S4T

Safety for Tunnel

Advanced Voice Evacuation System for tunnel application

✓ Advanced DSP functions for best audio transmission in difficult acoustic conditions – great speech intelligibility

✓ Redundant connection between control units and microphones

✓ Flexible and scalable configuration

✓ Specifically designed for tunnel applications

✓ Highly directional asymmetric loudspeaker construction

ambient SYSTEM

We make everyday life safer

SAFETY FOR TUNNEL

ADVANCED VES FOR ROAD TUNNELS APPLICATION

Road tunnels are a challenging application, where the top priority is to ensure the safety of travellers and to maintain traffic. Voice evacuation systems used in tunnels must ensure effective evacuation of occupants to safe locations.

In accordance with the guidelines for equipment and operation of road tunnels contained in the RABT Edition 2006 (Road and Transportation Research Association – Regulations for the Equipment and Operation of Road Tunnels), section 6.2.5, road tunnels of length of 400m or more must be equipped with loudspeakers in the tunnel, tunnel portals, evacuation routes and shelters. This provides the opportunity to address road users using direct voice announcements. It states that the capability to broadcast intelligible messages to individual or grouped loudspeakers must be managed not only from the tunnel maintenance building, but also from the tunnel control rooms dedicated for use by the emergency services.

A Voice evacuation system installed in a road tunnel allows for conveying messages to travellers. In the case of a fire hazard or other emergency, it allows the operator to instruct an evacuation and direct travellers to safe locations immediately. Using a voice evacuation system is the most effective and efficient system providing clear and understandable voice instruction from the first moment of broadcasting. As a result, in an emergency, passengers can quickly and efficiently respond to commands of emergency services. The transmission of the voice should be as clear as possible. In tunnels, due to the long reverberation time and the high level of prevailing noise, it is very difficult to meet this condition. Obtaining the highest degree of speech intelligibility, which is a critical parameter of evaluation of each voice evacuation system, becomes the most important challenge posed to a voice evacuation system inside these acoustically difficult spaces.

Acoustic Conditions Prevailing in Tunnels

Road tunnels are very difficult acoustic environments. Conventional loudspeaker solutions used in voice evacuation systems do not provide clear and understandable messages in such an environment. In the process of the voice evacuation system design in a tunnel, you should consider some important factors that have a huge impact on obtaining the required speech intelligibility.

The severe acoustic conditions prevailing inside the tunnel are associated with **long reverberation time and the reflections of sound waves** from the hard concrete surfaces. This means that it is very difficult to get the right ratio of direct sound energy above reflected sound energy,

which is essential to achieve a high level of speech intelligibility. The use of acoustic adaptation such as covering the tunnel internal surfaces with materials with high sound absorption is very costly and not used in practice. Reducing the reflections is however possible with highly directional speakers. Another negative factor impacting on the intelligibility of speech is the **noise generated by cars and ventilation and smoke exhaust systems.** The required values of signal to noise ratio, comparing the speech signal level to the general noise level in the tunnel, can be achieved using highly efficient loudspeakers. Such a solution can give the appropriate sound level and intelligibility

to the broadcast messages. Conventional loudspeakers for voice evacuation systems are not sufficiently directional, and their low efficiency and power cannot achieve a high enough level of SPL (Sound Pressure Level) without distorting the audio signal.

Considering the above problems, the use of effective and at the same time highly directional tunnel loudspeakers is a complete sound solution in difficult acoustic conditions prevailing in tunnels. By reducing the amount of sound reflections from the walls to the minimum, the ratio of the direct sound energy to the reflected sound energy value is increased. It is then possible to achieve the required values of speech intelligibility.
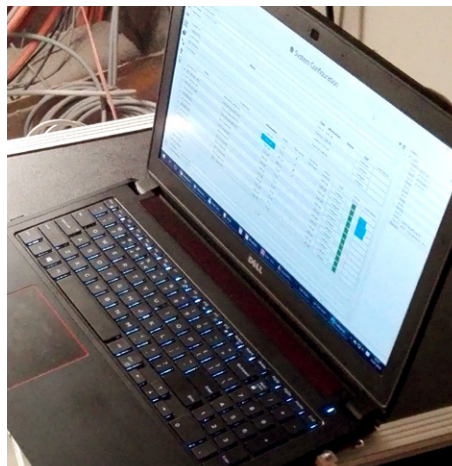
S4T – Safety for Tunnel

Ambient System sp. z o.o., as the only Polish manufacturer of sound evacuation systems, has introduced a solution dedicated to the audio systems for tunnels. **S4T – Safety for Tunnel** is a system based on **central units managed by the ABT-CU-11LCD digital control units** with built-in DSP and specially designed **ABT-TNL100 loudspeakers** for tunnel applications. The aim of the project was to design and implement a loudspeaker that generates the highest achievable speech intelligibility in the harsh sound environment in a tunnel.
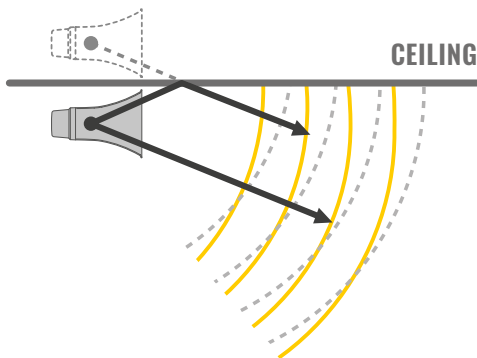

ABT-TNL100 Loudspeaker

The first manufactured batch of ABT-TNL100 loudspeakers has been **fully tested under the measurement conditions of anechoic chamber and in a real tunnel - the newly built tunnel in Istanbul, Turkey.** Measuring more than 5 km long, the trans-continental tunnel linking Europe with Asia has been dug under the Bosporus (Eurasia Tunnel).
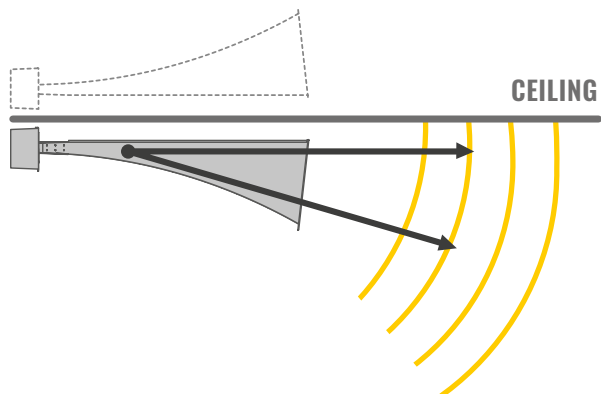
Tunnel Loudspeaker ABT-TNL100

Conventional Loudspeaker

CEILING

ABT-TNL100 Tunnel Loudspeaker

CEILING

S4T elements – Safety for Tunnel

MULTIVES devices		Fire Loudspeakers	
ABT-CU-11LT	control unit – 11 slots	**ABT-TNL100**	tunnel loudspeakers
ABT-CU-11LCD	control unit – 11 slots with touch screen	**MCR-SMSP20**	fire sound projector
ABT-DFMS	fireman microphone	**Amplifiers**	
ABT-DFMS BOX	fireman microphone	**ABT-PA4160B**	D class power amplifier, 8 × 80 W
ABT-DMS-LCD	zone microphone with LCD display	**ABT-PA8160B**	D class power amplifier, 8 × 160 W
ABT-DMS	zone microphone	**Standby Power Supply Unit**	
ABT-EKB-20M	microphone keyboard extension	**ABT-PSM48**	power supply manager
ABT-ISLE	Audio / RS485 interface	**ABT-PS48800**	power supply unit module 48 V / 800 W

Tests conducted by Ambient System confirmed that the new S4T solution gave a clean transmission of clear and understandable messages to the tunnel's users. Narrow dispersion angles and the ability to produce high sound pressure levels without distortion make the ABT-TNL100 an ideal solution for the noisy environments of road tunnels.

