Make Some Noise

schiphol

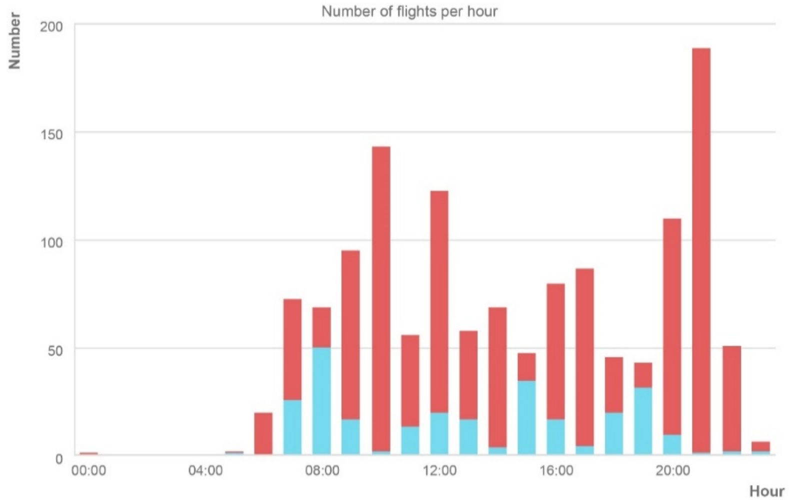
Building Technology graduation thesis

P5 presentation

Ioannis Tsionis

A study on a parametric architectural strategy for the design of aircraft noise abatement landscape elements within cities for the case of Rijsenhout.

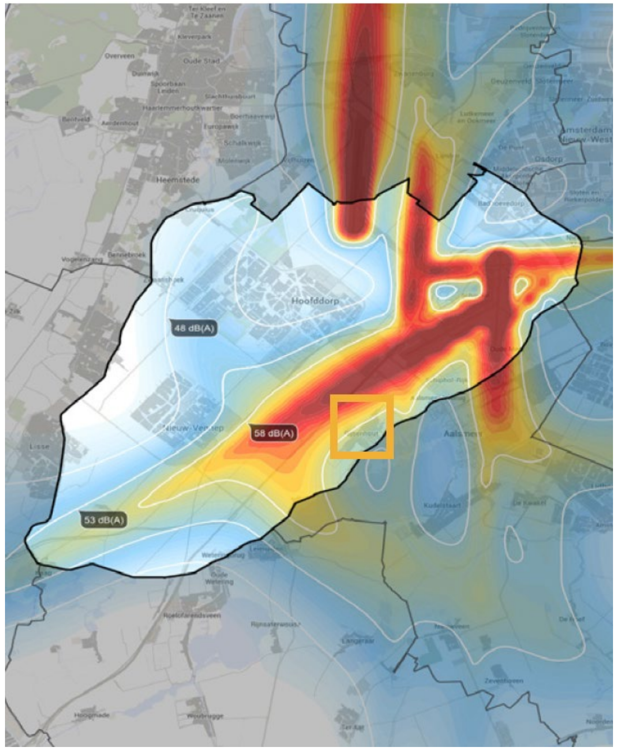
Flight routes
around Rijsenhout



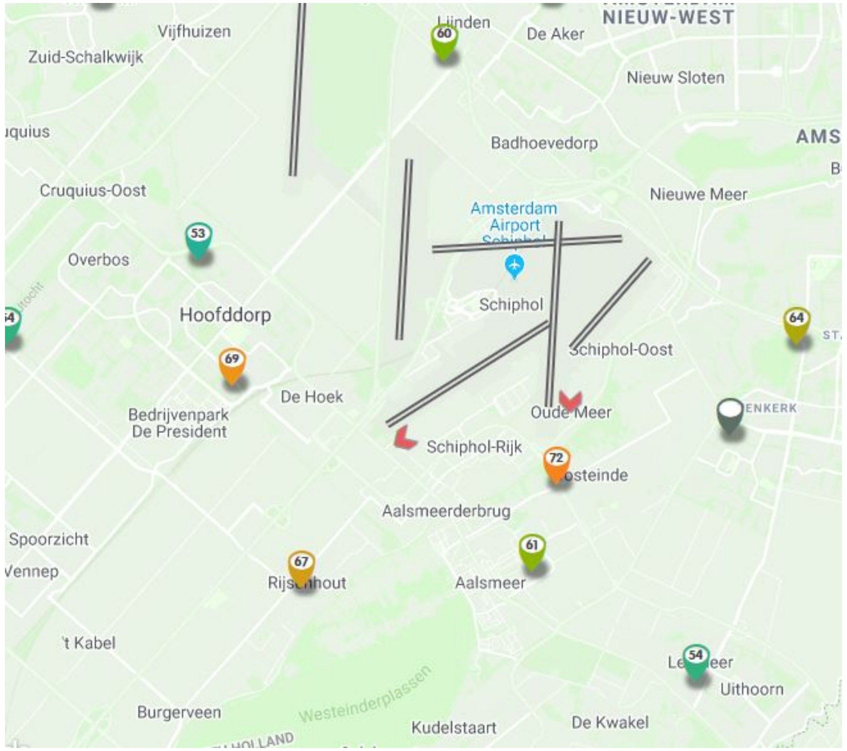
Number of flights per hour on
Kaagbaan runaway during 5 week days

Source: Noiselab.casper.aero (2020)

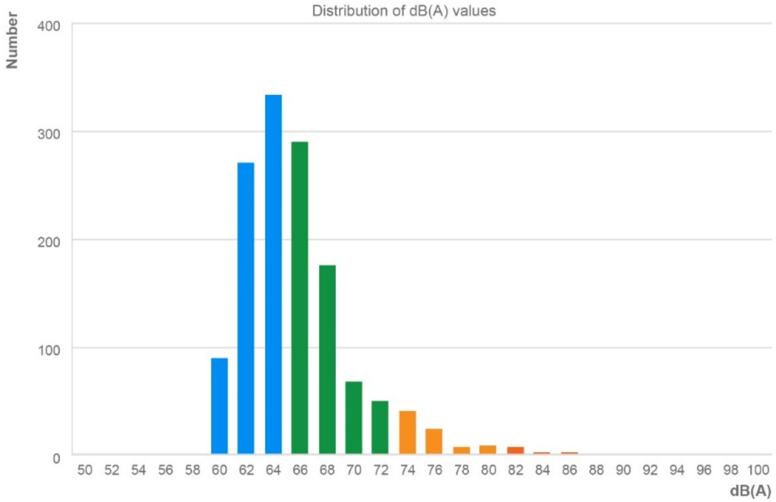
Noise levels
around Amsterdam Schiphol airport



Noise levels map



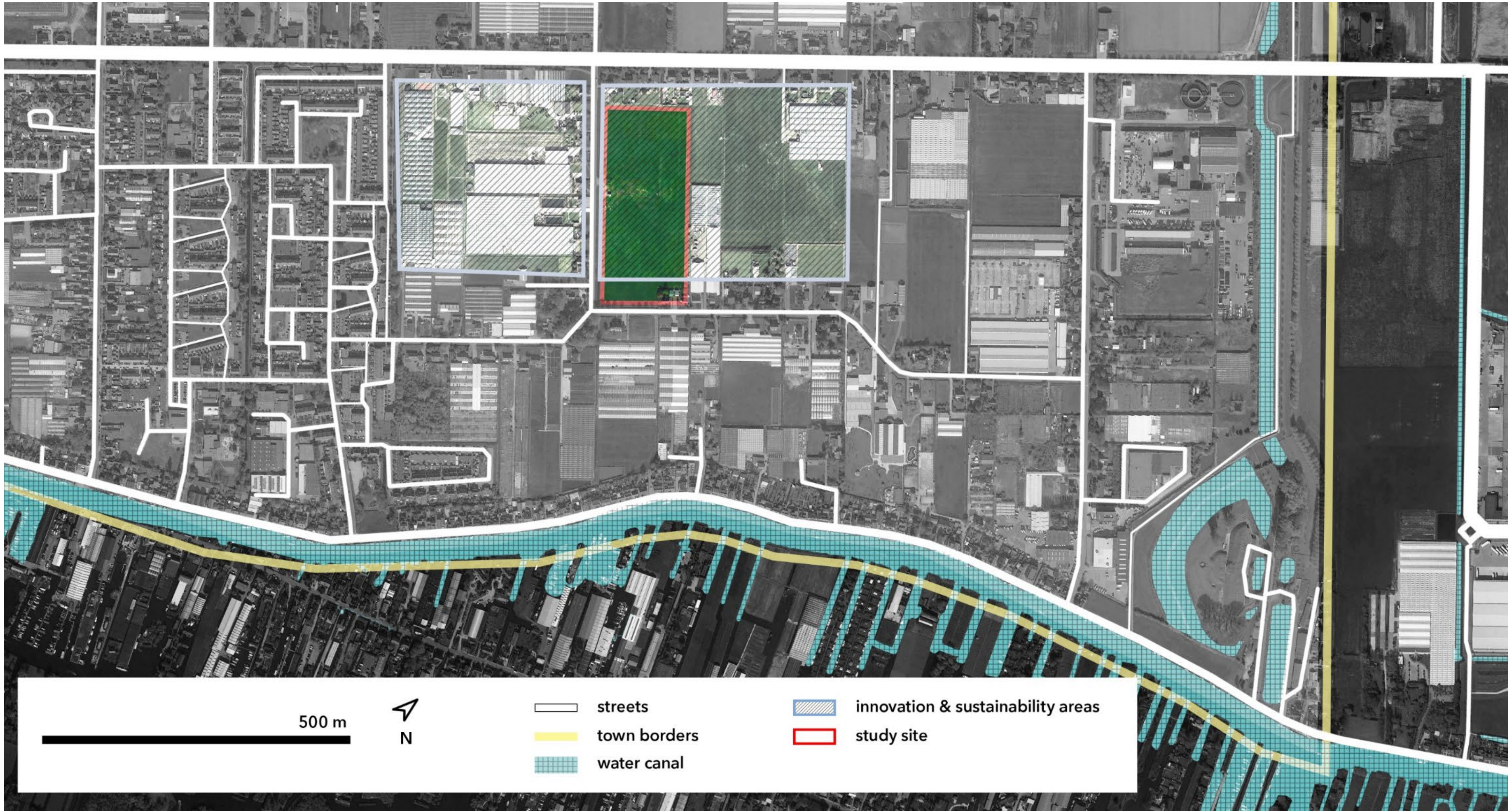
Microphone locations



Distribution of dB(A) values

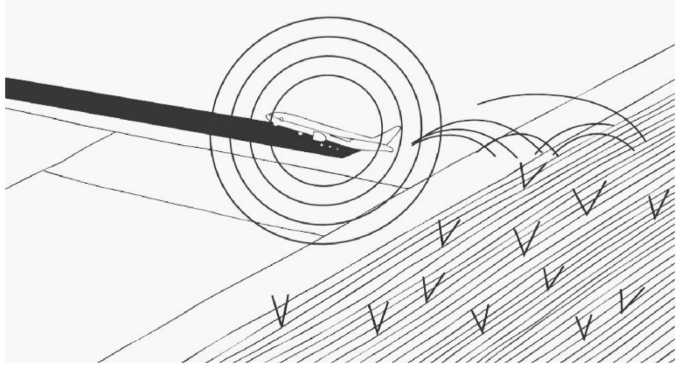
Source: Noiselab.casper.aero (2020)

