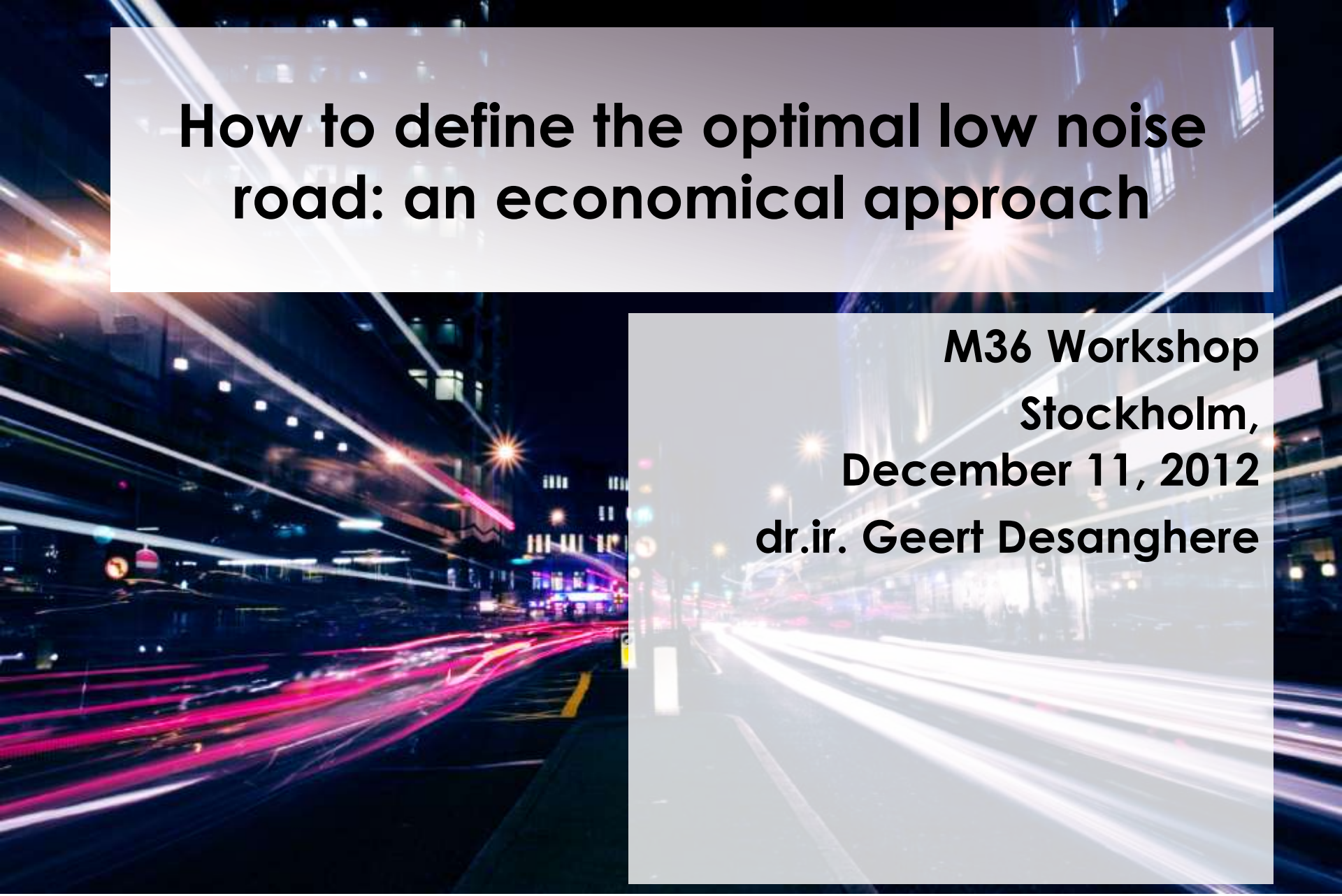
How to define the optimal low noise road: an economical approach



M36 Workshop

Stockholm,

December 11, 2012

dr.ir. Geert Desanghere

CityHush

SEVENTH FRAMEWORK PROGRAMME

- Situation:
  - Action planning
  - Road traffic
  - Road pavement/surface modification
- Aim: Evaluation of action plan
  - not only based on number of exposed/number of Highly Annoyed
  - but on cost/efficiency
- Cost efficiency:
  - cost/benefit analysis: CBA
  - prioritising: Hotspot