The asymmetric construction of the loudspeaker has been designed using the method of virtual sources in order to produce the flat front of the acoustic wave. Through the simple installation of ABT-TNL100 on the roof, the ceiling of the tunnel becomes a boundary surface and the waveguide for the coherent acoustic wave. By reducing the impact of additional reflections, it is possible to obtain a coherent wave front.
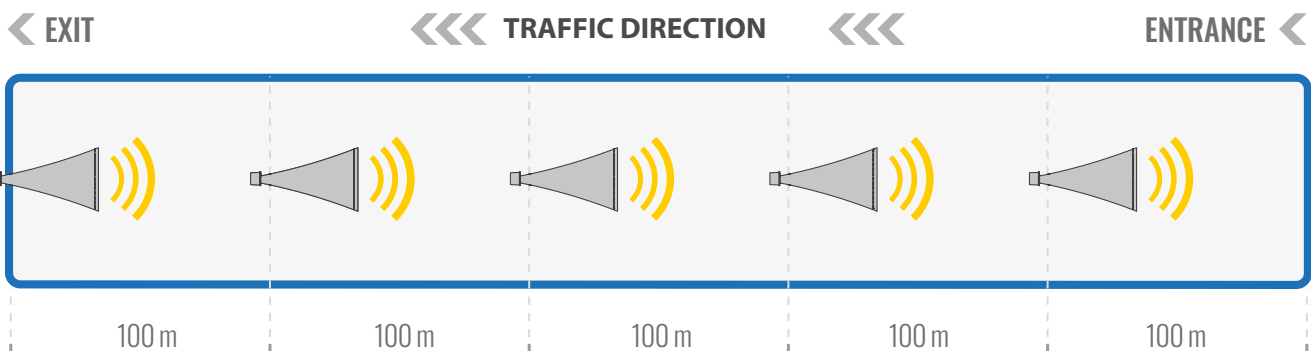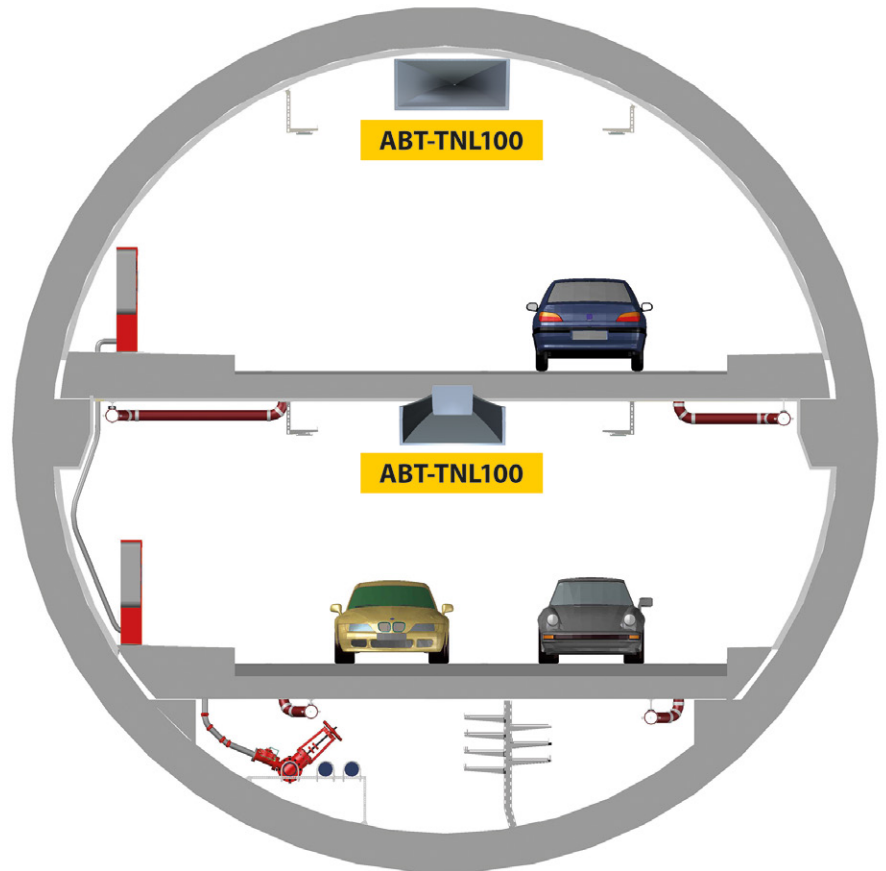
In contrast to the conventional horn loudspeakers, which have to be mounted at a distance from the wall or ceiling, the use of ABT-TNL100 prevents the occurrence of undesirable acoustic effects. This minimises the adverse impact of wave interference and comb filter caused by phase shift between the direct and reflected sounds across a wide frequency band.

The ABT-TNL100 has been designed not only to allow the transmission of clear and intelligible voice messages, but also to meet the environmental conditions during firefighting, maintenance and cleaning tunnels. During design, special attention was paid to the resistance of the loudspeaker to water extinguishing and sprinkler systems as well as water under high pressure. The interior of the loudspeaker is protected by a thick mesh of stainless steel carefully designed to ensure it had no effect on the primary

function of the loudspeaker to produce the acoustic wave. The outer casing is also fully made of stainless steel, making the loudspeaker fire and water resistant and providing the safe, long-term and reliable operation throughout the product life.

ABT-TNL100 is designed for installation on the round and flat ceilings. The best location for the loudspeaker is at the centre of the tunnel, above the line dividing the lanes.

The Eurasia tunnel tests have shown that the achievement of the required acoustic parameters, such as SPL (105 dB) and STI (0.45) (Speech Transmission Index – speech intelligibility index), was possible even with the loudspeakers spaced of 100 m. However, depending on the architecture of the tunnel, selecting the quantity and locations of the ABT-TNL100 loudspeakers should be supported by acoustic simulations, to ensure the best results.

EXIT **TRAFFIC DIRECTION** **ENTRANCE**

100 m 100 m 100 m 100 m 100 m

Acoustic simulations

Several acoustic simulations were carried out during the design process of the sound system for tunnels and these showed significant differences in the SPL and STI parameters depending on the loudspeaker system used. The results of for the speech intelligibility index STI for the system design based on the S4T solution

using the ABT-TNL100 tunnel speakers were considerably higher than for conventional systems with horn loudspeakers or line array loudspeakers. The use of horn or column loudspeakers in a tunnel causes undesired multiple reflections from the walls which negatively impact speech

