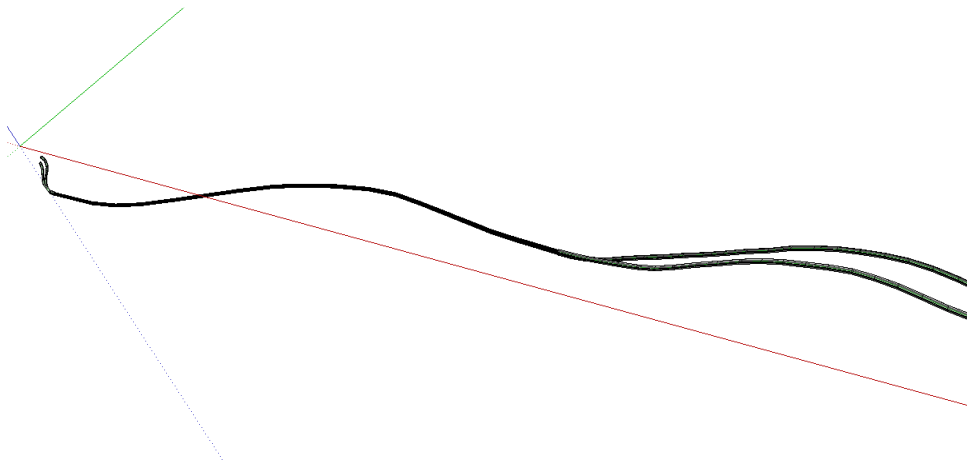


Acoustic Simulation

PUBLIC ADDRESS & VOICE EVACUATION SYSTEM



We make everyday life safer

May 2016

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1. Introduction

The study covers the presentation and analysis of results of the acoustic simulation designed for Public Address & Voice Evacuation system in the tunnel.

In order to perform acoustic simulation a three-dimensional (3D) model was built.

Analyzed:

- Tunnel - speakers placed every 100 m

To perform simulations there were used loudspeakers with a special structure dedicated to the tunnels.

Applied one speaker type:

- Speaker tunnel ABT-TNL100

2. The input to the simulation

To perform acoustic analysis we used three-dimensional object models built on the basis of the submitted architectural documentation. Surface materials were chosen according to the submitted interior design.

- Assumed the background sound on the level of 95 dBA - road noise and noise from ventilation - on the basis of measurements made in the facilities of this type.
- Applied reverberation time calculated by the EASE program on the basis of surface materials
- The calculations were made for the rooms empty (without the presence of people in the room) - in the least favorable acoustic conditions

Analyzed the following parameters:

- The sound level of the total [TOTAL SPL (A)]
- The ratio of speech transmission STI determined by STIPa method with weighing F, taking into account the phenomenon of masking and background noise

The simulation assumed the following settings:

Simulation method: Standard Simulation

Scattering [%] 20

Scattering Method: Standard

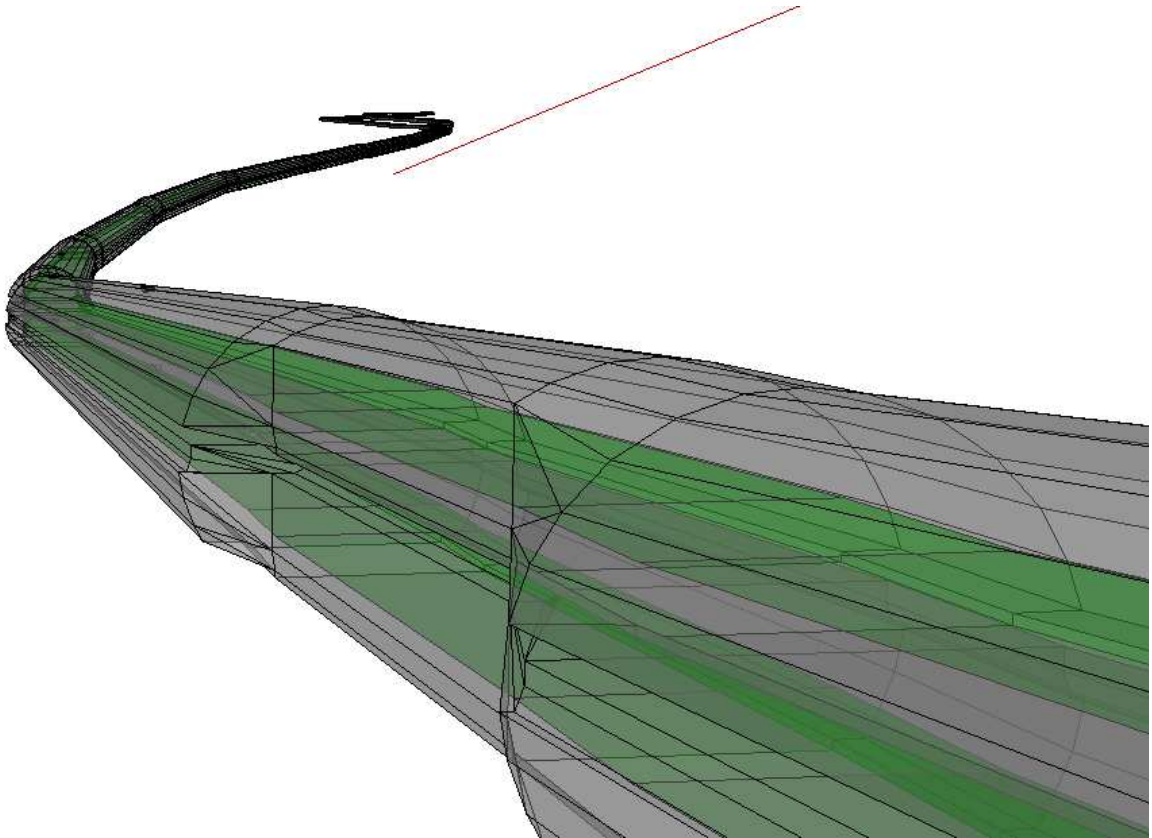
The height of the listener: 1,5m

Calculation method: Pink Noise

Mapping: Broadband weighted weighting curve A

2.1 Tunnel

2.1.1 Model



Tunnel

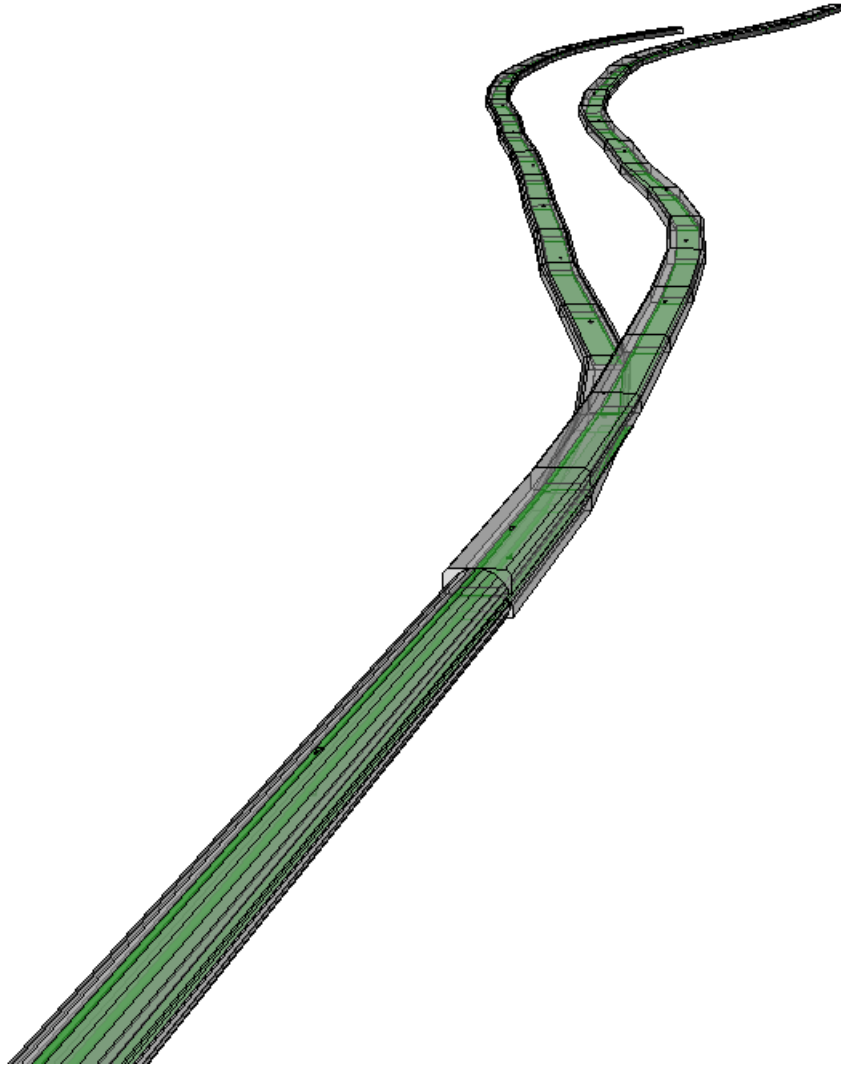


Figure 1 3D model of the object

Room volume is about 446000 m³.

Surfaces of the room is primarily concrete (walls, ceiling) and asphalt (roadway)