CBA: benefit

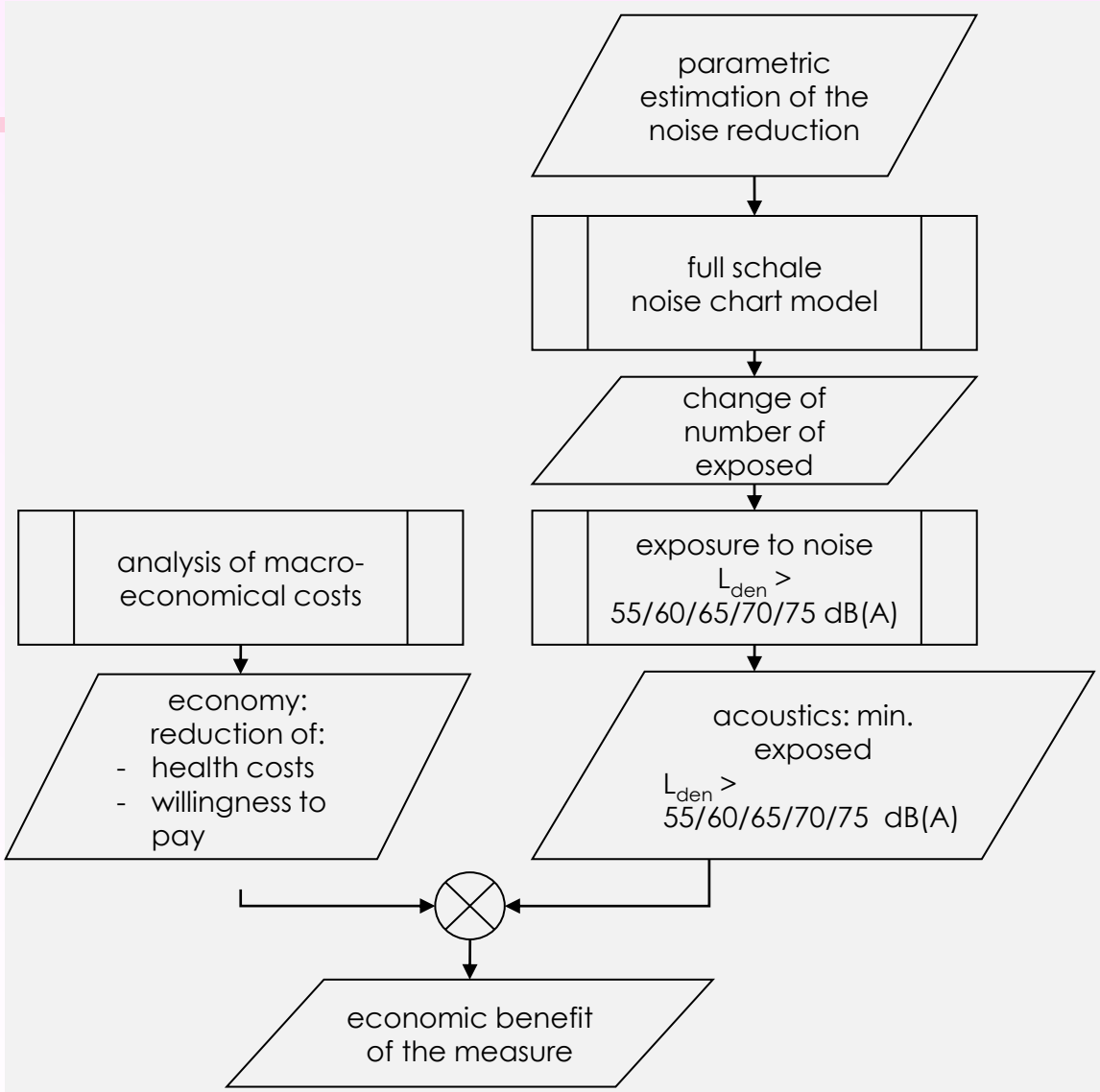
- Based on Position Paper: WHSEA (2003)
  - Direct Effect
  - Health Effect
- Direct Effect
  - Stated Preference (SP): willingness to pay
  - Hedonic Preference (HP): hedonic evaluation
- Stated Preference ("Navrud"-2002):
  - 25€/family/dB
  - 11€/person/dB
    - (for Lden = 50 – 75 dB)
    - (varies: 2 – 99€/family/dB)