intelligibility. The large number of loudspeakers that need to be used and the lack of any time delays between the speakers decreases STI due to the masking effect.
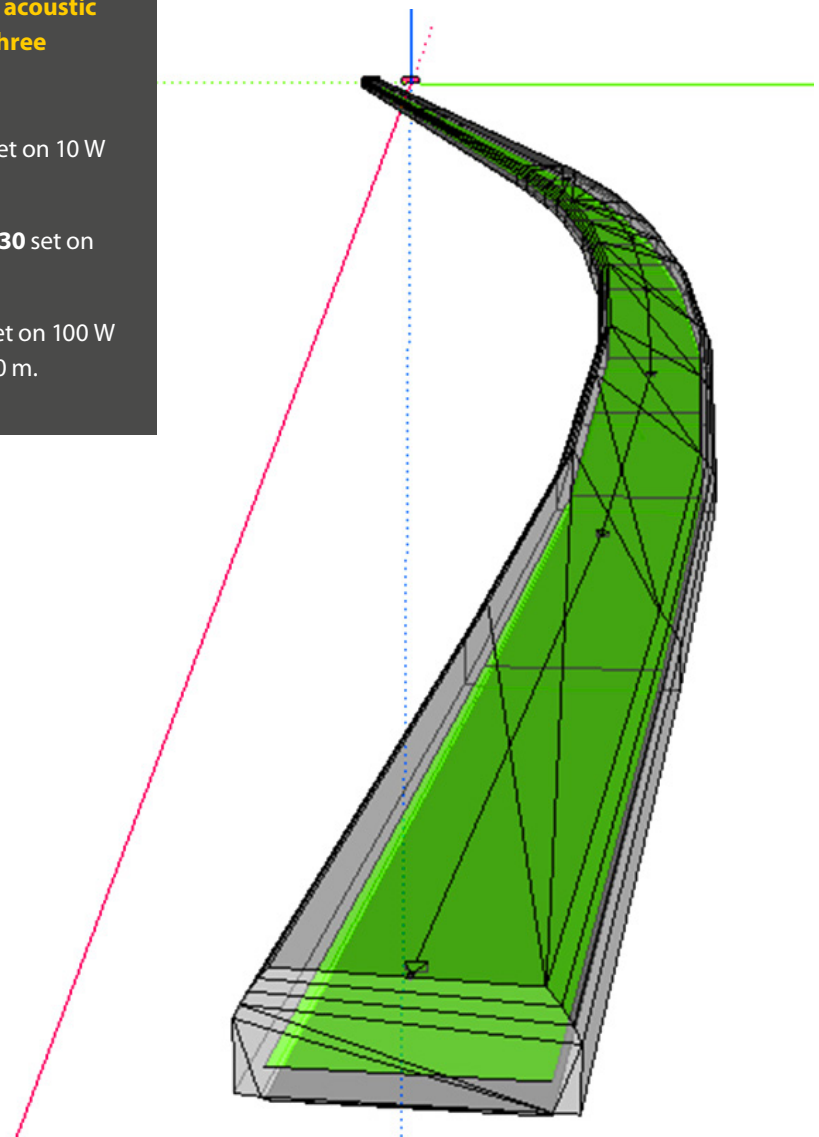
Acoustic simulation results of a 2100 m long TUNNEL

The following pages summarize the results of acoustic simulations of the 2100 m long tunnel using three speakers types:

1. **192 pcs. of horn loudspeakers ABT-T1510** set on 10 W and placed every 10.7 m on tunnel walls.

2. **192 pcs. of line array loudspeakers ABT-LA30** set on 30 W and places every 10,7 m on tunnel walls.

3. **21 pcs. tunnel loudspeakers ABT-TNL100** set on 100 W and placed on the flat tunnel ceiling every 100 m.
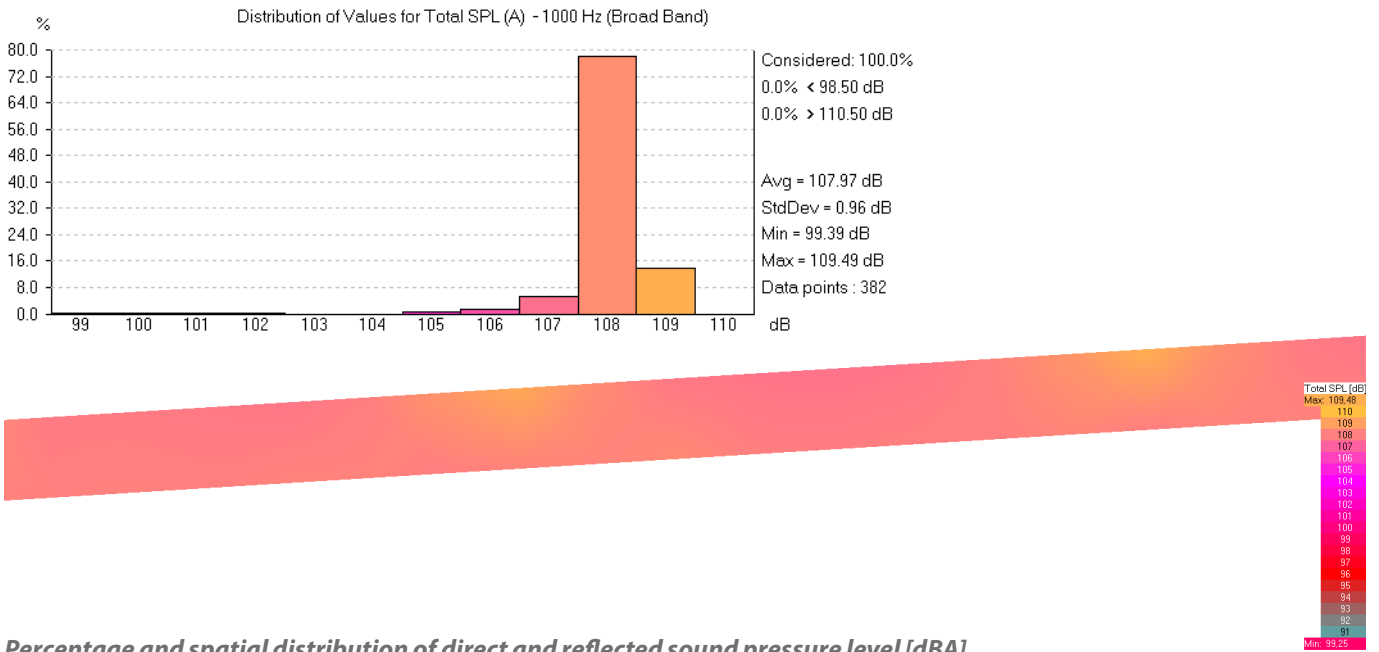
»   For comparison, it is shown the **effect of time delay setting between the ABT-TNL100 loudspeakers** in the non-delay variant and with delay of 291 ms.