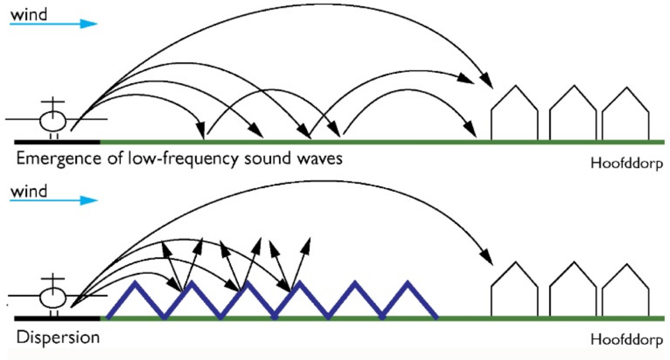
Urban context
Rijsenhout site area



Noise-reducing landscape
Buitenschot park // Hoofddorp

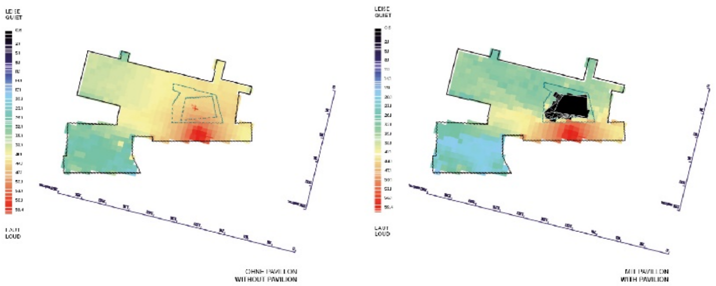
source: H+N+S Landschapsarchitecten



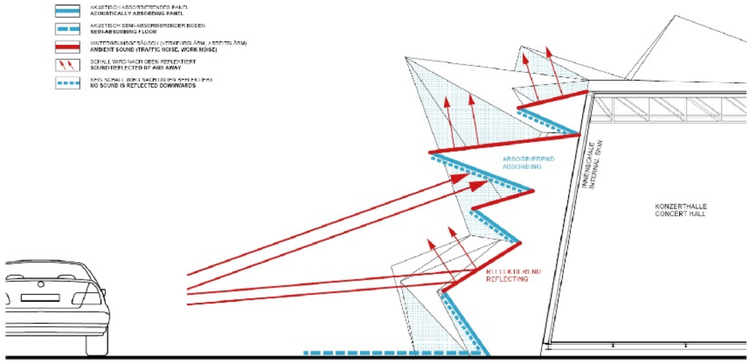


Pavilion 21 MINI opera space
Co-op Himmelb(l)au // Munich

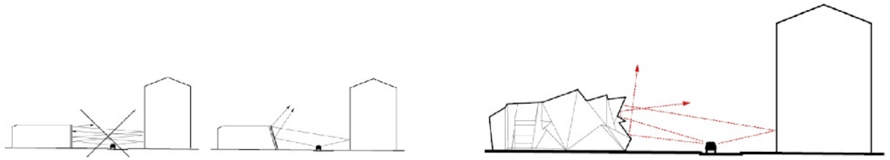
source: co-ophimmelblau.at



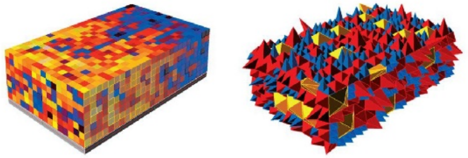
sound level analysis in urban space



acoustical properties of facade



traffic noise reflection

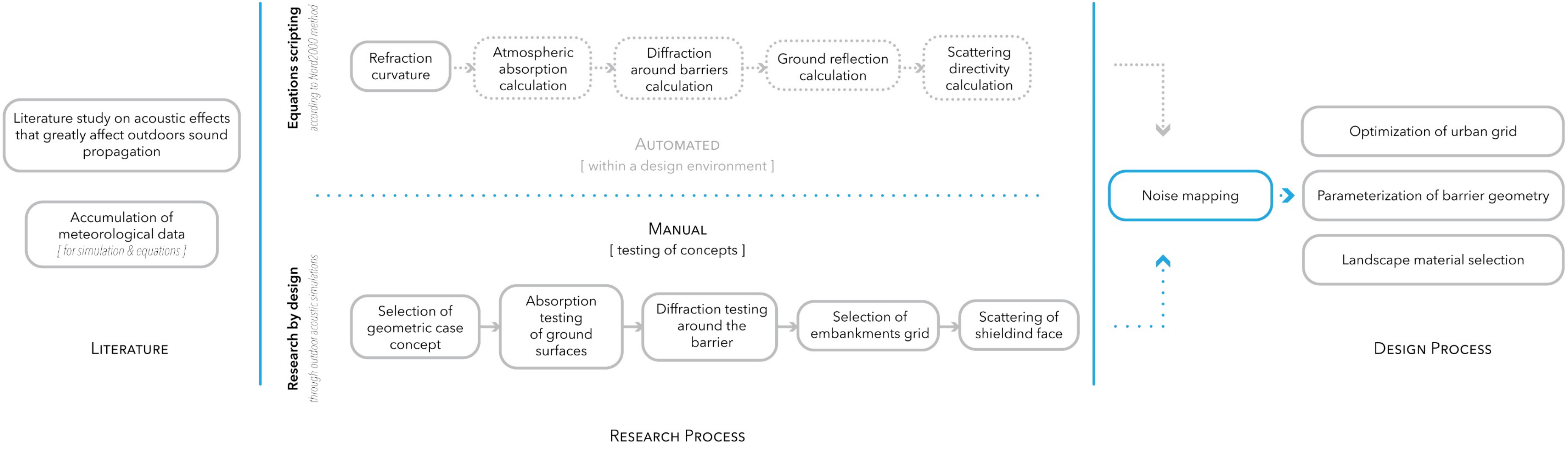


scripting concept

Research workflow

Research question

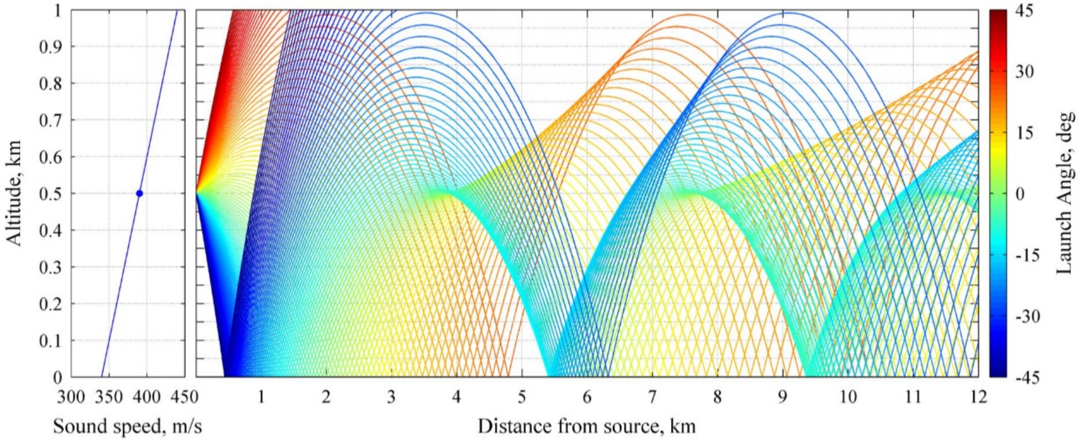
How can acoustic parametric landscape design and optimization tools contribute to the reduction of aircraft noise and to what extent can it improve the soundscape quality of areas near airports?



Sound propagation effects

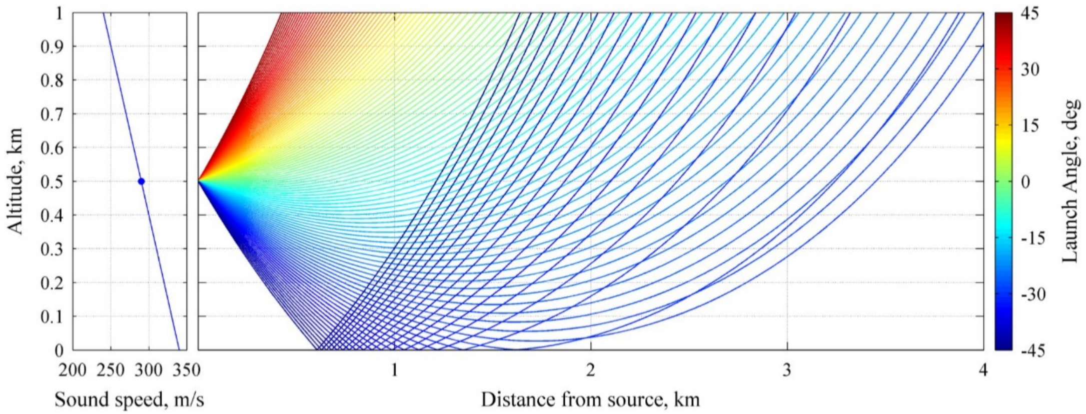
- Air absorption
- Ground reflections
- Scattering zones
- Atmospheric refraction
- Edge diffraction

Downward refraction



Rays from a source at 500 m in an atmosphere with a linearly **increasing** (positive gradient) sound speed with altitude.

Upward refraction

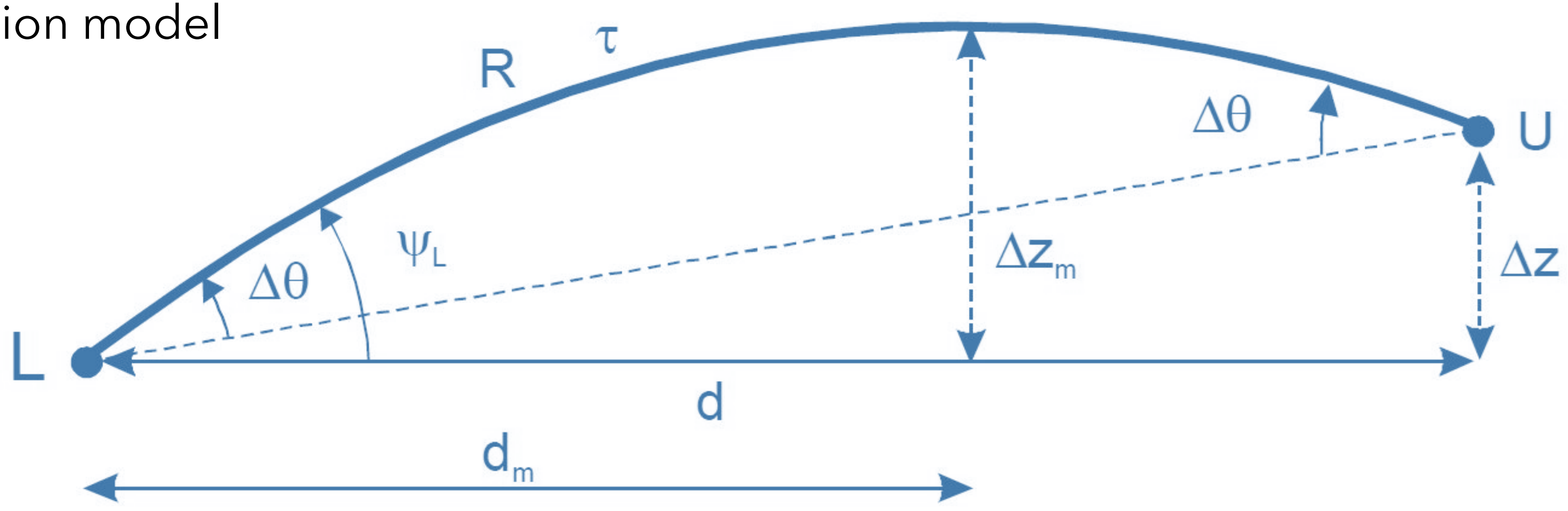


Rays from a source at 500 m in an atmosphere with a linearly **decreasing** (negative gradient) sound speed with altitude.

Source: Arntzen, M. (2014)

Difference in incident angle

Nord2000 prediction model



$$c(z) = A \ln\left(\frac{z}{z_0} + 1\right) + B\,z + C$$

Vertical speed of sound profile

$$A = \frac{u(z_u)}{\ln\left(\frac{z_u}{z_0} + 1\right)}$$

Logarithmic part -
depends on **wind** component

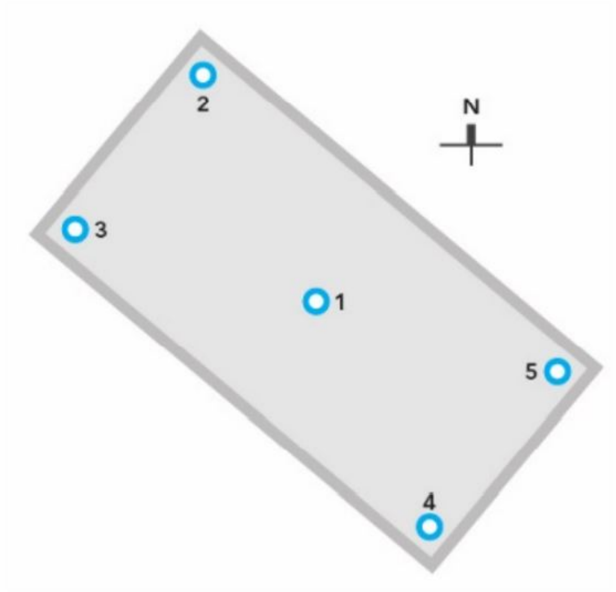
$$B = \frac{dt}{dz}\frac{10.025}{\sqrt{t + 273.15}}$$

Linear part -
depends on **temperature**

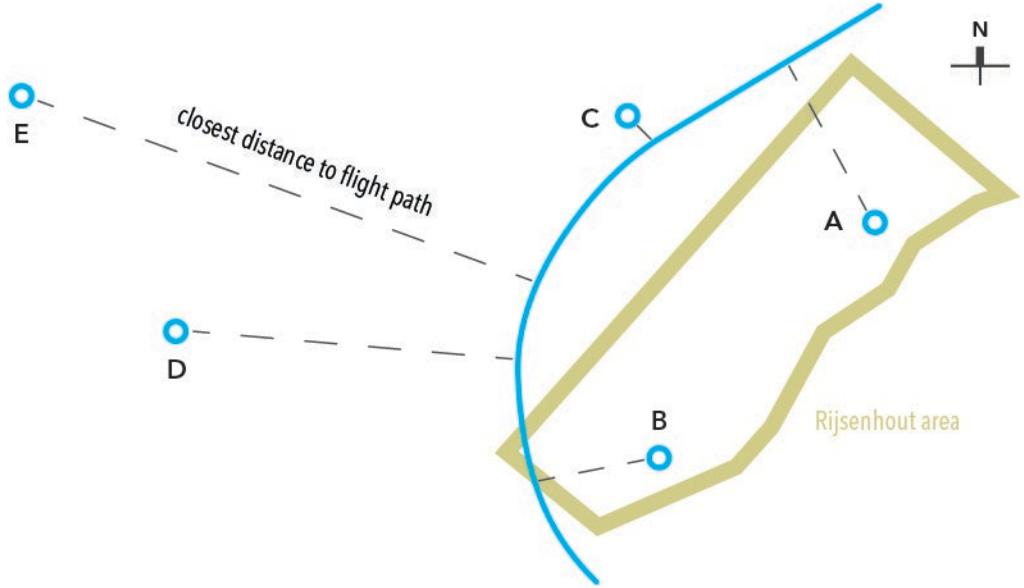
Source: Delta (2006)