CBA: benefit

- Health Effect:
  - could be expressed as DALY (Disability Adjusted Life Year)
  - mainly cardo-vascular
  - factor 1.15

- **Global Benefit (?): 12.5€/person/dB**

Approach CBA



CBA: cost

- Based on:
  - width
  - type of road surface & number of km
  - load
- Width:
  - speed regime 90 -120 km/h 13 m per lane
  - speed regime 70 km/h 6 m per lane
  - speed regime 50 km/h 3.5 m per lane

Road Surface Types

SMA: Split Mastic Asphalt:

- SMA : (lt:15y)
- SMA-D: -1 dB (lt:12y)

ZOA: Porous Asphalt:

- ZOA (lt: 8y)
- 2-ZOA (lt: 6y)

AB: Hot Rolled Asphalt:

- Asphalt with concrete parts
- (lt: 15y)

CC: Cement Concrete Chemically Washed: (lf:30y)

- CC (0/20)
- 2-CC (0/6.3)
- BCC: Broomed Concrete

CBA: cost

- Type of road surface & number of km

Road surface database Road surface id.	Name	average correction [dB]	Statistic road surface length [m]	[%]	Definition potential road surface length [%]	potential [dB]
206	Along grooved concrete	5,5	33 507	0,9	3,8	> 5 dB
205	Transverse grooved concrete	6,0	103 015	2,8		
208	Broomed concrete	4,5	324 665	8,7		>= 3 dB en <= 5 dB
207	Chemically washed concrete	3,0	176 558	4,7		
202	AB	2,0	799 442	21,5	21,8	< 3 dB
201	SMA	0,0	1 500 453	40,3	40,3	Reference surface
203	SMA D	-1,0	307 141	8,3	20,4	Better than reference surface
204	ZOA	-1,5	448 951	12,1		

CBA: cost

- Load

speed [km/h]	type
90-120	B1
70	B3
50	B5

- Total Cost per lineair meter:
  - cost based on a 30 year lifetime
  - including additional new layers

	SMA	SMA-D	TL	AB	ZOA	2-ZOA	CC	2CC	B
B1	611	614	955	611	858	1241	513	546	552
B3	216	214	372	216	327	510	210	225	228
B5	115	115	206	115	180	287	122	131	122

- Total Cost (30 years)

	Cost	Difference
Actual (reference)	1.698 M€	-
Ambition 1	2.078 M€	+22%
Ambition 2	2.934 M€	+72%

CBA: Action Plan

Reference situation

Actual	Max. speed [km/h]	Future
Asphalt	90-120	SMA-C (or SMA-D)
	70	SMA-C (or SMA-D)
	50	AB-4C (or AB-4D)
Concrete	90-120	CC (0/20)
	70	CC (0/20) (or broomed)
	50	Broomed CC

Ambition level 1

Actual	Max. Speed [km/u]	Future
Asphalt	90-120	ZOA
	70	SMA-D
	50	50% TL and 50% AB-4C (or AB-4D)
Concrete	90-120	ZOA-C (on concrete) (composiet)
	70	SMA-D (on concrete) (composiet)
	50	CC (0/20)

Ambition level 2

Actual	Max. speed [km/h]	Future
Asfalt	120	2-ZOA
	90	2-ZOA
	70	SMA-D
	50	SMA-D
Beton	120	ZOA (on concrete)
	90	TL (on concrete)
	70	TL (on concrete)
	50	CC

Number of exposed

Number of exposed

Total – **Reference situation**: phase 1 road traffic							
Category	som	>55-60 dB	>60-65 dB	>65-70 dB	>70-75 dB	>75-80 dB	>80 dB
Inhabitants	4 849 299	257 871	125 719	121 623	143 023	33 337	248
... in dwellings with a silent facade	589 838	44 215	45 146	88 338	128 446	31 580	191
Dwellings	2 040 650	108 800	54 709	55 857	66 546	14 901	112