»   **Road background noise level of 95 dBA was assumed**

»   The reverberation time of the example tunnel calculated by the **EASE program** using the AURA module is 9 s.
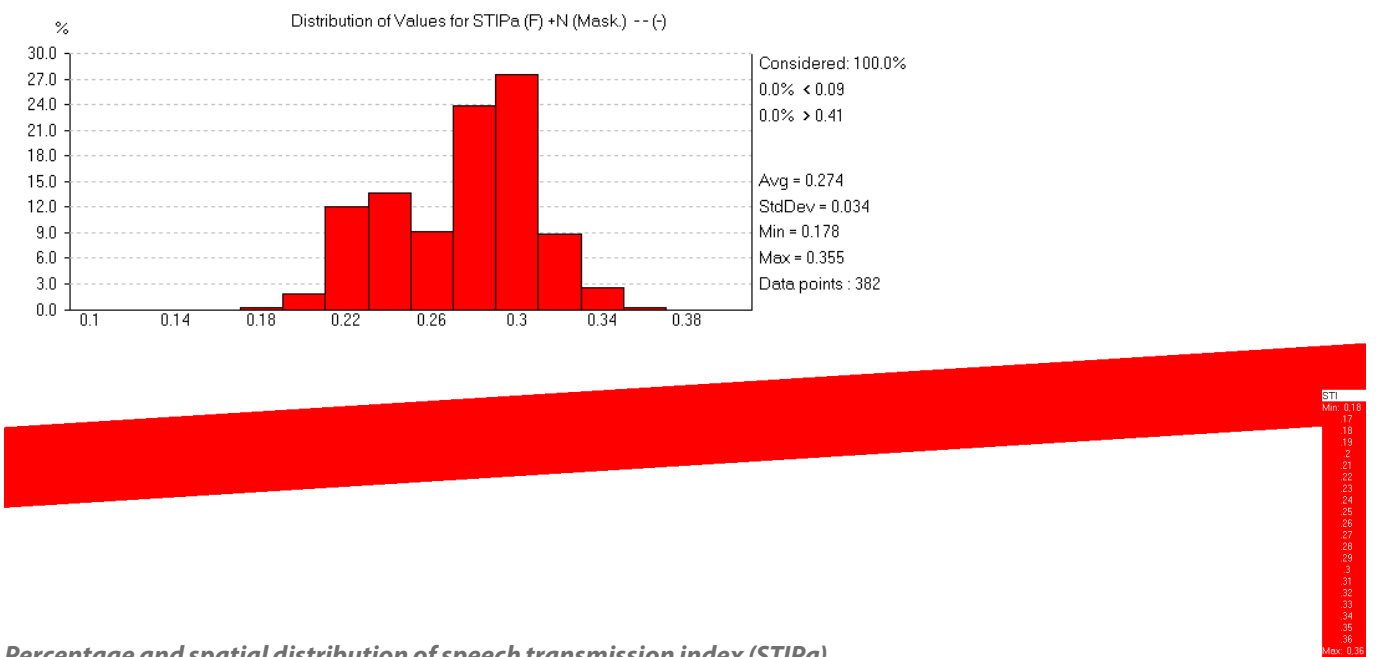
3D model of 2100 m long tunnel

1. 192 horn loudspeakers ABT-T1510

Total SPL [dBA]

Distribution of Values for Total SPL (A) - 1000 Hz (Broad Band)

Considered: 100.0%
0.0% < 98.50 dB
0.0% > 110.50 dB

Avg = 107.97 dB
StdDev = 0.96 dB
Min = 99.39 dB
Max = 109.49 dB
Data points : 382

Percentage and spatial distribution of direct and reflected sound pressure level [dBA]

STIPA

Distribution of Values for STIPa (F) +N (Mask.) -- (-)

Considered: 100.0%
0.0% < 0.09
0.0% > 0.41

Avg = 0.274
StdDev = 0.034
Min = 0.178
Max = 0.355
Data points : 382

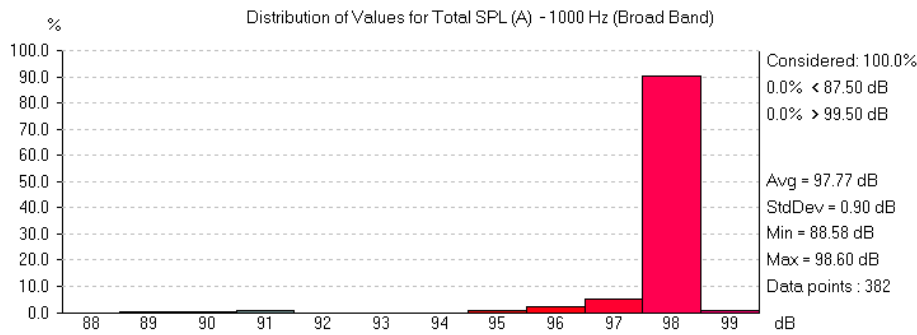*Percentage and spatial distribution of speech transmission index (STIPa),
including signal masking and background noise (95 dBA)*

2. 192 pcs. of line array column loudspeakers ABT-LA30

Total SPL [dBA]

Percentage and spatial distribution of direct and reflected sound pressure level [dBA]

STIPA

*Percentage and spatial distribution of speech transmission index (STIPa),
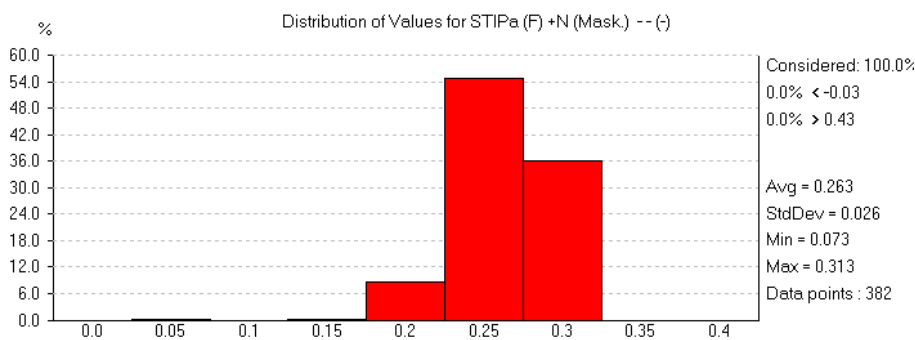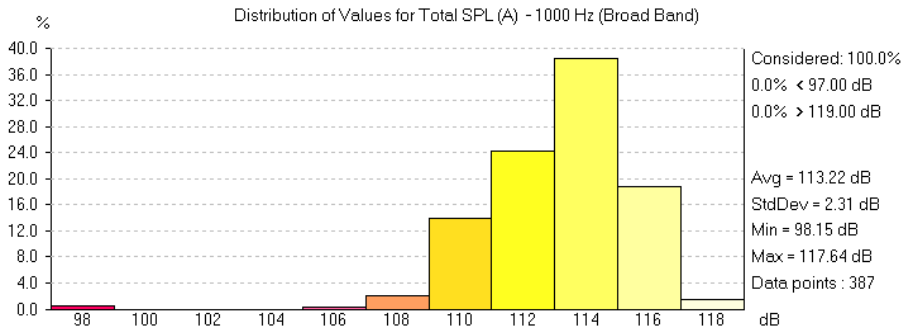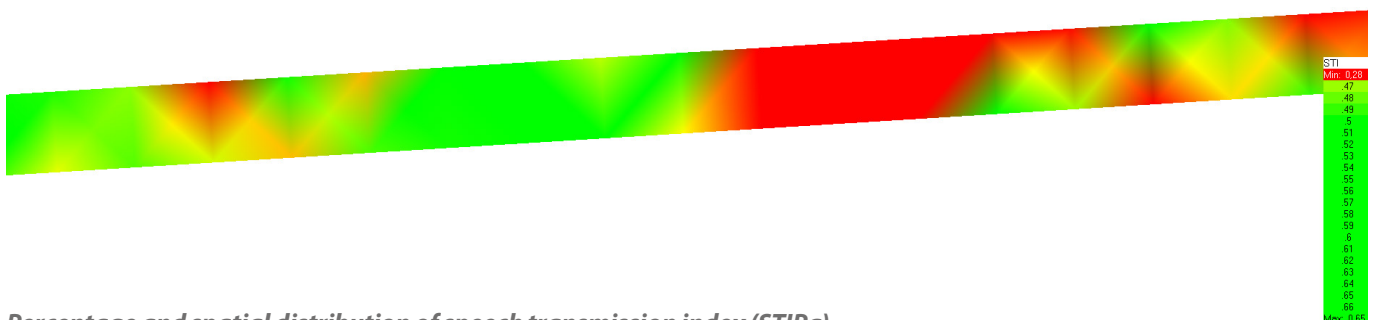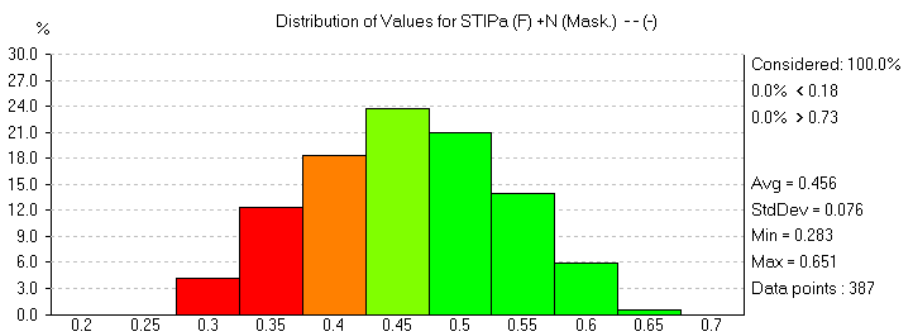including signal masking and background noise (95 dBA)*