Refraction calculation
at study site

Position	Distance to source [m]	Incident angle (straight path) [deg]	Winter	Summer
			Δθ [deg]	
1	**1800**	17,9	-0,2	-1,1
2	**1644**	19,6	-0,2	-1,0
3	**1694**	19,4	-0,1	-1,0
4	**1953**	16,5	-0,2	-1,2
5	**1909**	16,6	-0,2	-1,2

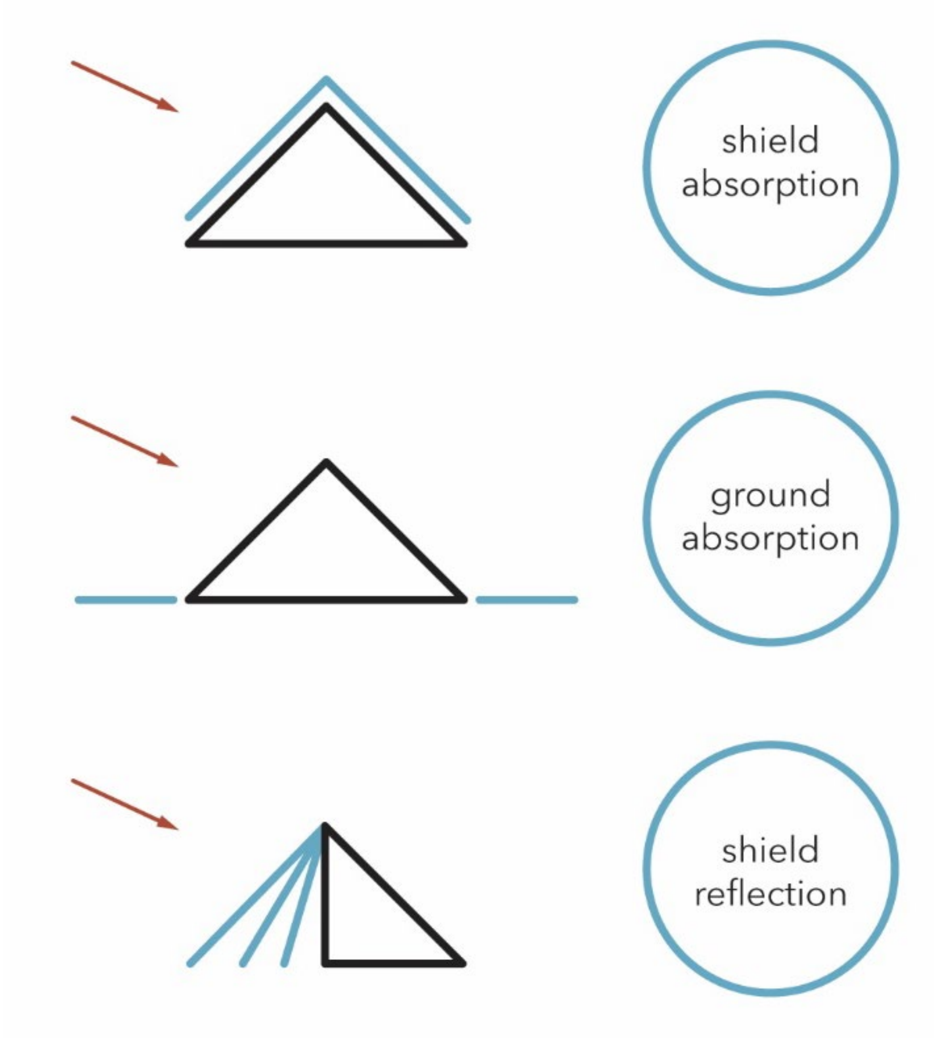


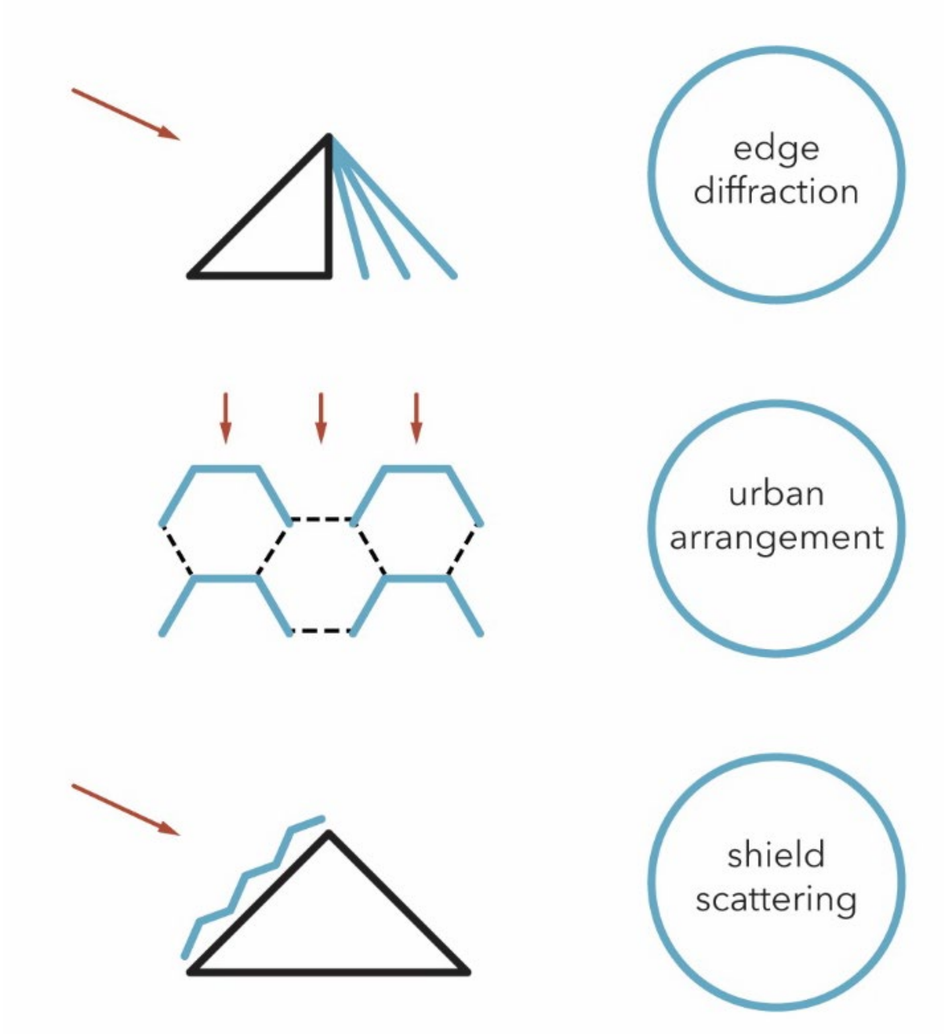
Refraction calculation
at multiple sites



Site	Distance to source [m]	Source height [m]	Incident angle (straight path) [deg]	Winter	Summer
				Δθ [deg]	
A	1800	559	17,9	-0,2	-1,1
B	1670	995	36,3	0,6	-0,2
C	759	677	62	-0,2	-0,2
D	3346	860	14,8	-3,6	-3,0
E	5202	806	8,8	-5,3	-4,5

Manual testing method steps





iNoise simulation set-up

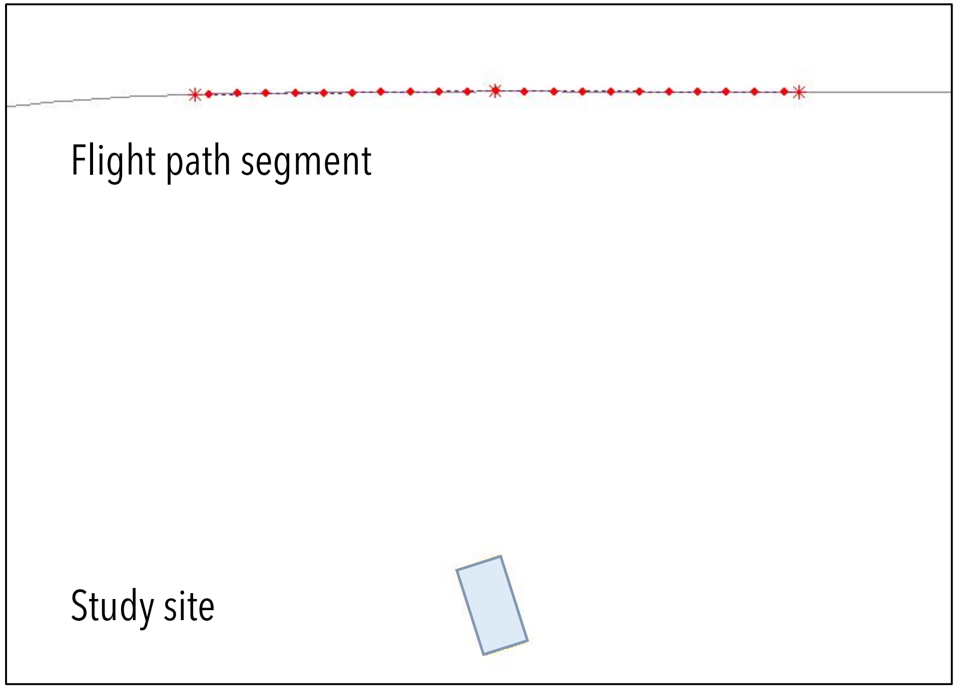
Noise source emission level

	63	125	250	500	1000	2000	4000	8000
Low	138,70	138,70	138,70	138,70	138,70	138,70	138,70	138,70
Medium	138,70	138,70	138,70	138,70	138,70	138,70	138,70	138,70
High	138,70	138,70	138,70	138,70	138,70	138,70	138,70	138,70
							Lw [dB(A)]	152,50

Average velocity [km/h] 150
Length route segment [m] 2014,36
Distance between sources [m] 100,00
Number of point sources 21

Period	From	To	Flow	Cb [dB]
Day	07:00	19:00	500	15,74
Evening	19:00	23:00	500	10,97
Night	23:00	07:00	--	--
--	--	--	--	--

Moving source properties



Wind direction [°] 220
Air temperature [°C] 6
Wind speed class W3 - 3..6 m/s
Air humidity [%] 85,00
Stability class S2 - day, 3..5/8
Air pressure [kPa] 101,33
Fetching radius [m] --
Maximum number of reflections [-] 2
Reflection distance receptor [m] 30,00
Reflection distance source [m] 30,00

Default ground properties

Impedance classes E - Compacted field and gravel(compacted lawns
[KNs/m4] 500,00

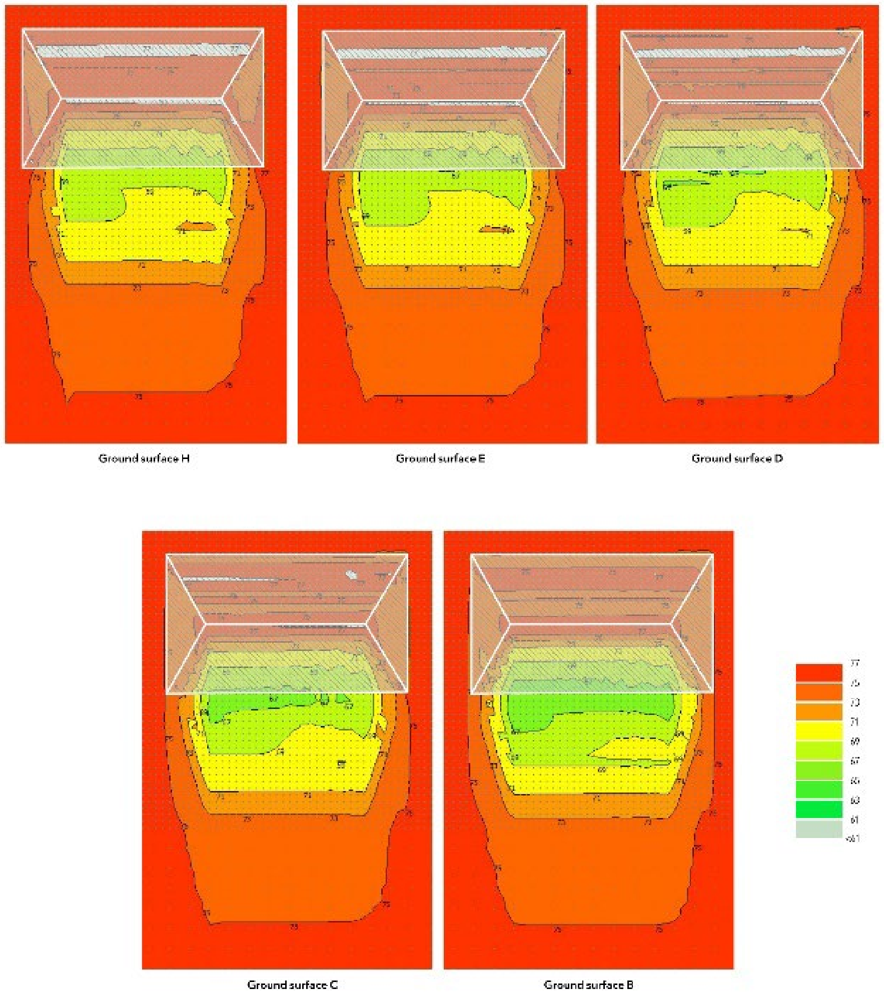
Z (real)	63	125	250	500	1000	2000	4000	8000
Low	52,36	31,54	19,16	11,80	7,42	4,82	3,27	2,35
Medium	44,19	26,68	16,27	10,08	6,40	4,21	2,91	2,14
High	37,32	22,60	13,84	8,64	5,54	3,70	2,61	1,95