Tunnel

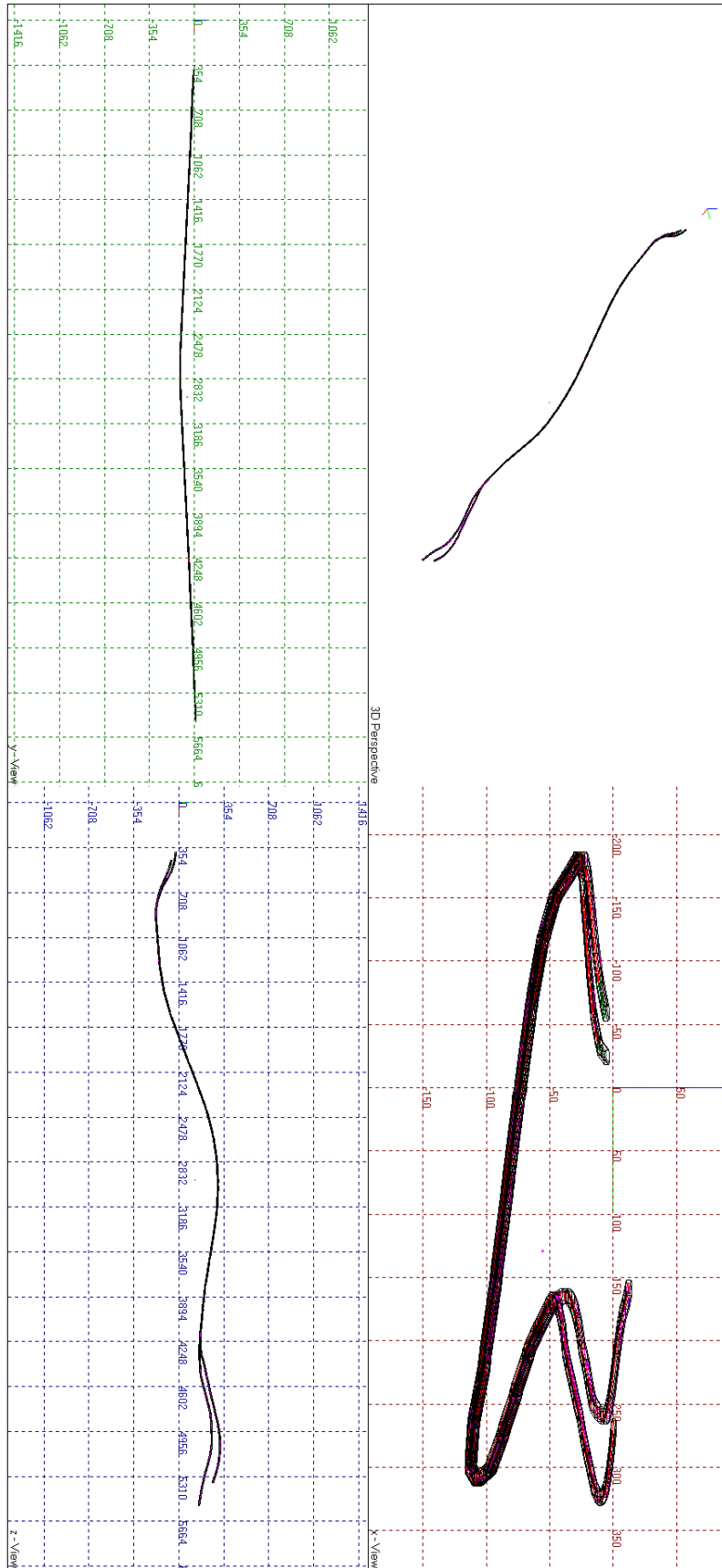


Figure 2 View of room in the EASE

2.1.2 Speakers

Acoustic simulations were performed using 101 tunnel loudspeakers TNL ABT-100 for the taps of 100W

Table 1 Technical data used loudspeakers

Speaker type	Data	
ABT-TNL100	Rated power [W]	100
	Tapping power [W]	100; 50
	Impedance [Ω]	100; 200
	SPL at rated power / 1W [dB]	131 / 111
	Frequency response [Hz]	250-8000
	Angle of coverage H / V [$^{\circ}$]	35 / 25
	Operating temperature [$^{\circ}$ C]	-25 / +70
	Material	Stainless steel
	Working environment	B
	Level of security	IP 66
	Colour	Gray
	Dimensions [mm]	1770 x 1020 x 455
	Weight [kg]	30




Table 2 Speaker Placement ABT-TNL100 used in the simulation

No.	Name	Model	x [m]	y [m]	z [m]	Hor [$^{\circ}$]	Ver [$^{\circ}$]	Power [W]
1	1	ABT-TNL100	576.39	-76.69	-15.30	-117.0	2.0	100W
2	2	ABT-TNL100	662.75	-127.11	-19.50	-120.3	2.0	100W
3	3	ABT-TNL100	756.44	-162.06	-22.30	-110.9	1.0	100W
4	4	ABT-TNL100	854.65	-180.91	-26.00	-99.6	2.0	100W