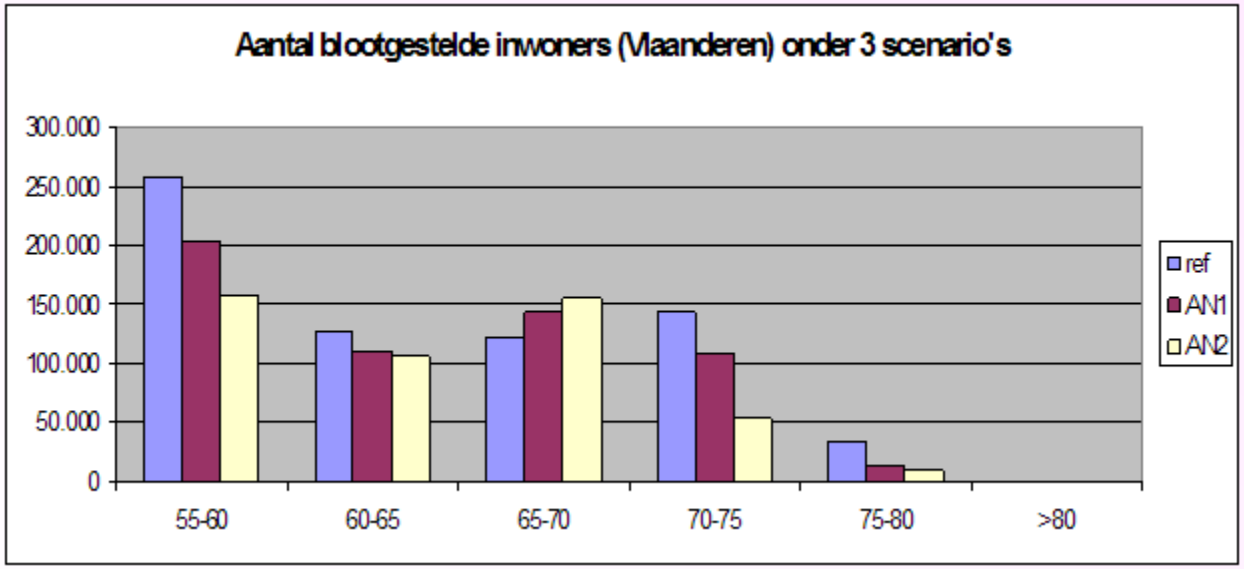
Total – **Ambition level 1**: road traffic							
Category	som	>55-60 dB	>60-65 dB	>65-70 dB	>70-75 dB	>75-80 dB	>80 dB
Inhabitants	4 849 299	203 459	109 285	142 432	108 289	14 034	31
... in dwellings with a silent facade	586 744	47 199	50 805	115 756	99 311	13 557	20
Dwellings	2 040 652	86 122	48 531	65 742	49 788	6 222	12
Inhabitants exposed to L_{den} >				264 786	121 858	14 065	

Total – **Ambition level 2**: road traffic							
Category	som	>55-60 dB	>60-65 dB	>65-70 dB	>70-75 dB	>75-80 dB	>80 dB
Inhabitants	4 849 299	156 167	105 953	154 917	53 930	10 408	105
... in dwellings with a silent facade	582 617	47 922	63 785	136 115	49 791	10 308	100
Dwellings	2 040 651	67 209	47 671	71 821	24 868	4 695	53
Inhabitants exposed to L_{den} >				219 360	64 443	10513	

Number of exposed

3 Average noise reduction for each ambition level:

- AN 1: 3.8 dB(A)
- AN 2: 5.4 dB(A)



Number of %HA

Agglomeratie Gent - Referentie: fase 1 wegverkeer							
Methode 2002/49/EG: meest blootgestelde gevel							
Category	som	>55-60 dB	>60-65 dB	>65-70 dB	>70-75 dB	>75-80 dB	>80 dB
Inhabitants	228 503	20 730	10 617	10 468	18 744	3 353	0
... in dwellings with a silent facade	40 206	4 728	4 226	7 635	17 729	3 168	0
Dwellings	109 714	9 606	5 115	5 366	9 674	1 659	0
Inhabitants exposed to L_{den} >				32 565	21 912	3 353	