Z (imaginary)	63	125	250	500	1000	2000	4000	8000
Low	64,28	38,75	23,36	14,09	8,49	5,12	3,09	1,86
Medium	54,30	32,74	19,74	11,90	7,17	4,33	2,61	1,57
High	45,87	27,66	16,67	10,05	6,06	3,65	2,20	1,33

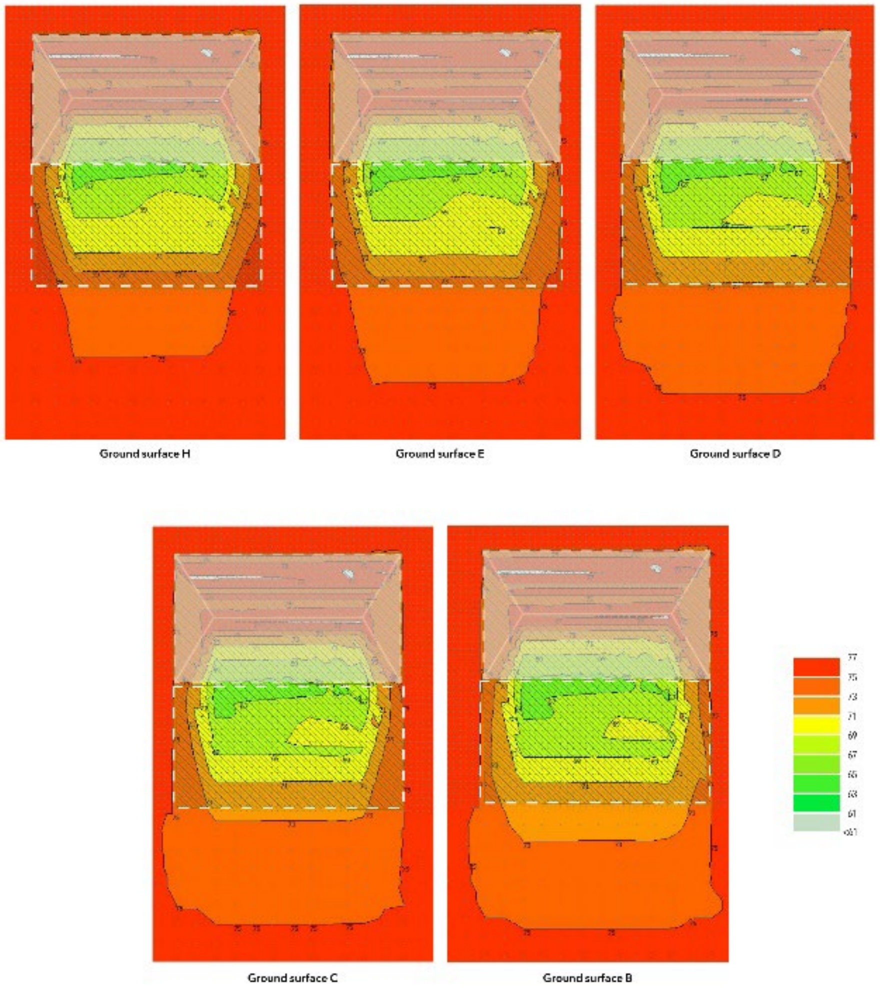
Calculation settings

Absorption of ground coverage materials

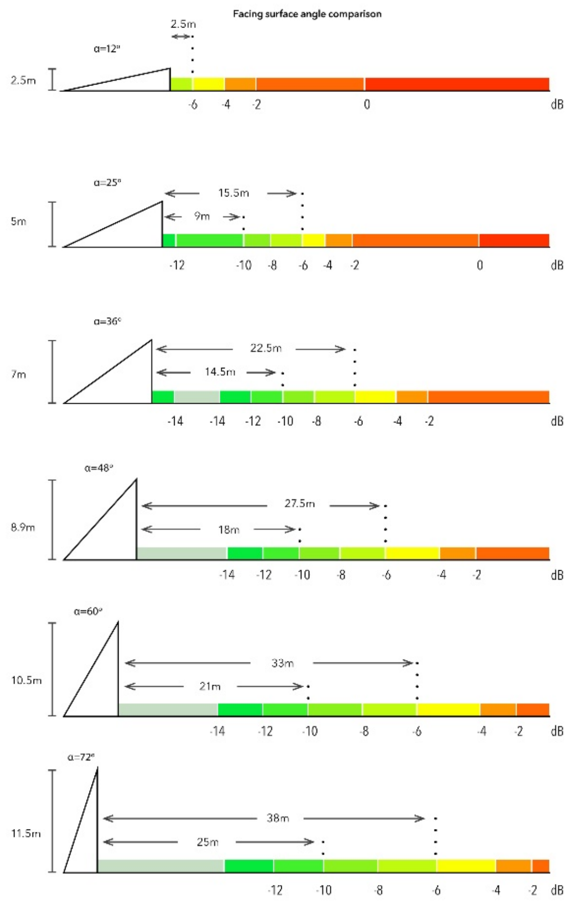
Ground impedance comparison

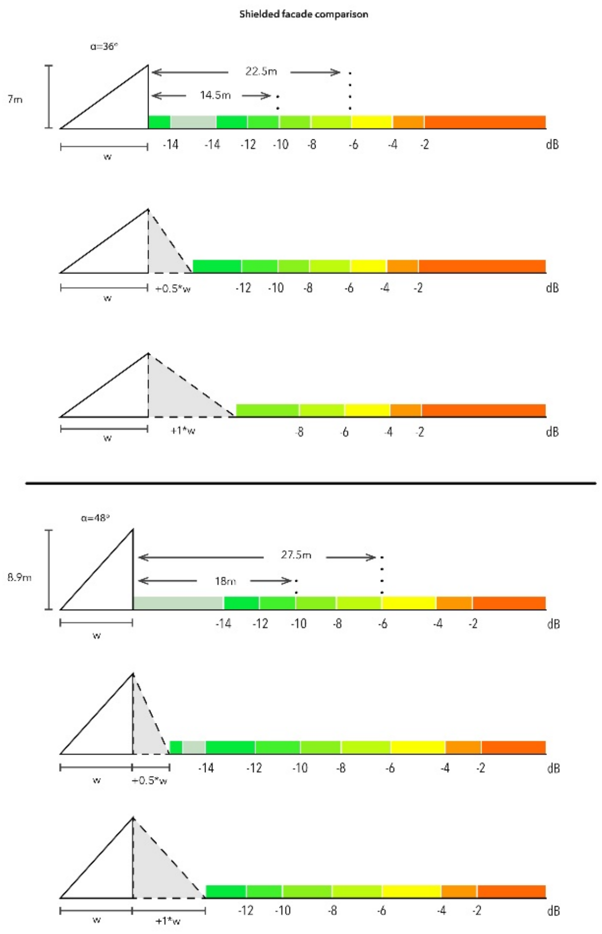


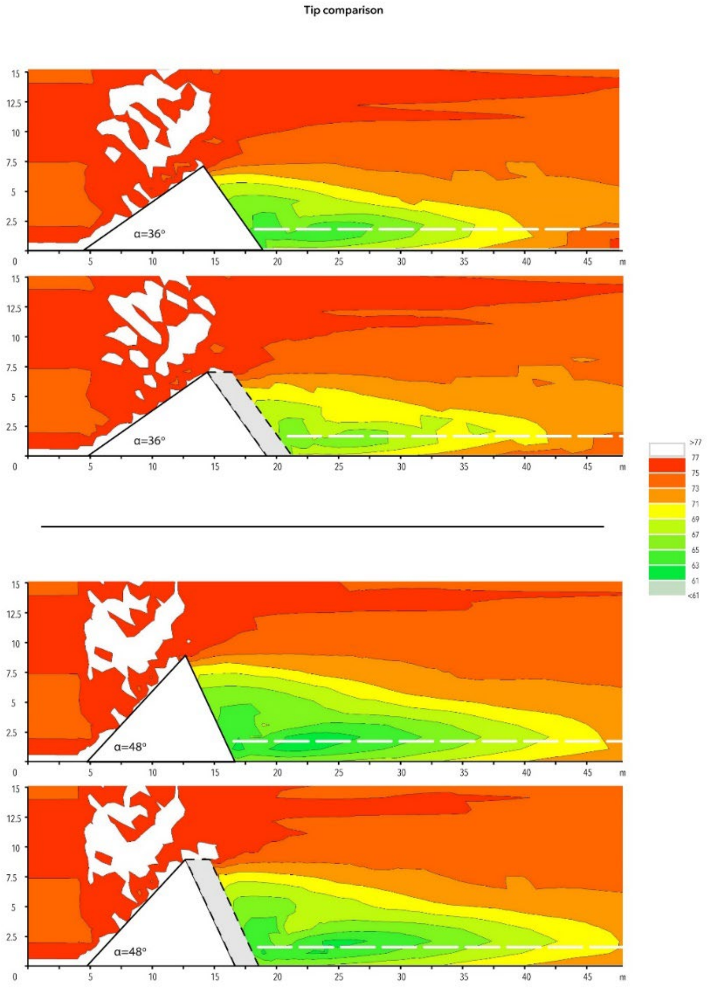
Beyond ground impedance comparison



Diffraction & noise shadow output

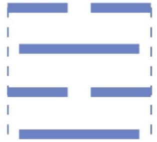


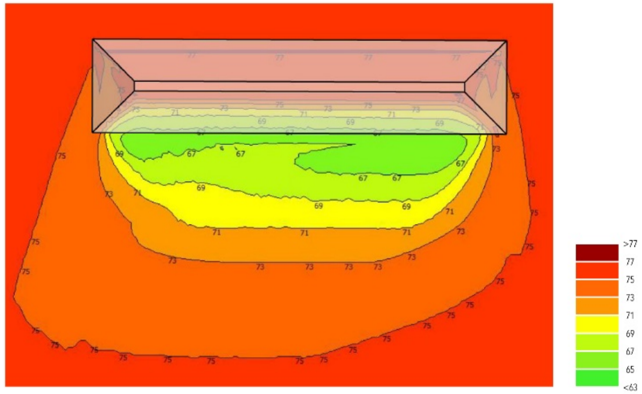




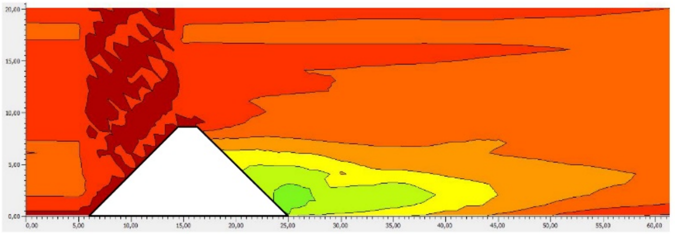
Urban arrangement
Linear configurations


Solid linear element


Potential urban grid arrangement



Noise mapping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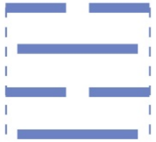
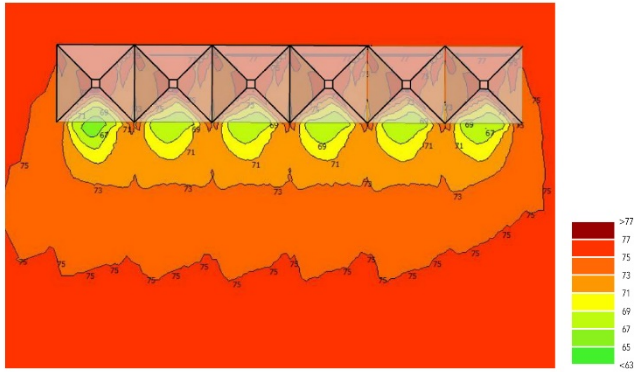
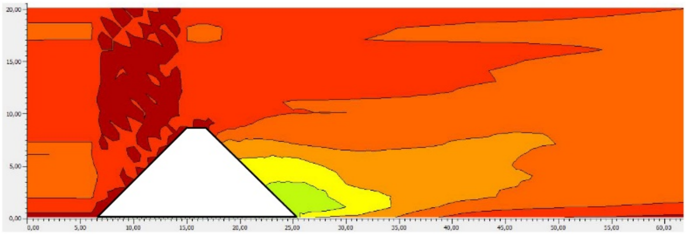
Multiple pyramidic elements