3. 21 pcs. of tunnel loudspeakers ABT-TNL100
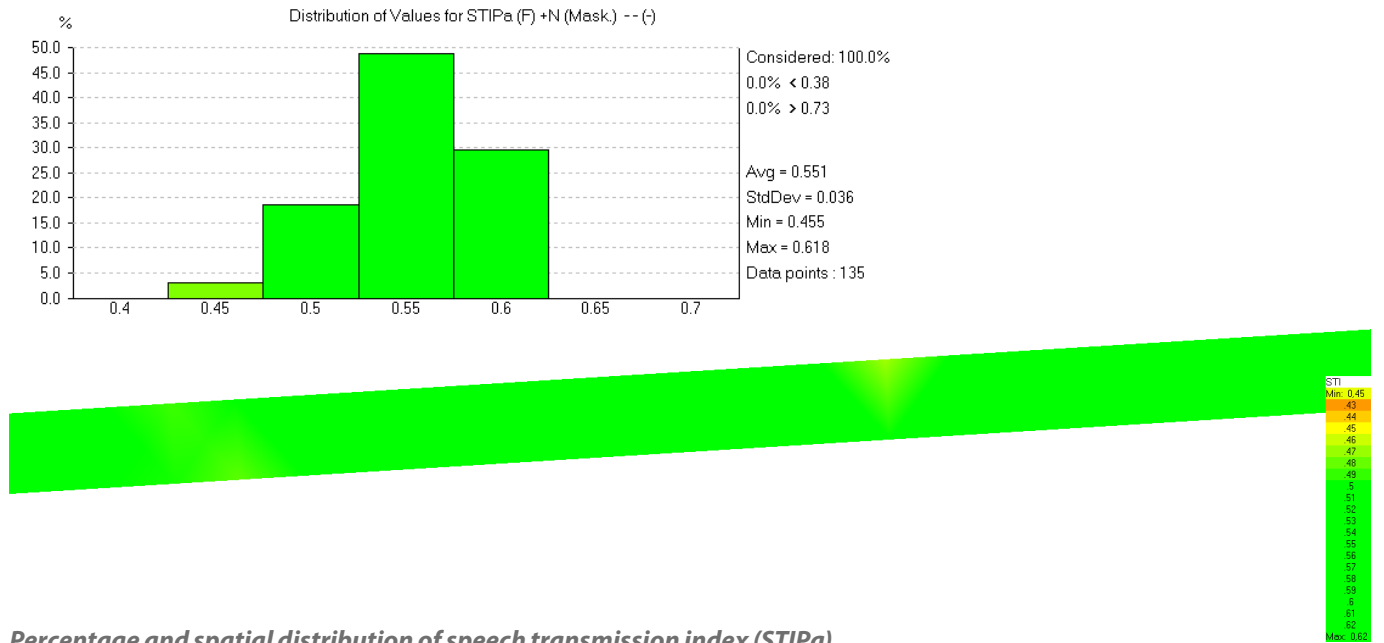
Total SPL [dBA]

Percentage and spatial distribution of direct and reflected sound pressure level [dBA]

STIPA without time delay between speakers

Percentage and spatial distribution of speech transmission index (STIPa), including signal masking and background noise (95 dBA)

STIPA with time delay between speakers – 291 ms

Distribution of Values for STIPa (F) +N (Mask.) – – (-)

%

Considered: 100.0%	
0.0% < 0.38	
0.0% > 0.73	
Avg = 0.551	
StdDev = 0.036	
Min = 0.455	
Max = 0.618	
Data points : 135	

STI
Min: 0.45
43
44
45
46
47
48
49
5
51
52
53
54
55
56
57
58
59
6
61
62
Max: 0.62

Percentage and spatial distribution of speech transmission index (STIPa), including signal masking and background noise (95 dBA)

Results comparison

TABLE 1:   Results summary

PARAMETER	192 pcs. of horn speakers ABT-T1510	192 pcs. of line array loudspeakers ABT-LA30	21 pcs.of tunnel loudspeakers ABT-TNL100 without time delay	21 pcs. of tunnel loudspeakers ABT-TNL100 with time delay of 291 ms
Total SPL [dBA]	108	98	113	113
STIPa(F)+N(Mask)	0,27	0,26	0,46	**0,55**

The results of the detailed acoustic analysis obtained in the simulations clearly show the advantage of S4T over conventional loudspeaker systems. The STI values obtained with the use of horn loudspeakers and line array column speakers do not give acceptable intelligibility for messages broadcast by notification and evacuation systems in tunnels. Using appropriate calibration and time alignment of the system based on the **S4T solution gives values of the speech intelligibility index STI at the level of 0.55**. This is a very high result value and impossible to achieve for other loudspeaker systems in such difficult acoustic conditions in tunnel. Speaker placement every 100 m also allows to provide the appropriate SPL at 113 dBA. An optimal 18 dBA between signal and noise guarantees the highest STI value achievable.

TABLE 2:   STI value summary

STI value	Subjective speech intelligibility
0 – 0.3	bad
0,3 – 0,45	weak
0,45 – 0,6	correct
0,6 – 0,75	good
0,75 – 1	excellent