CBA: evaluation

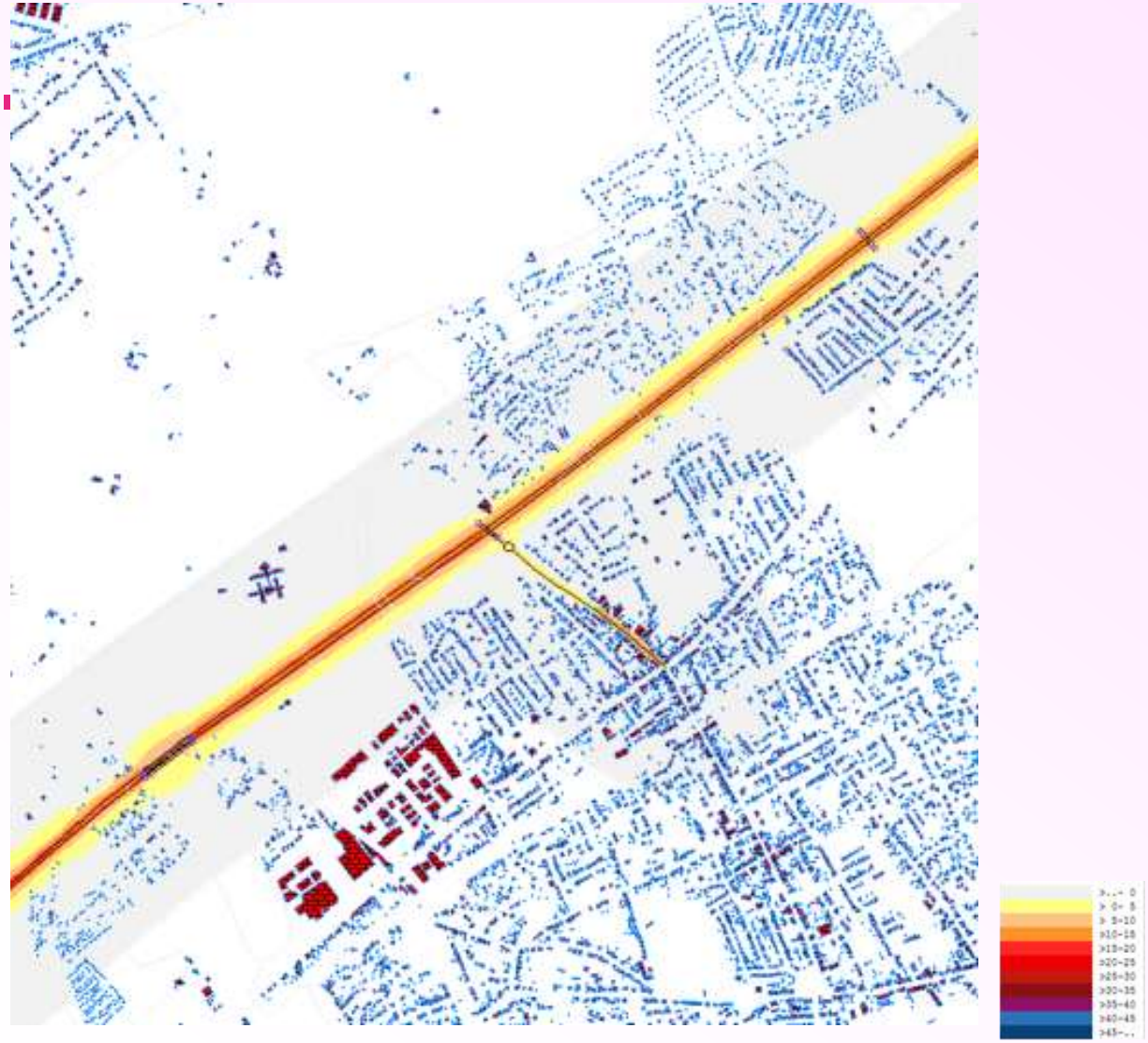
Exposure class	ref	AN1	Reduction	Benefit per year
55-60	257 871	203 459	-54 412	3 400 750
60-65	125 719	109 285	-16 434	2 054 250
65-70	121 623	142 432	20 809	-3 901 688
70-75	143 023	108 289	-34 734	8 683 500
75-80	33 337	14 034	-19 303	6 032 188
>80	248	31	-217	81 375
			Total benefit	16,4 million
			(Total extra cost)	(12,7 million)