Potential urban grid arrangement



Noise mapping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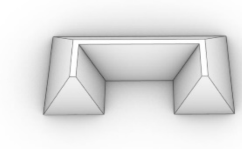
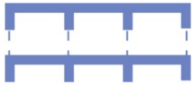
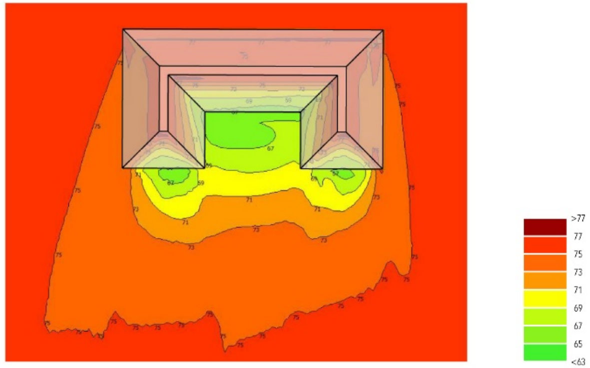
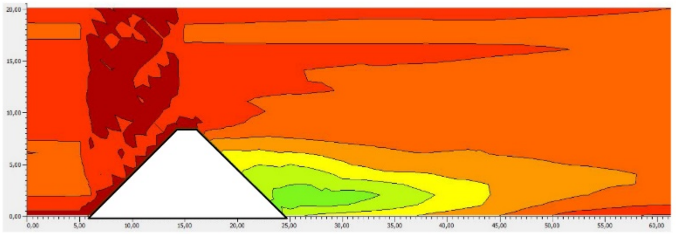

Rectangular element


Potential urban grid arrangement



Noise mapping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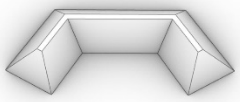
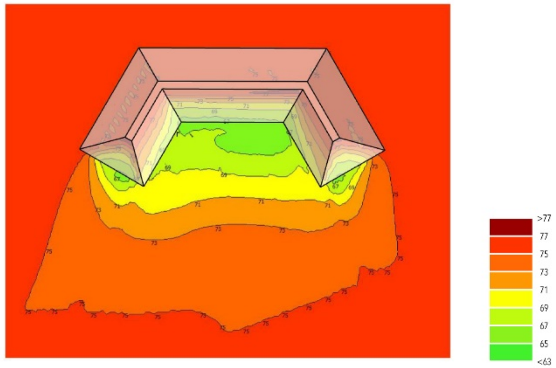
Urban arrangement

Hexagonal configurations

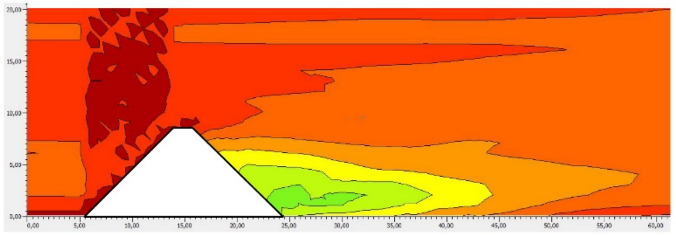


Hexagonal
outer edge shielding

Potential urban grid
arrangement



Noise mapping



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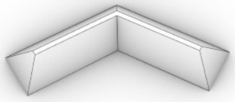
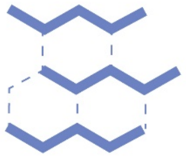
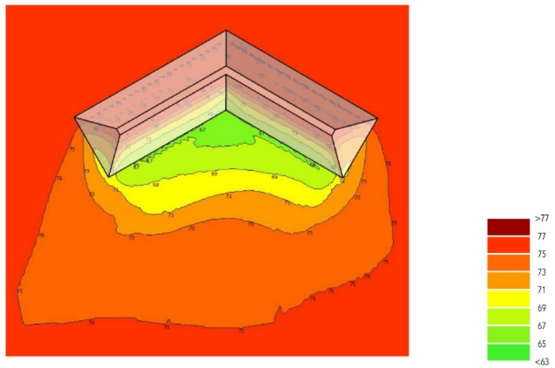


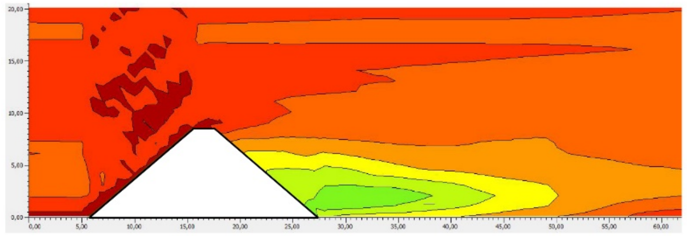
Hexagonal
outer corner shielding



Potential urban grid
arrangement



Noise mapping



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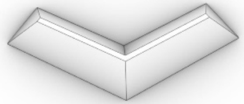
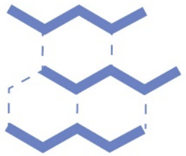
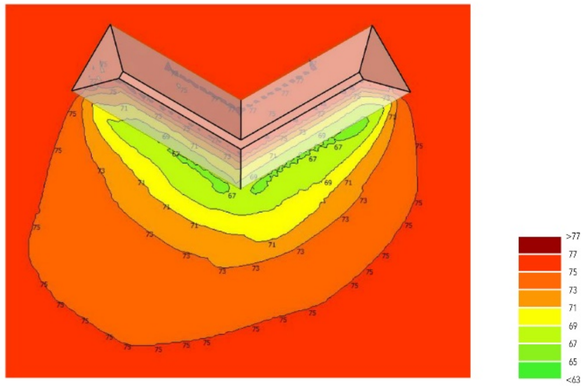


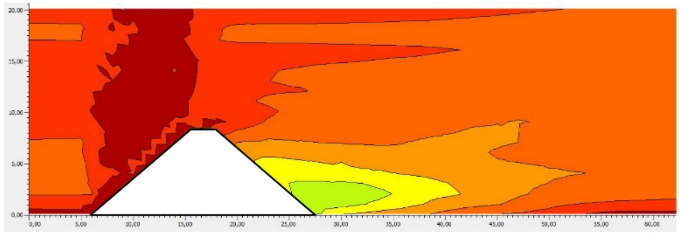
Hexagonal
inner corner shielding



Potential urban grid
arrangement



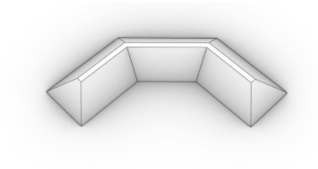
Noise mapping



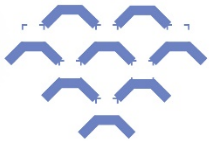
Section

Urban arrangement

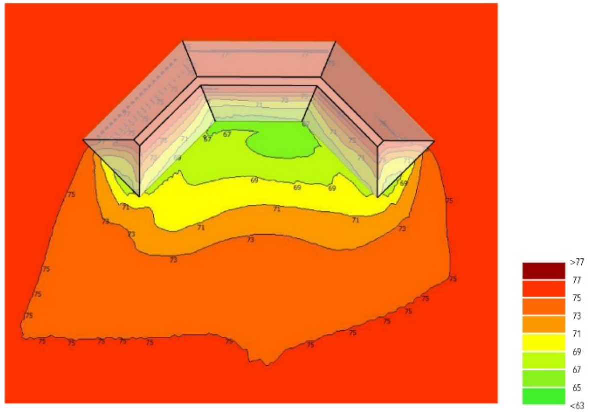
Polygonal configurations



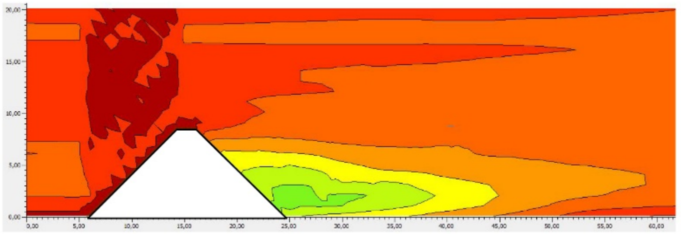
Octagonal element



Potential urban grid arrangement



Noise mapping



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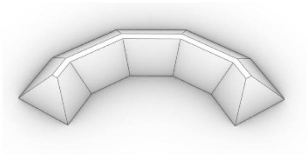
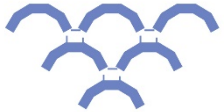
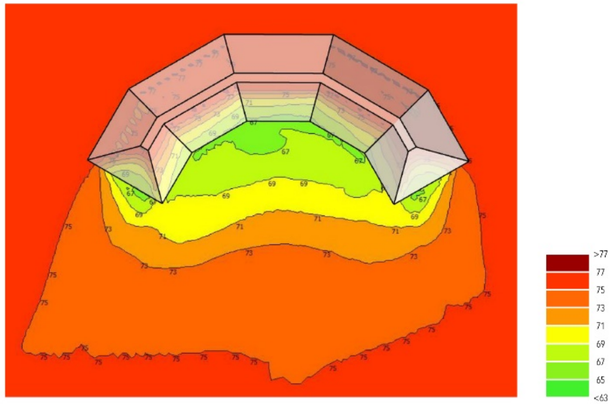