5	5	ABT-TNL100	954.52	-175.79	-30.10	-85.9	2.0	100W
6	6	ABT-TNL100	1054.28	-168.29	-34.90	-85.1	2.0	100W
7	7	ABT-TNL100	1153.85	-159.65	-39.80	-85.2	2.0	100W
8	8	ABT-TNL100	1253.53	-151.58	-44.50	-85.0	2.0	100W
9	9	ABT-TNL100	1352.66	-138.45	-49.40	-80.0	2.0	100W
10	10	ABT-TNL100	1451.29	-121.92	-54.00	-80.0	2.0	100W
11	11	ABT-TNL100	1548.46	-98.28	-59.00	-74.0	2.0	100W
12	12	ABT-TNL100	1644.95	-72.03	-64.00	-75.0	2.0	100W
13	13	ABT-TNL100	1739.24	-38.75	-68.40	-69.8	2.0	100W
14	14	ABT-TNL100	1832.83	-3.50	-73.10	-69.0	2.0	100W
15	15	ABT-TNL100	1926.41	31.74	-77.90	-68.9	2.0	100W
16	16	ABT-TNL100	2019.57	68.09	-82.50	-68.7	2.0	100W
17	17	ABT-TNL100	2112.74	104.41	-86.90	-68.5	2.0	100W
18	18	ABT-TNL100	2206.09	140.29	-91.60	-70.1	2.0	100W
19	19	ABT-TNL100	2300.06	174.48	-96.10	-70.2	2.0	100W
20	20	ABT-TNL100	2394.27	208.02	-101.00	-70.0	2.0	100W
21	21	ABT-TNL100	2490.10	236.58	-105.10	-75.0	2.0	100W
22	22	ABT-TNL100	2586.84	261.90	-110.00	-71.7	2.0	100W
23	23	ABT-TNL100	2685.30	279.37	-111.50	-80.0	0.0	100W