For round-shaped tunnels, we recommend using additional flat boundary surfaces with dimensions of 10 m × 2 m or larger to create a flat coherent sound wave front. This allows an increase in the speech intelligibility level to 0.49 STI when placing the speakers at 100 m. For comparison the fo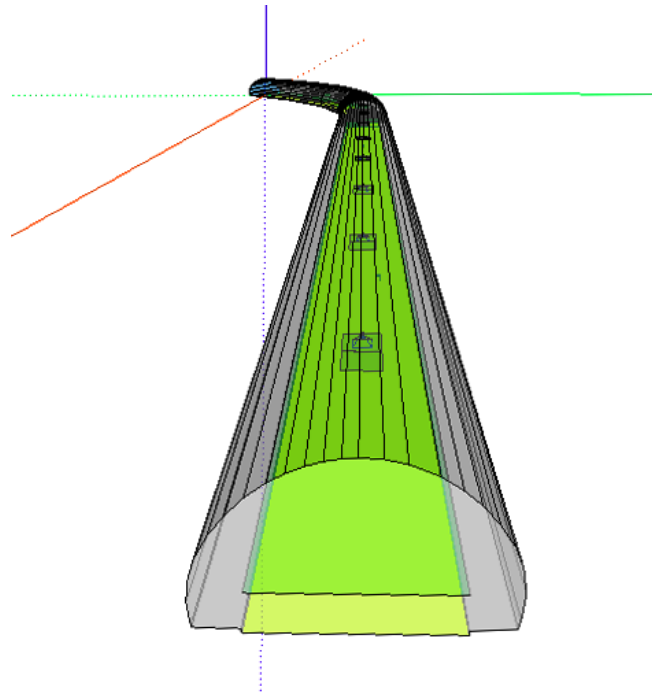llowing variant of acoustic analysis of a 700 m long tunnel with a speaker placement every 50 m is presented below. As it's shown, with a synchronized and tuned system, even halving the distance between the speakers ABT-TNL100 does not significantly increase the speech intelligibility index in relation to the results obtained at a distance of 100 m. With the use of additional flat surfaces, the difference in the average value of STI over the entire tunnel mapping surface is only 0.001. In the acoustic simulation, the time delay for the speakers placed every 50m was set at 145ms and for 100m at 291ms. The reverberation time of that tunnel calculated by the EASE program using the AURA module is 7 s.
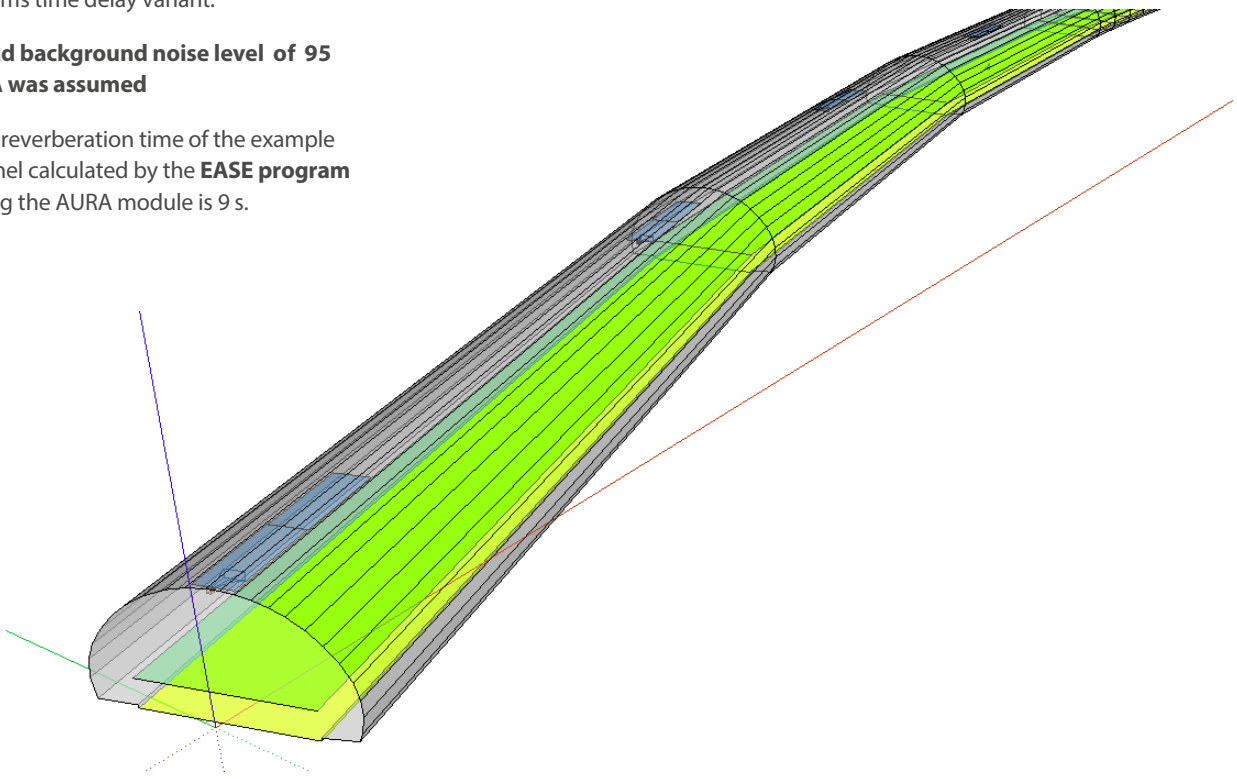
Acoustic simulation results of a tunnel with length of 700 m

The following pages summarize the results of acoustic simulations of a 700 m long tunnel using the following loudspeaker placement:

1. **14 tunnel Loudspeakers ABT-TNL100 delayed by 145 ms**

2. **7 tunnel Loudspeakers ABT-TNL100 delayed by 291 ms**

3. **14 tunnel loudspeakers ABT-TNL delayed by 145 ms with 10 m × 2 m boundary surface**

4. **7 tunnel loudspeakers ABT-TNL delayed by 291 ms with 10 m × 2 m boundary surface**
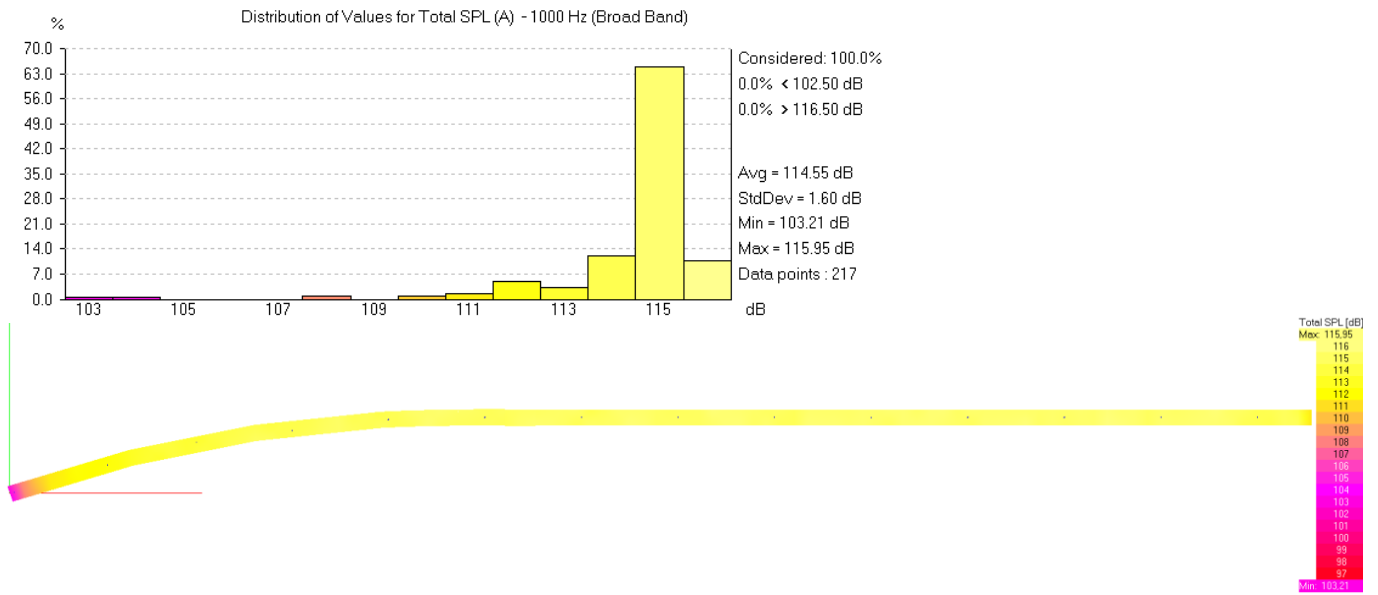
» For comparison, this shows the **effect of time delay setting between the ABT-TNL100 loudspeakers** in 145 ms and 291 ms time delay variant.