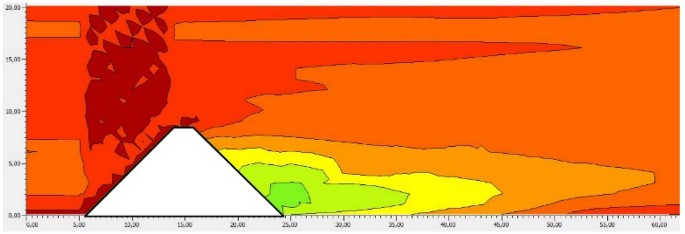
Dodecagonal element



Potential urban grid arrangement



Noise mapping

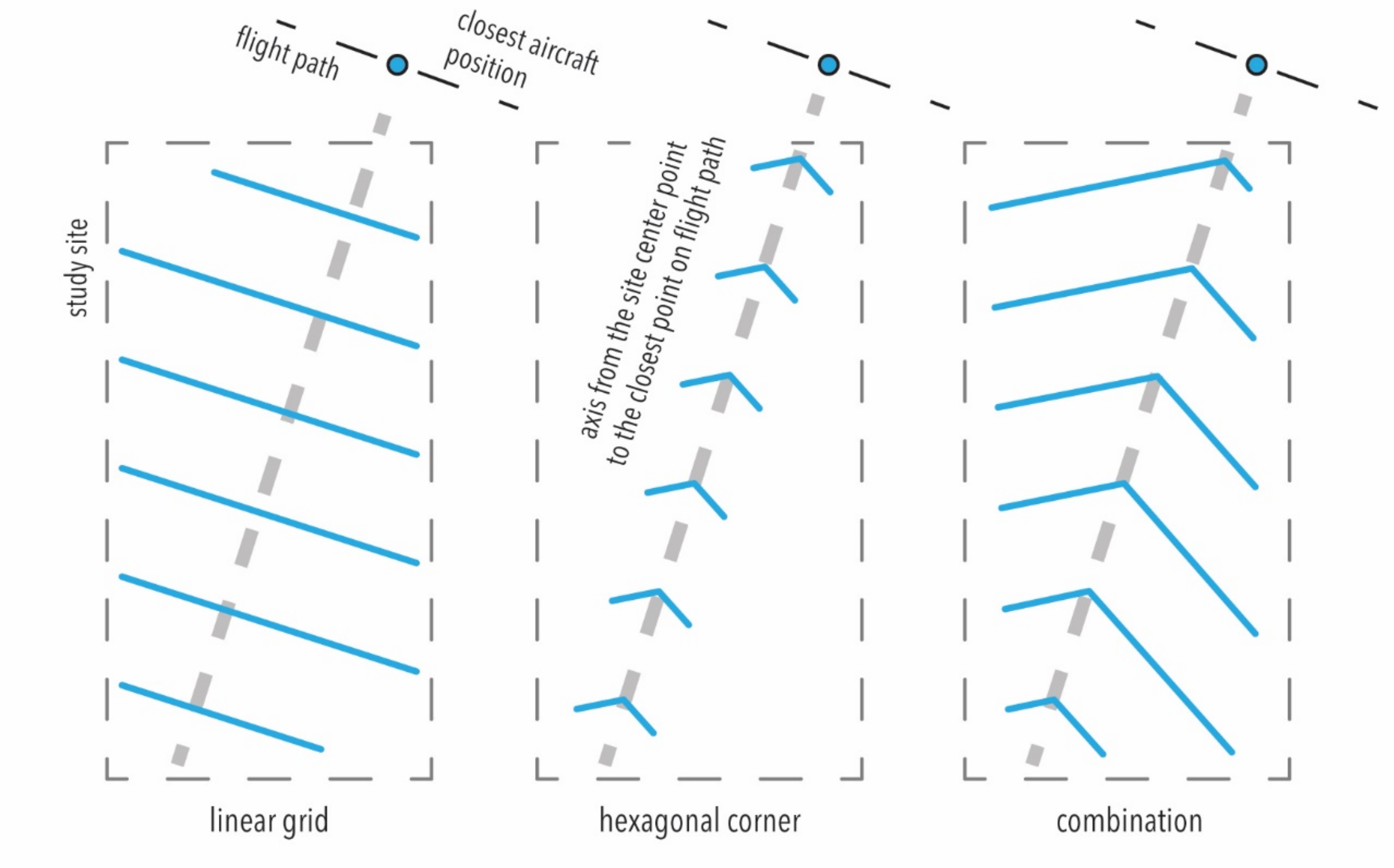


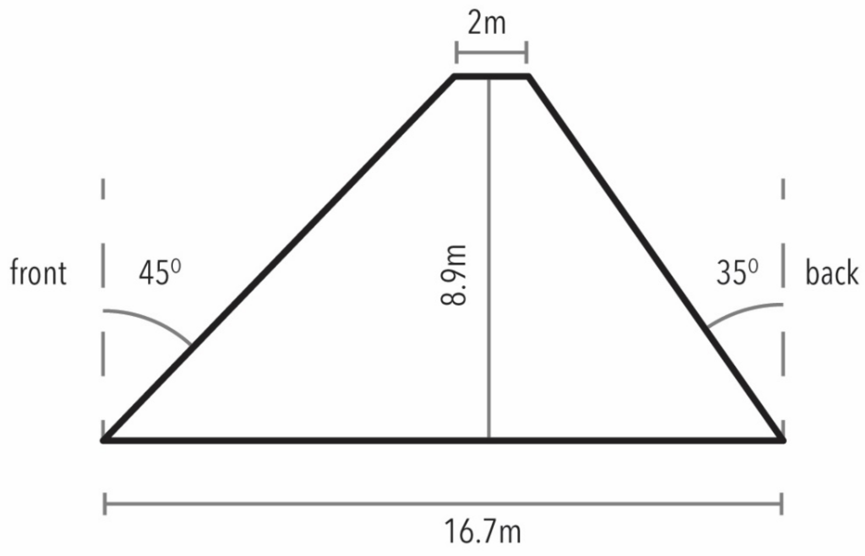
Section

Simulation results
Comparison of arrangements

Arrangement			Area of mitigated noise [m²]			Max Reduction [dB]
Case		Volume [m³]	Total area	2 < Rd < 6	6 < Rd	
Linear	Solid	6922	4169	994	834	10
Linear	Multiple	6819	4466	1398	216	8
Rectangular		7105	3275	684	397	10
Hexagonal	Edge	7109	3482	935	488	10
Hexagonal	Outer Corner	7015	4374	992	583	10
Hexagonal	Inner Corner	7015	3838	1039	494	8
Octagonal		7125	3898	1026	494	10
Dodecagonal		7249	3876	1027	563	10

Conceptual design proposal



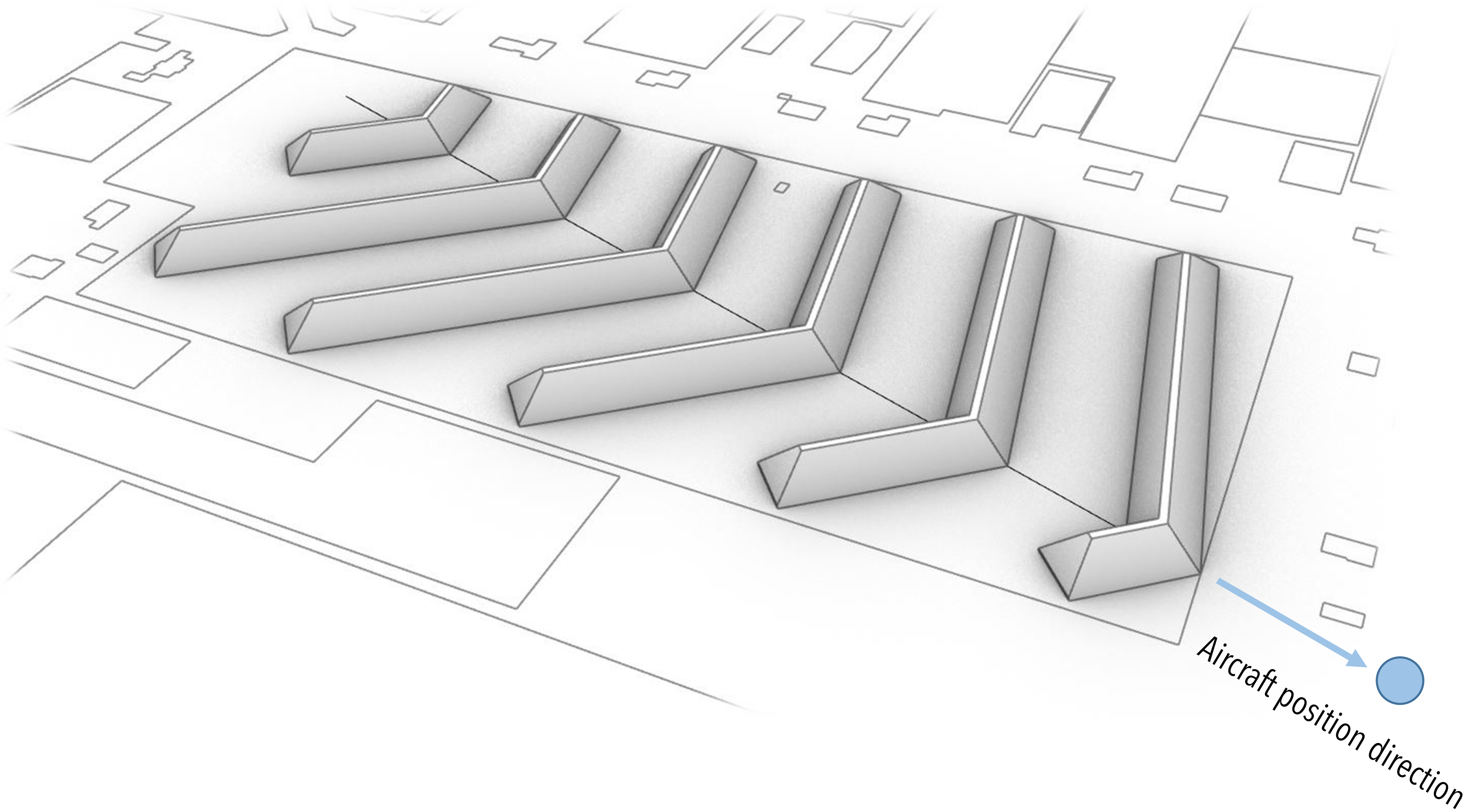


Principle of urban placement

1 - Array of elements along the perpendicular axis to the most dominant noise source position

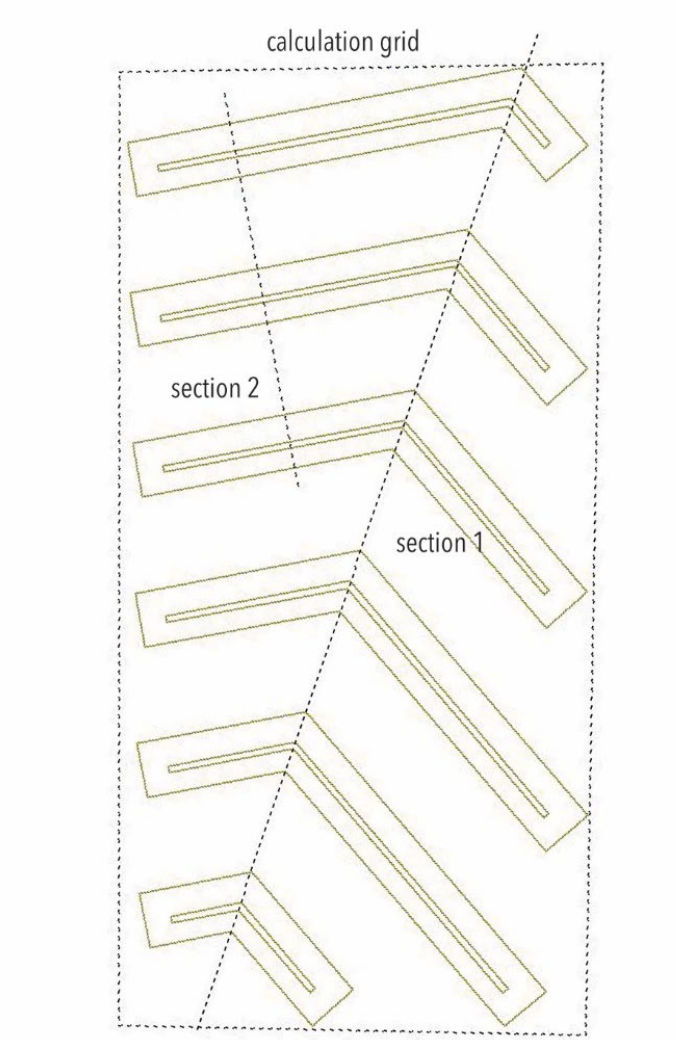
2 - Offset elements according to the distance and area of effect

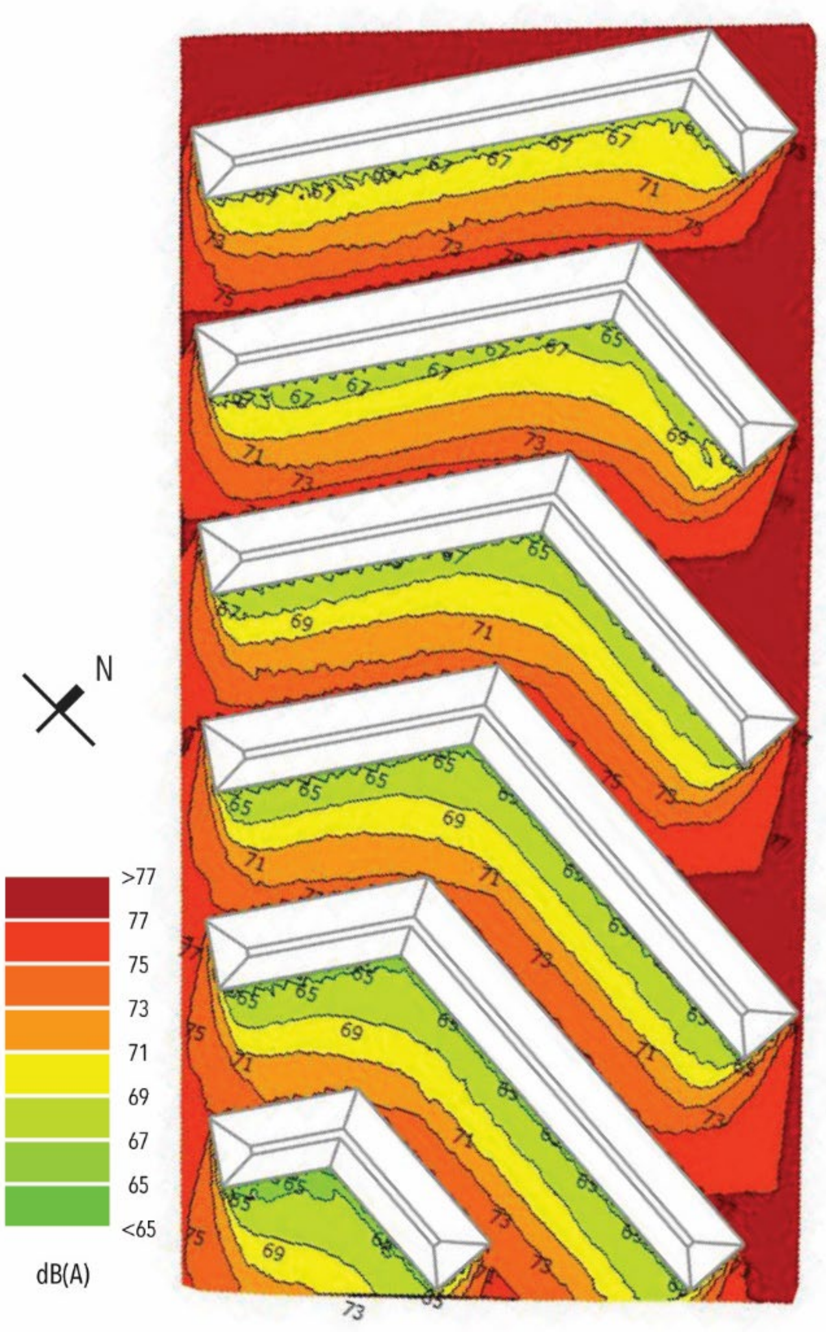
3 - Import noise map in Rhino and optimize ground coverage materials