Exposure class	ref	AN2	Reduction	Benefit per year
55-60	257 871	156 167	-101 704	6 356 500
60-65	125 719	105 953	-19 766	2 470 750
65-70	121 623	154 917	33 294	-6 242 625
70-75	143 023	53 930	-89 093	22 273 250
75-80	33 337	10 408	-22 929	7 165 313
>80	248	105	-143	53 625
			Total benefit	28.1 million
			(Total extra cost)	(41,2 million)

Prioritising

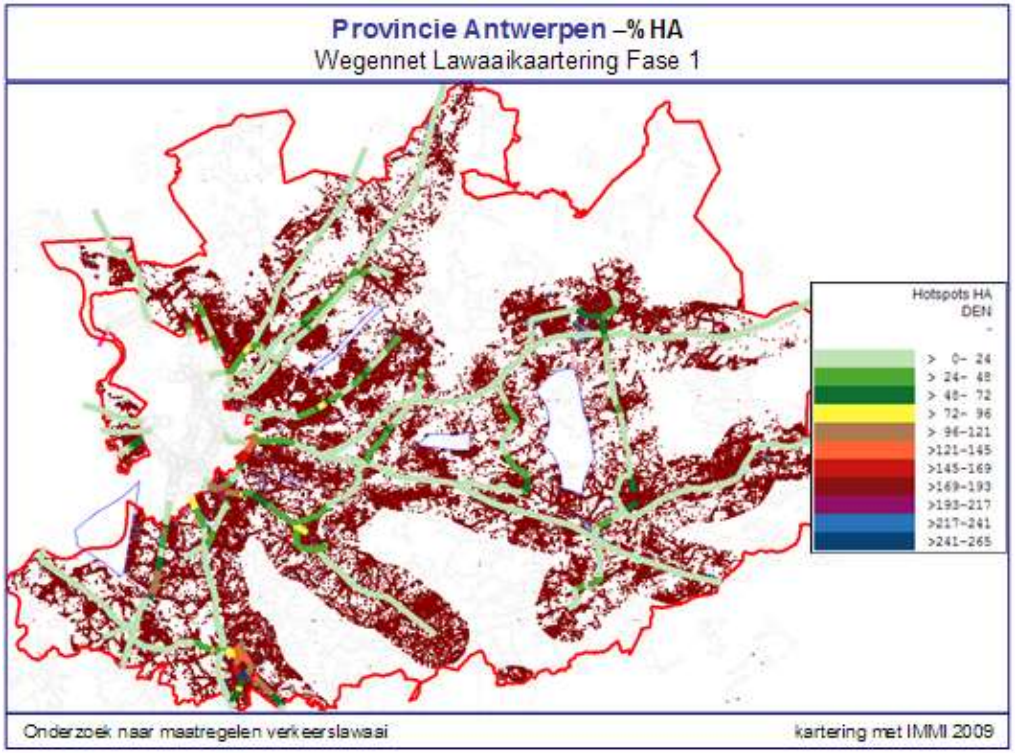
- Hotspot identification
- Efficient approach:
  - most exposed first
  - objective values
  - automated
- Could be based on:
  - number of exposed
  - number of HA
- Methods for priority setting:
  - type 1: exceedance level
  - type 2: calculated noise level + number of inhabitants
  - type 3: calculation of nuisance based on dose/effect relationships, number of annoyed, unit of length.

Exceedence map



Percentage Highly Annoyed (%HA)

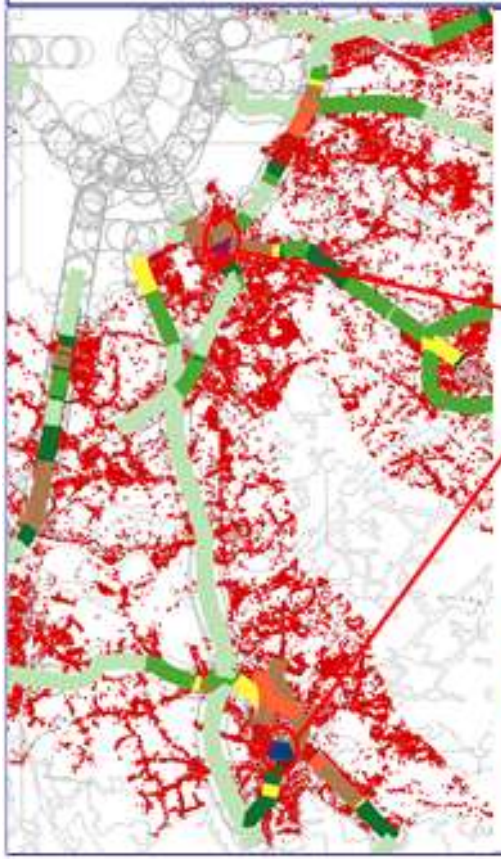
name	type	formula
%HA	3	%HA = 9,868*10-4 (L_{den}-42)3 – 1,436*10-2 (L_{den}-42)2+ 0,5118 (L_{den}-42)
Description		Proposed by the European "Working Group 2" en de "HSEA". Based: Calculation of level on most exposed facade, coupled to the number of inhabitants.