Tunnel

No.	Name	Model	x [m]	y [m]	z [m]	Hor [°]	Ver [°]	Power [W]
24	24	ABT-TNL100	2784.20	294.18	-112.70	-80.0	0.0	100W
25	25	ABT-TNL100	2883.65	303.98	-111.00	-85.0	-3.0	100W
26	26	ABT-TNL100	2983.61	308.56	-107.80	-87.0	-3.0	100W
27	27	ABT-TNL100	3083.60	306.48	-102.80	-91.9	-3.0	100W
28	28	ABT-TNL100	3183.50	302.01	-97.70	-92.5	-3.0	100W
29	29	ABT-TNL100	3282.82	290.39	-93.20	-97.5	-3.0	100W
30	30	ABT-TNL100	3381.74	276.86	-88.20	-97.5	-3.0	100W
31	31	ABT-TNL100	3480.70	261.29	-83.50	-98.5	-3.0	100W
32	32	ABT-TNL100	3579.47	245.66	-78.10	-98.8	-3.0	100W
33	33	ABT-TNL100	3678.33	230.59	-73.50	-98.4	-3.0	100W
34	34	ABT-TNL100	3777.09	214.92	-68.30	-96.3	-3.0	100W
35	35	ABT-TNL100	3876.19	201.53	-63.50	-95.8	-3.0	100W
36	36	ABT-TNL100	3975.58	189.66	-58.50	-96.0	-3.0	100W
37	37	ABT-TNL100	4075.06	180.25	-53.60	-95.8	-3.0	100W
38	38	ABT-TNL100	4174.61	170.88	-48.00	-93.6	-3.0	100W
39	39	ABT-TNL100	4274.59	167.52	-43.20	-85.2	-3.0	100W
40	40	ABT-TNL100	4373.30	184.92	-38.80	-76.2	-3.0	100W
41	41	ABT-TNL100	4470.42	208.73	-35.50	-76.0	-3.0	100W
42	42	ABT-TNL100	4568.09	230.19	-30.80	-77.7	-3.0	100W
43	43	ABT-TNL100	4665.94	250.82	-26.00	-79.0	-3.0	100W
44	44	ABT-TNL100	4762.56	276.60	-21.30	-75.6	-3.0	100W
45	45	ABT-TNL100	4860.04	298.92	-16.70	-77.3	-3.0	100W
46	46	ABT-TNL100	4958.15	318.28	-12.00	-80.0	-3.0	100W
47	47	ABT-TNL100	5057.97	324.18	-8.30	-87.0	-3.0	100W
48	48	ABT-TNL100	5157.86	319.45	-4.40	-92.3	-3.0	100W
49	49	ABT-TNL100	5256.19	301.26	-1.00	-100.6	-2.0	100W
50	50	ABT-TNL100	5351.29	270.35	lut.40	-106.5	-2.0	100W
51	51	ABT-TNL100	4274.59	167.52	-38.10	89.0	1.0	100W
52	52	ABT-TNL100	4374.25	164.67	-33.40	92.0	1.0	100W
53	53	ABT-TNL100	4473.92	169.07	-30.00	97.0	2.0	100W
54	54	ABT-TNL100	4572.42	186.32	-25.20	106.0	2.0	100W
55	55	ABT-TNL100	4668.61	213.67	-20.60	104.0	2.0	100W
56	56	ABT-TNL100	4765.57	238.14	-15.90	101.0	2.0	100W
57	57	ABT-TNL100	4863.87	254.46	-11.00	92.0	2.0	100W
58	58	ABT-TNL100	4963.83	259.41	-6.60	90.2	2.0	100W
59	59	ABT-TNL100	5063.83	258.80	-3.00	81.9	2.0	100W
60	60	ABT-TNL100	5162.72	242.85	0.90	75.0	2.0	100W
61	61	ABT-TNL100	5258.90	216.57	kwi.40	76.0	1.0	100W
62	62	ABT-TNL100	5355.85	192.07	lip.70	79.0	1.0	100W
63	63	ABT-TNL100	5454.04	173.15	lis.60	81.0	1.0	100W
64	64	ABT-TNL100	4176.31	170.88	-43.20	88.0	1.0	100W
65	65	ABT-TNL100	4076.76	180.09	-48.30	84.7	2.0	100W
66	66	ABT-TNL100	3977.29	189.55	-53.00	84.5	2.0	100W
67	67	ABT-TNL100	3877.90	201.37	-58.10	83.0	2.0	100W
68	68	ABT-TNL100	3778.78	214.73	-63.10	81.0	2.0	100W
69	69	ABT-TNL100	3680.01	230.33	-68.20	80.8	3.0	100W
70	70	ABT-TNL100	3581.15	245.41	-72.80	81.7	2.0	100W
71	71	ABT-TNL100	3482.39	261.02	-78.10	80.4	2.0	100W