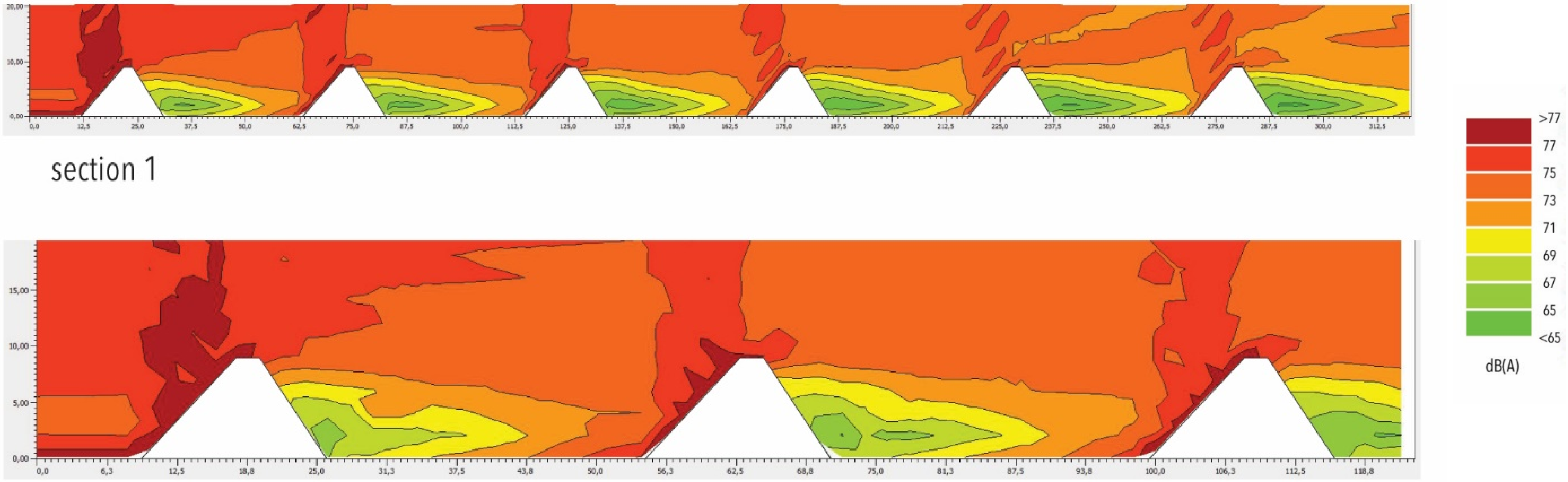
Testing of concept

simulation

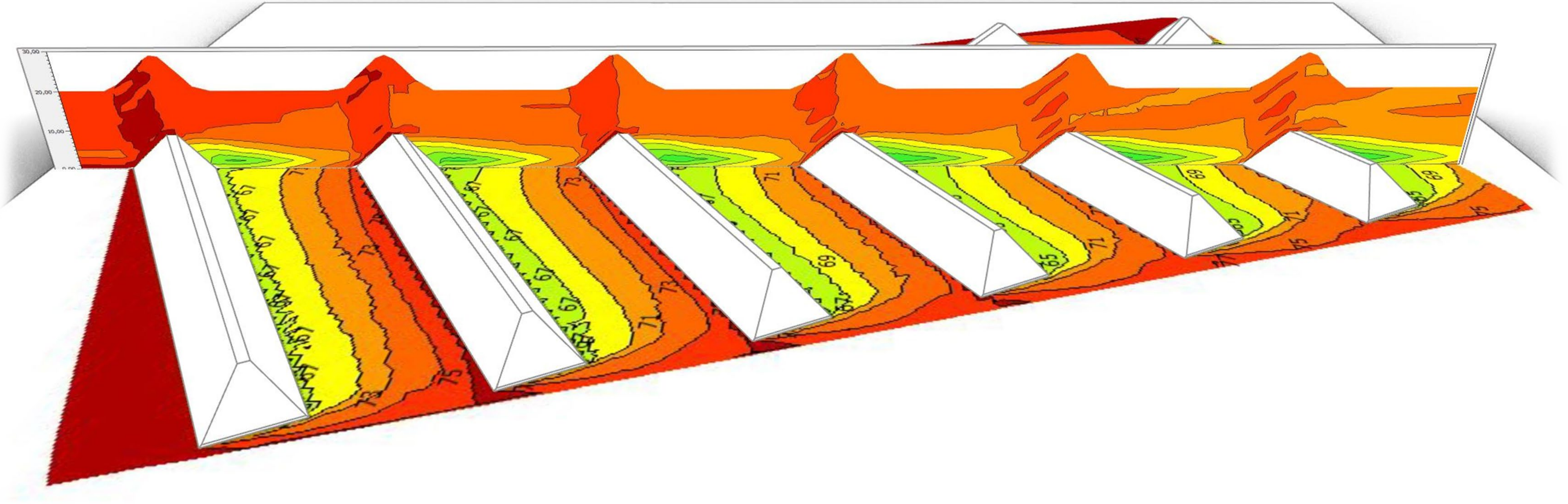




Calculation at +0,10 height



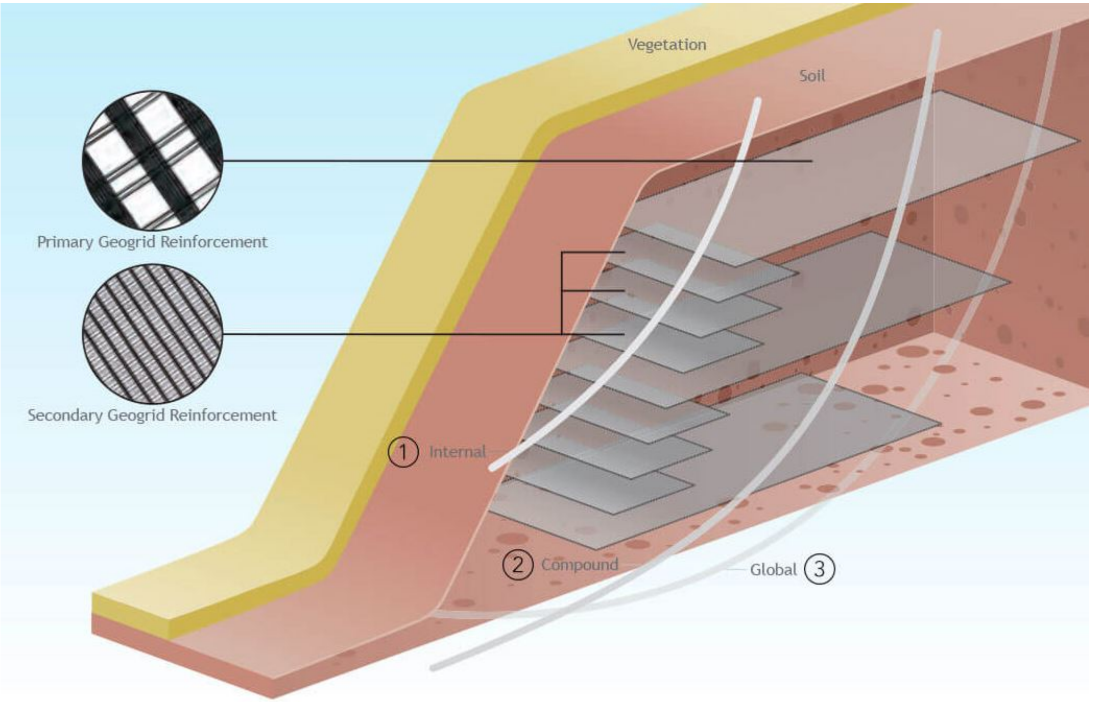
section 2



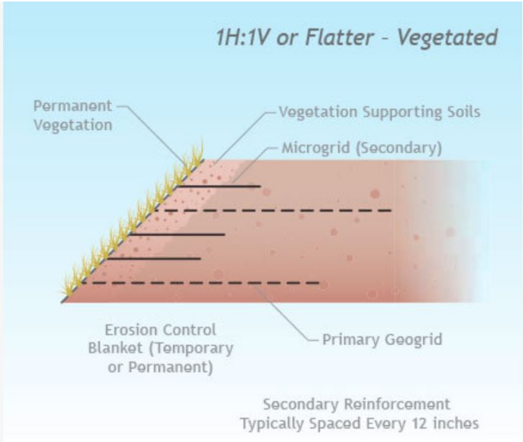
Perspective view of calculation grids

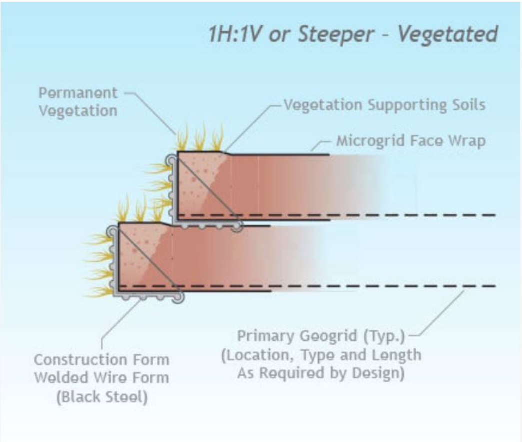
Soil stabilization

Failure types



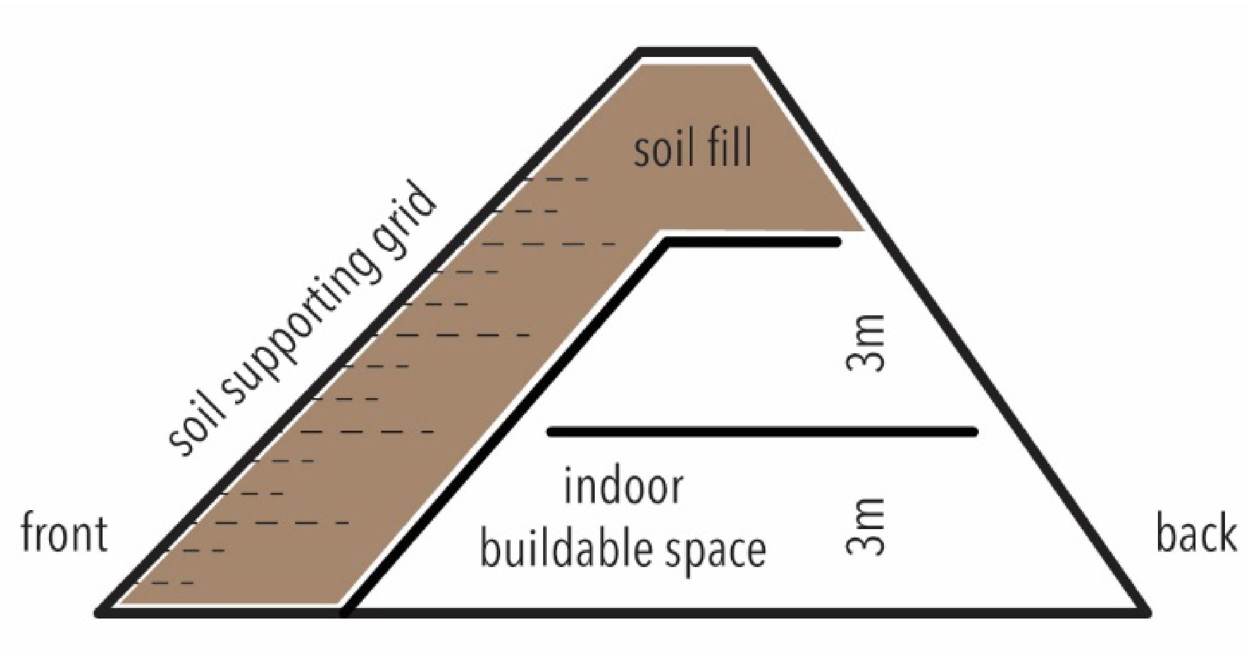
Facing reinforcement

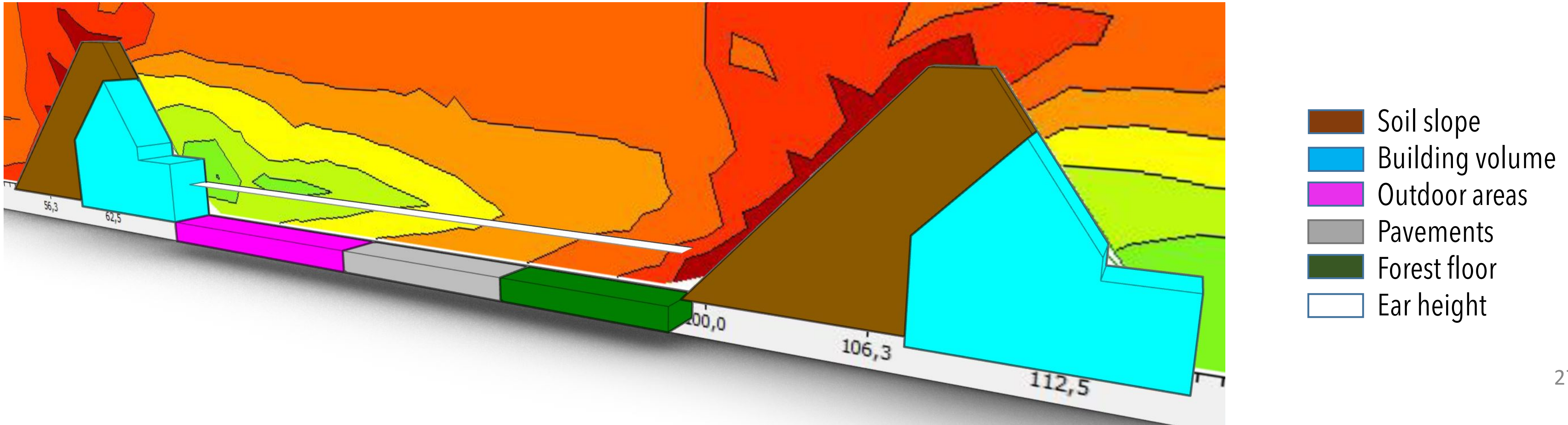




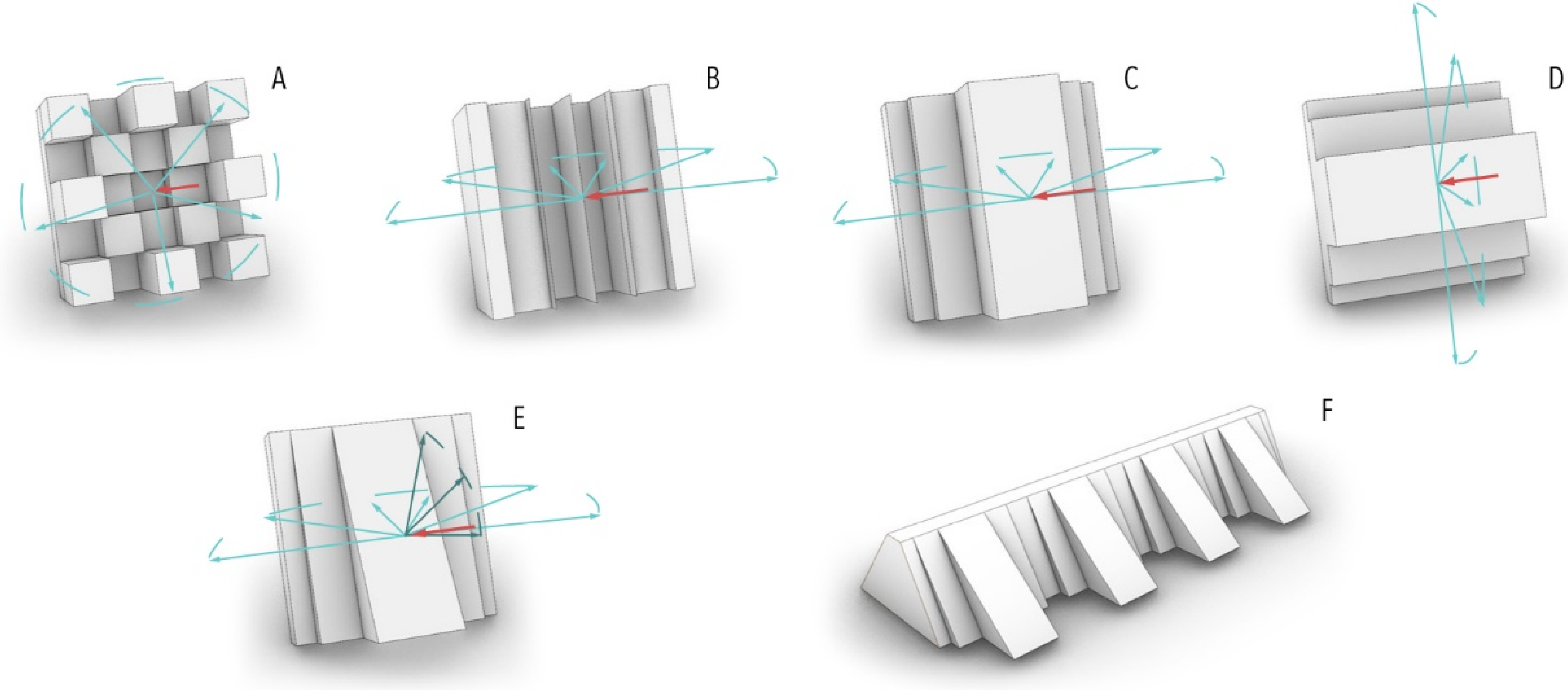
Source: www.geogrid.com

Refinement
of ground coverage and façades



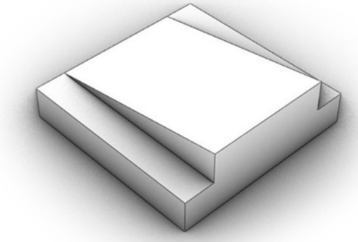


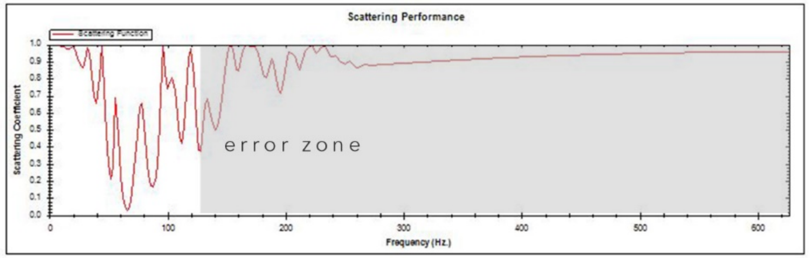
Integration of scattering surfaces
for the low frequency range

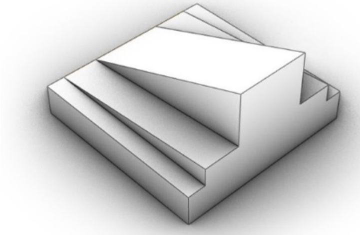