Link to acoustical model

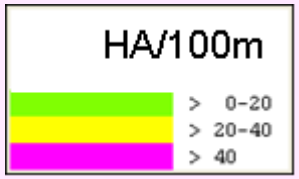
Provincie Antwerpen –% HA

Wegennet Lawaaikaartering Fase 1 – ZOOM op zwarte punten

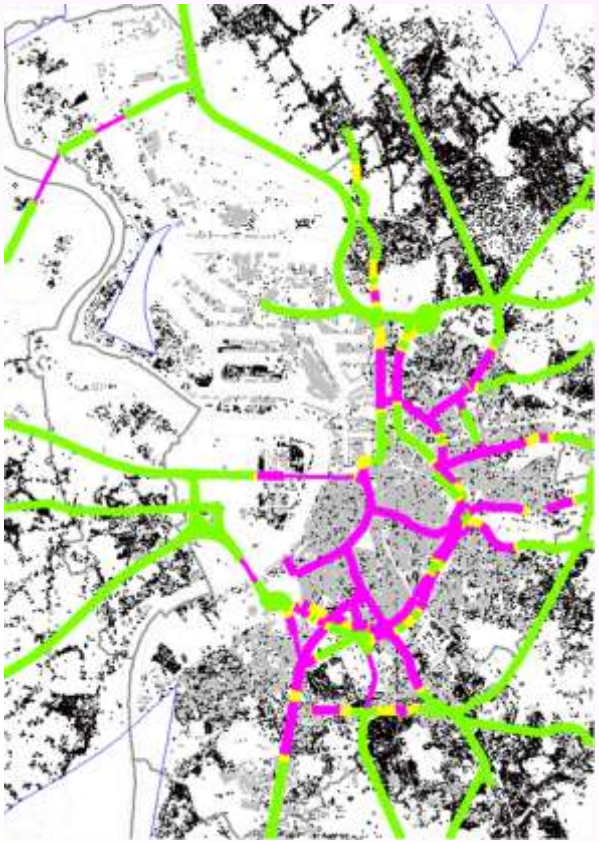


No.		Label	Length /m	HA / Highly Annoyed maximum
1	STRt5250	xR0120002	517	265
2	STRt4885	xR0120001	542	263
3	STRt5252	xR0120002	107	256
4	STRt4886	xR0120001	99	256
5	STRt5248	xR0120002	1206	254
6	STRt0839	xN0019012	571	260
7	STRt4882	xR0120001	1219	253
8	STRt1541	xN0100001	379	226
9	STRt1923	xN0100002	379	225
10	STRt1908	xN0010002	284	234
11	STRt0772	xN0010001	285	234
12	STRt0755	xN0010001	676	218
13	STRt0754	xN0010001	165	217
14	STRt0329	xN0010002	698	216
15	STRt0266	xN0010002	163	215
	TRt1235	xN0100001	134	210
	TRt1759	xN0100002	134	210
	TRt5249	xR0120002	142	225
	TRt4888	xR0120001	152	225
	TRt0753	xN0010001	1346	202
	TRt0327	xN0010002	1208	201
	TRt4887	xR0120001	1225	181
	TRt0774	xN0010001	702	166
	TRt5247	xR0120002	1216	179
	TRt0775	xN0010001	395	165