» **Road background noise level of 95 dBA was assumed**

» The reverberation time of the example tunnel calculated by the **EASE program** using the AURA module is 9 s.
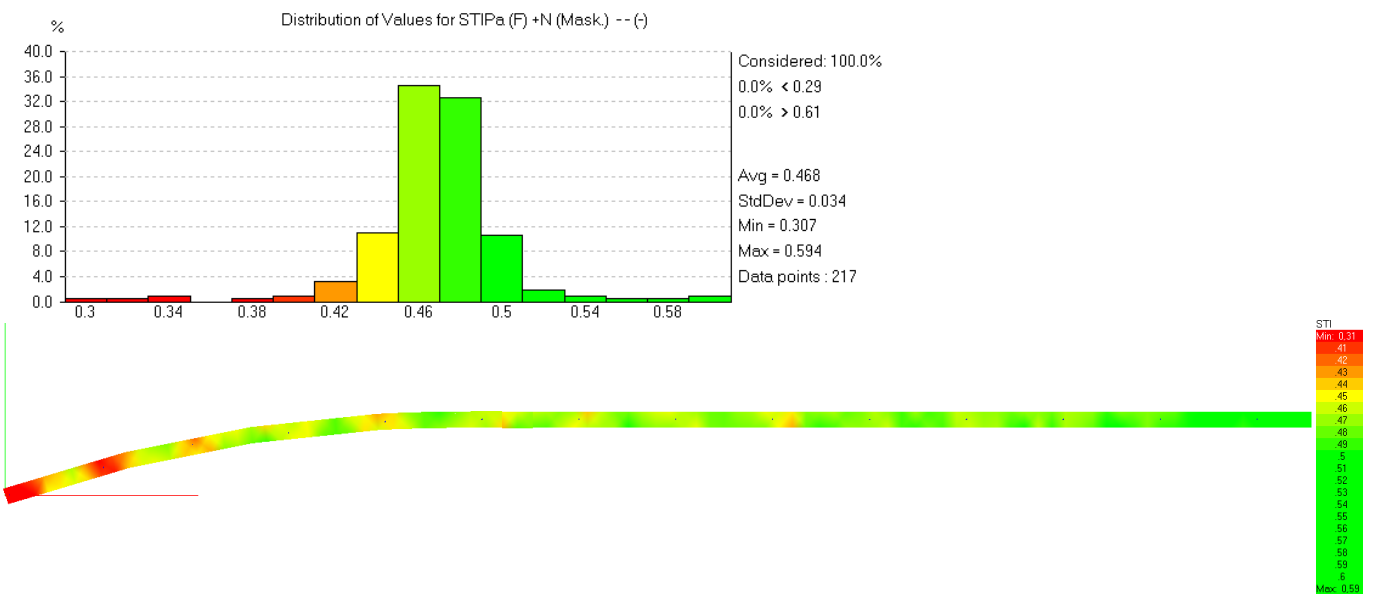
3D model of 700 m long tunnel

1. 14 pcs. of tunnel loudspeakers ABT-TNL100 delayed by 145 ms

Total SPL [dBA]

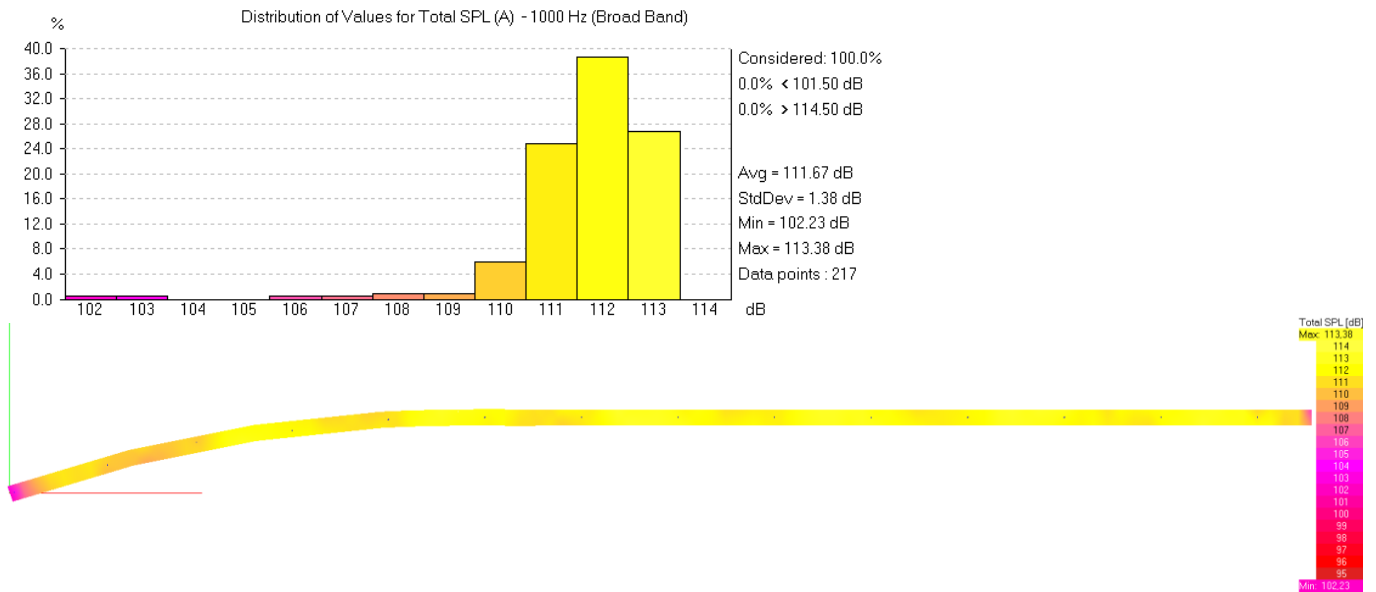*Percentage and spatial distribution of direct and reflected sound pressure level [dBA]*

STIPA

Percentage and spatial distribution of speech transmission index (STIPa), including signal masking and background noise (95 dBA)
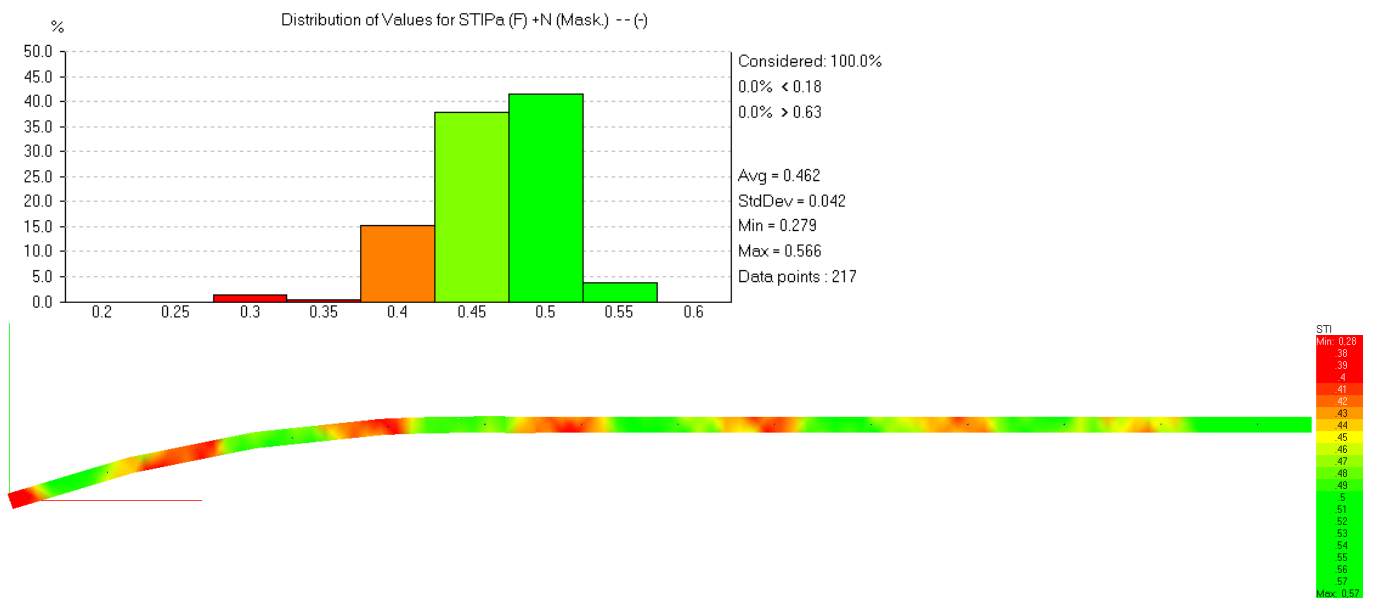
2. 7 tunnel loudspeakers ABT-TNL100 delayed by 291 ms