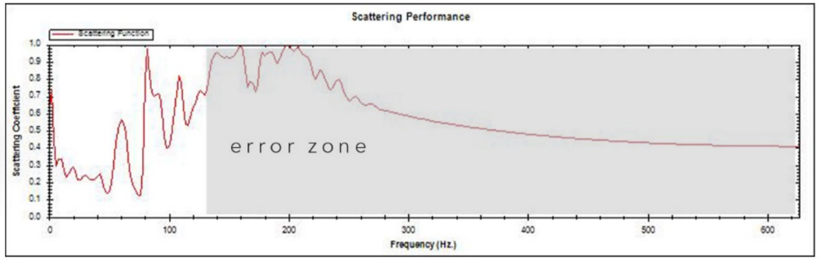
Scattering coefficients

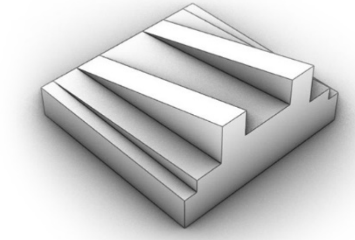
for inclined surfaces up to 125 Hz

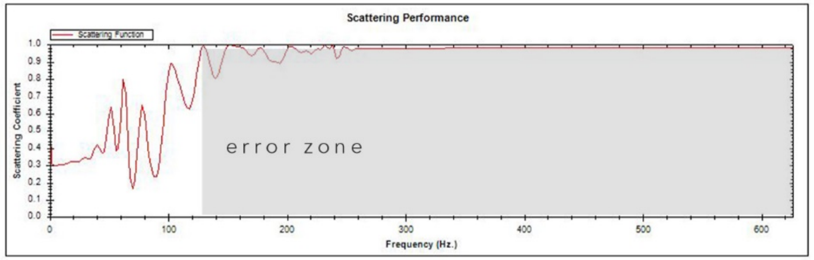




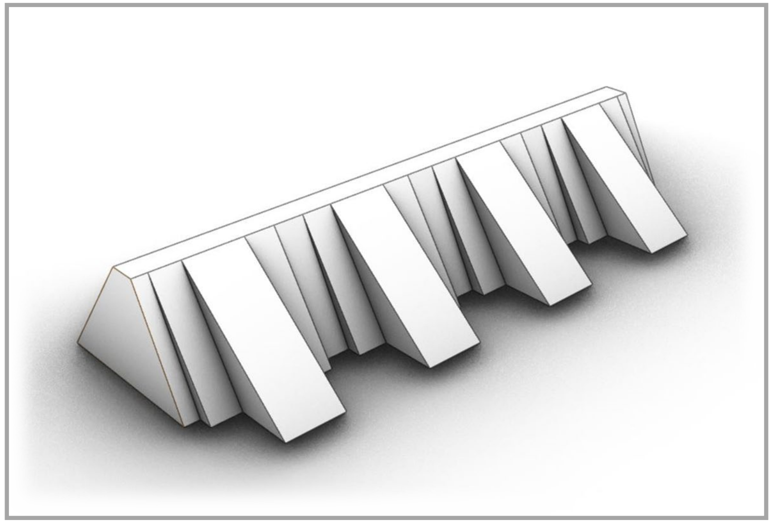




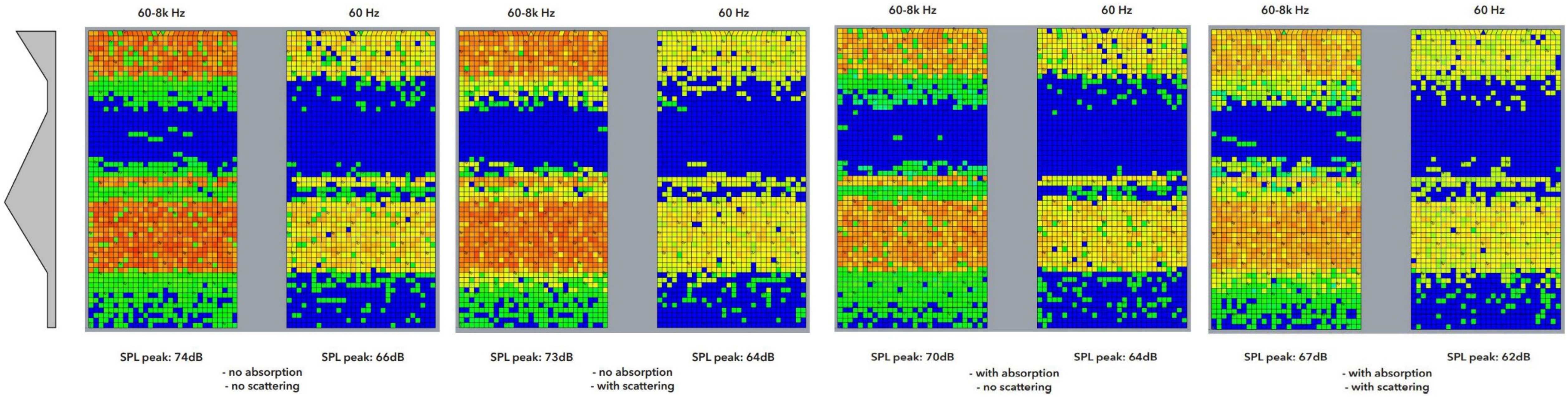




Facing shield integration



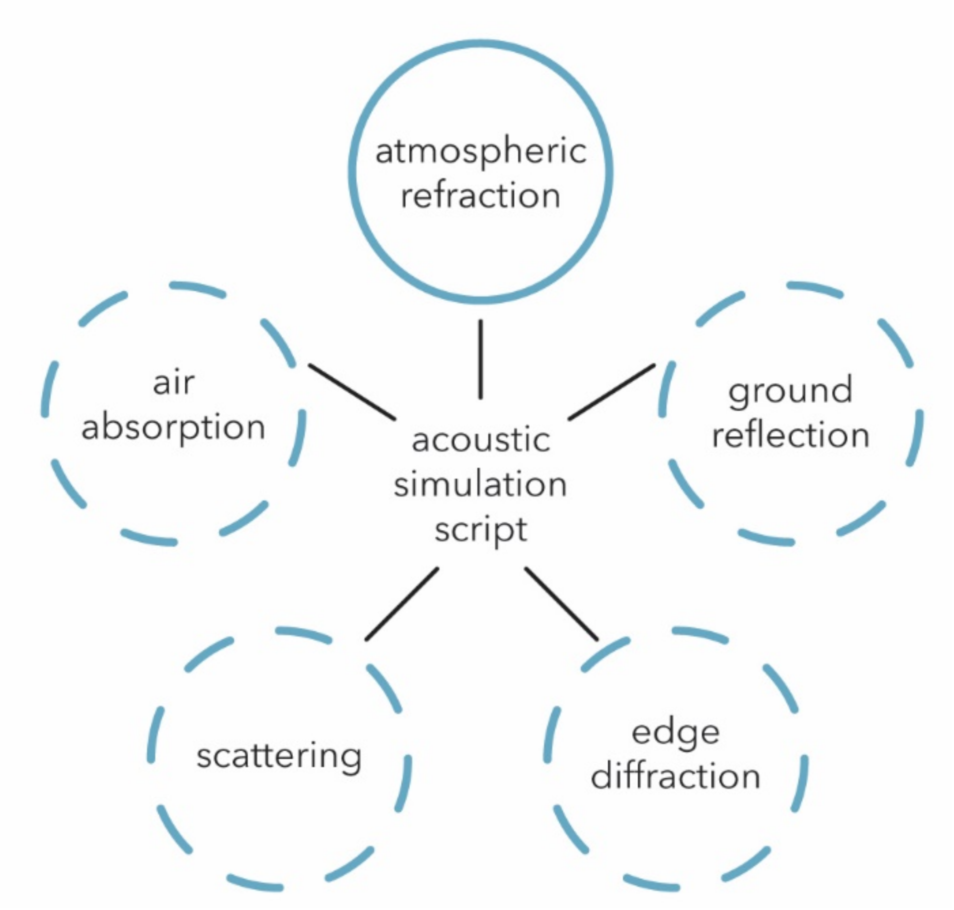
Scattering of reflected rays



Harmonoise model

[geometric acoustics-based method]

- A_{div} : attenuation due to geometrical spreading
- $A_{atm,i}$: attenuation due to atmospheric absorption
- $A_{excess,i}$: excess attenuation due to ground reflections and diffraction effects
- $A_{refl,i}$: attenuation due to energy loss during reflection
- $A_{scat,i}$: attenuation due to scattering zones



What is still to be developed

Thank you for your attention.