Tunnel

No.	Name	Model	x [m]	y [m]	z [m]	Hor [°]	Ver [°]	Power [W]
72	72	ABT-TNL100	3383.43	276.65	-82.80	81.0	2.0	100W
73	73	ABT-TNL100	3284.52	290.13	-87.90	82.0	2.0	100W
74	74	ABT-TNL100	3185.20	301.91	-92.30	85.5	1.0	100W
75	75	ABT-TNL100	3085.32	306.41	-97.50	87.0	2.0	100W
76	76	ABT-TNL100	2985.31	308.54	-102.70	90.0	1.0	100W
77	77	ABT-TNL100	2885.36	304.04	-105.70	93.0	1.0	100W
78	78	ABT-TNL100	2785.88	294.44	-107.50	96.0	-2.0	100W
79	79	ABT-TNL100	2686.99	279.65	-106.30	99.0	-2.0	100W
80	80	ABT-TNL100	2588.50	262.33	-104.70	100.7	-3.0	100W
81	81	ABT-TNL100	2491.74	237.02	-99.80	104.5	-3.0	100W
82	82	ABT-TNL100	2395.92	208.50	-95.80	106.5	-3.0	100W
83	83	ABT-TNL100	2301.67	175.05	-90.80	110.0	-3.0	100W
84	84	ABT-TNL100	2207.70	140.87	-86.40	109.0	-3.0	100W
85	85	ABT-TNL100	2114.35	105.01	-81.60	111.0	-3.0	100W
86	86	ABT-TNL100	2021.15	68.72	-77.20	111.0	-3.0	100W
87	87	ABT-TNL100	1928.01	32.36	-72.70	110.9	-3.0	100W
88	88	ABT-TNL100	1834.42	-2.92	-67.90	109.1	-4.0	100W
89	89	ABT-TNL100	1740.85	-38.14	-63.30	110.5	-3.0	100W
90	90	ABT-TNL100	1646.57	-71.54	-58.70	106.0	-3.0	100W
91	91	ABT-TNL100	1550.07	-97.74	-53.90	105.0	-3.0	100W
92	92	ABT-TNL100	1452.95	-121.58	-49.00	100.0	-4.0	100W
93	93	ABT-TNL100	1354.34	-138.17	-44.20	99.0	-3.0	100W
94	94	ABT-TNL100	1255.23	-151.39	-39.40	96.0	-4.0	100W
95	95	ABT-TNL100	1155.56	-159.50	-34.40	95.5	-3.0	100W
96	96	ABT-TNL100	1055.99	-168.17	-29.70	93.4	-3.0	100W
97	97	ABT-TNL100	956.23	-175.67	-25.00	93.8	-3.0	100W
98	98	ABT-TNL100	856.33	-181.03	-20.70	91.3	-3.0	100W
99	99	ABT-TNL100	756.14	-164.35	-17.00	79.2	-3.0	100W
100	100	ABT-TNL100	660.49	-138.24	-14.10	74.3	-3.0	100W
101	101	ABT-TNL100	569.08	-97.37	-9.80	67.2	-3.0	100W

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