants

Noise mapping



Murphy, E., & King, E. (2014). *Environmental noise pollution: Noise mapping, public health, and policy*. Newnes.

Noise mapping: Environmental Noise Directive

- Population exposure estimation: number of people living in dwellings that are exposed to values of L_{den} and L_{night} in various categories at the most exposed exposed building façade, separately for road, rail, air traffic and industrial noise
- The categories stated in the Directive are
 - 55-59, 60-64, 65-69, 70-74 and >75 L_{den} and
 - 50-54, 55-59, 60-64, 65-69 and >70 for L_{night} .
- In addition, people living in dwellings that have special insulation against environmental noise or have a quiet facade should also be reported



Noise mapping: Environmental Noise Directive

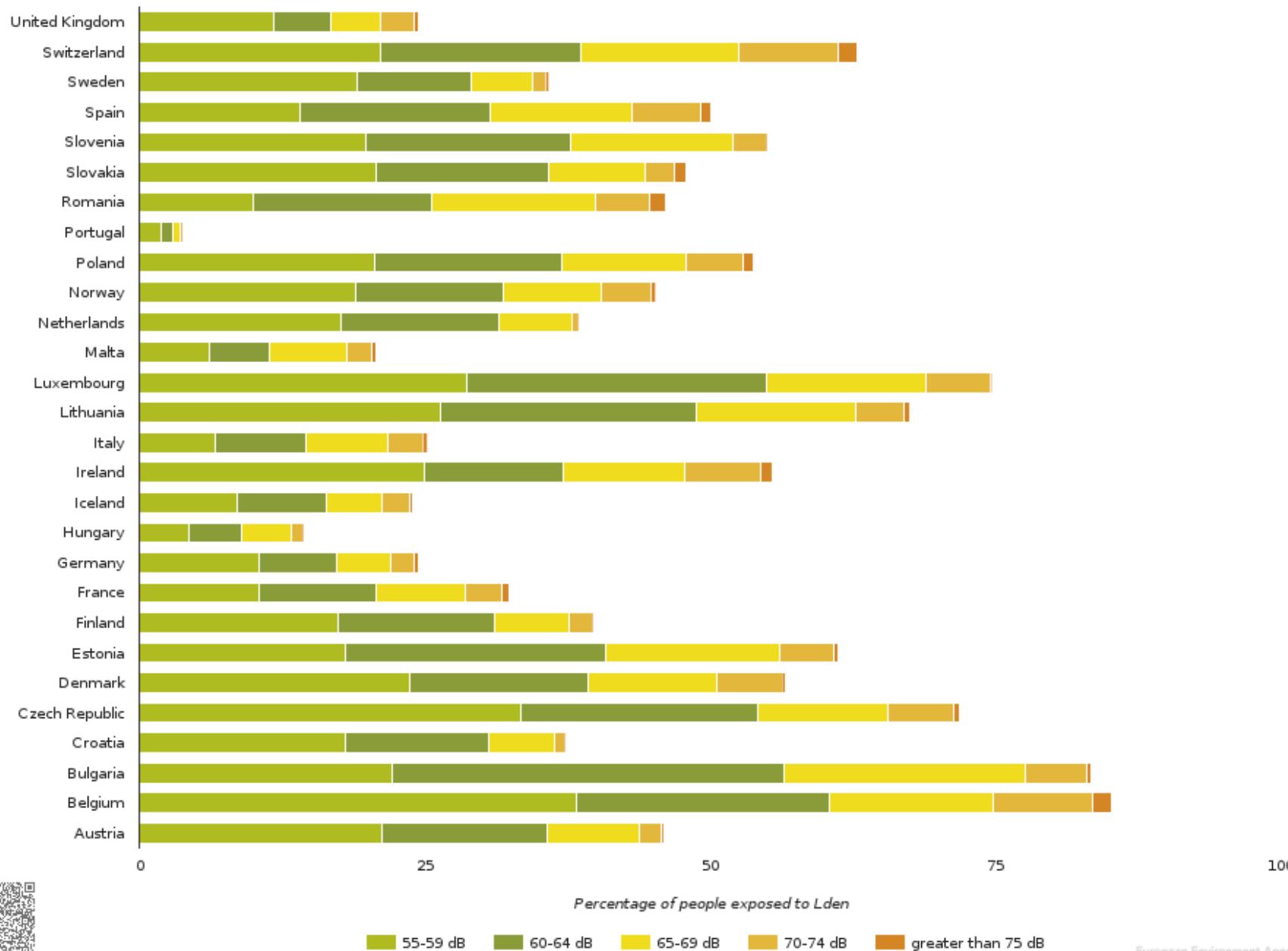
- Issue Calculation methodology: Various methods have been used so far. The ultimate objective is to have the common noise assessment methodology implemented and operational.
- Issue Quiet side: Action plans should also aim to protect quiet areas against an increase in noise. However, no clear definition of a quiet side, resulting in a considerable divergence in the approaches used for noise mitigation and sound quality preservation.



Qside.eu

Noise mapping: Environmental Noise Directive

Chart — Percentage of population exposed to road noise within urban areas above Lden 55dB, by country



7SOXO



European Environment Agency



References

- Hurtley, C. ed., 2009. *Night noise guidelines for Europe*. WHO Regional Office Europe.
- WHO Regional Office for Europe, Burden of Disease from Environmental Noise - Quantification of Healthy Life Years Lost in Europe, 2011, ISBN 9789289002295.
- Babisch, W., Beule, B., Schust, M., Kersten, N. and Ising, H., 2005. Traffic noise and risk of myocardial infarction. *Epidemiology*, 16(1), pp.33-40.
- Den Boer, L.C. and Schroten, A., 2007. Traffic noise reduction in Europe. *CE Delft*, 14, pp.2057-2068.
- Evans, G.W. and Maxwell, L., 1997. Chronic noise exposure and reading deficits the mediating effects of language acquisition. *Environment and Behavior*, 29(5), pp.638-656.
- Murphy, E. and King, E., 2014. *Environmental noise pollution: Noise mapping, public health, and policy*. Newnes.