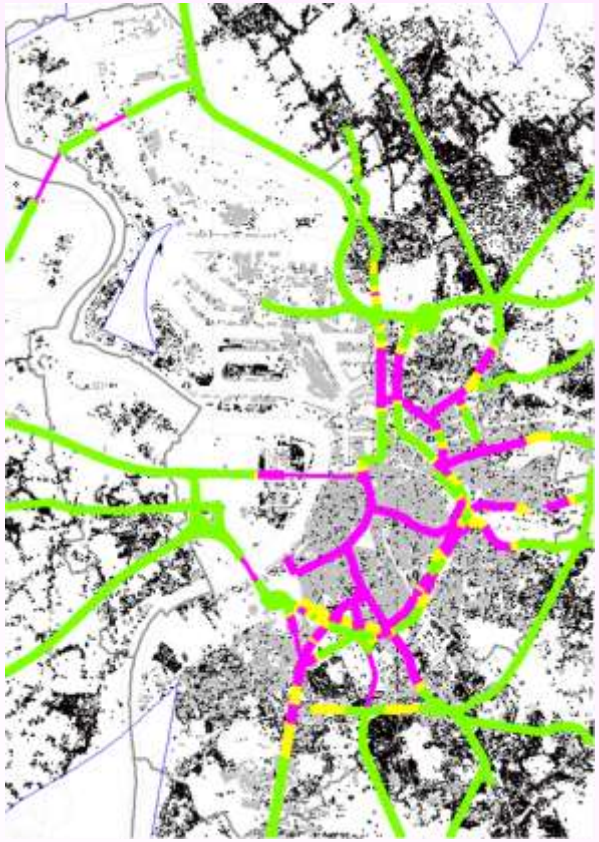
%HA/unit of length



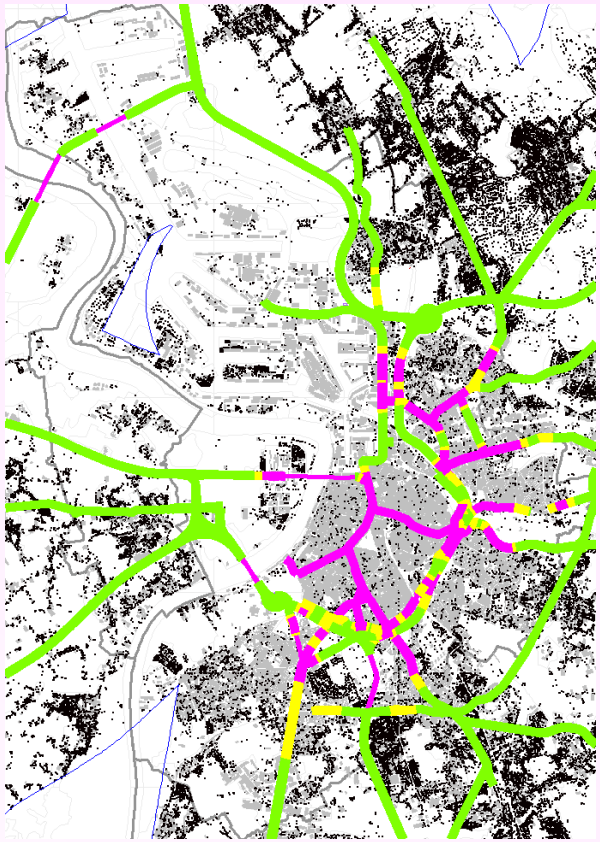
Reference



Ambition 1



Ambition 2



Hotspot analysis

Hotspots HA >= 20, length (km)				Hotspots HA >= 40, length (km)			
	REF	AMB 1	AMB 2		REF	AMB 1	AMB 2
Provinces				Provinces			
ANT	112,4	90,6	72,5	ANT	48,9	35,3	26,6
VLB	128,1	79,4	50,6	VLB	30,1	19,2	12,6
WVL	65,4	52,3	36,3	WVL	16,2	12,6	8,0
OVL	110,0	83,1	47,8	OVL	14,7	6,9	3,5
LIM	47,6	34,0	16,4	LIM	6,6	3,3	1,1
Agglomerations				Agglomerations			
Antw.	116,4	108,1	102,1	Antw.	93,3	75,8	65,2
Gent	67,7	59,6	48,9	Gent	40,2	33,9	28,5
Total				Total			
#km	647,6	507,1	374,6	#km	250,0	187,0	145,5
Difference versus reference		-21,7%	-42,2%	Difference versus reference		-25,2%	-41,8%