Total SPL [dBA]

Percentage and spatial distribution of direct and reflected sound level [dBA]

STIPA

Percentage and spatial distribution of speech transmission indicator (STIPa),
including masking and acoustic background (95 dBA)

3. 14 tunnel loudspeakers ABT-TNL100 delayed by 145 ms with the boundary surface 10 m × 2 m

Total SPL [dBA]

Percentage and spatial distribution of direct and reflected sound level [dBA]

STIPA

Percentage and spatial distribution of speech transmission indicator (STIPa), including masking and acoustic background (95 dBA)

4. 7 tunnel loudspeakers ABT-TNL100 delayed by 291 ms with the boundary surface 10 m x 2 m

Total SPL [dBA]

Percentage and spatial distribution of direct and reflected sound level [dBA]
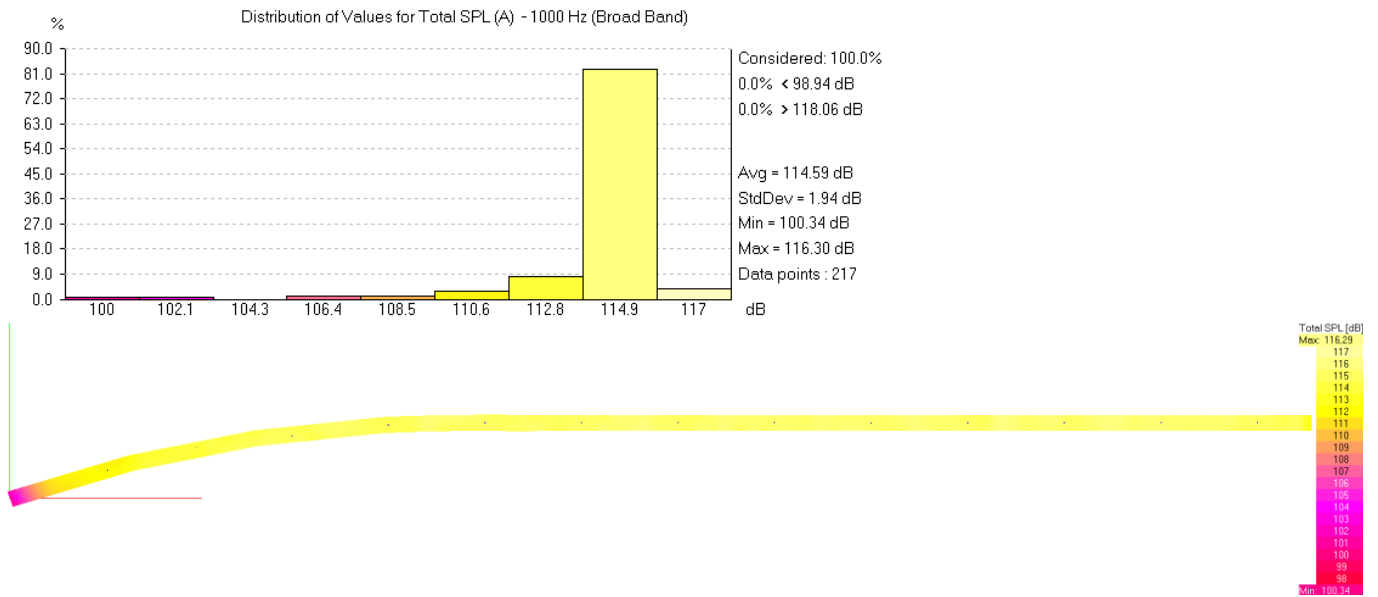
STIPA

Percentage and spatial distribution of speech transmission indicator (STIPa),
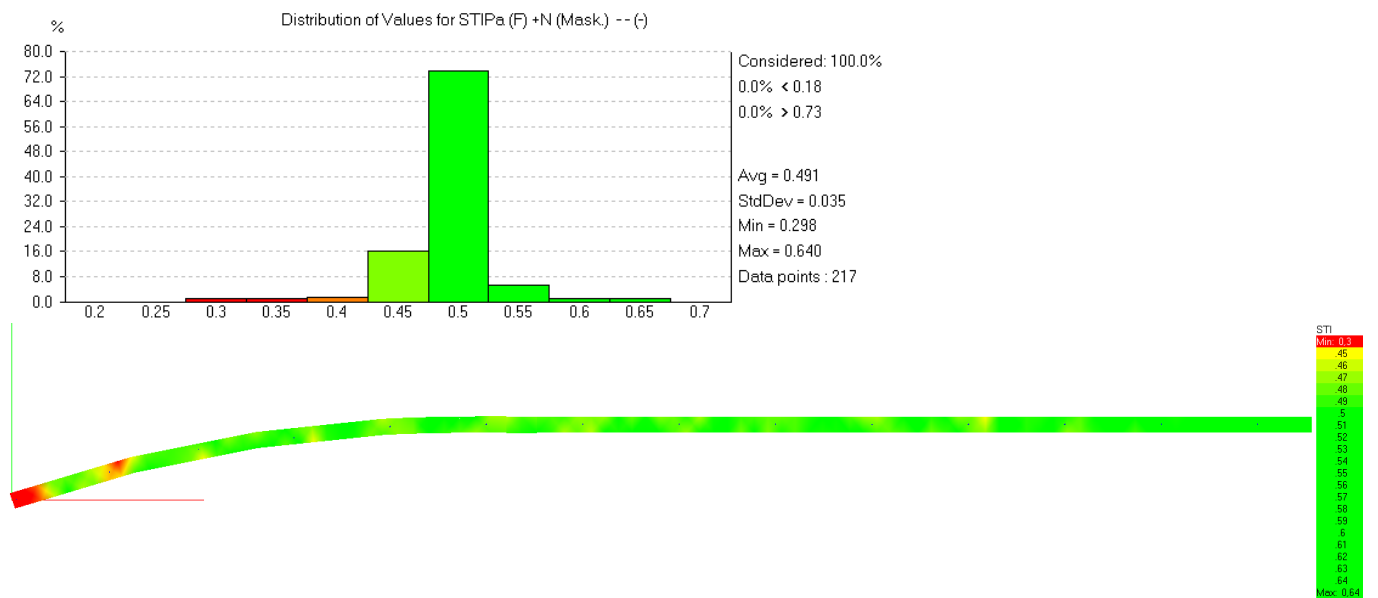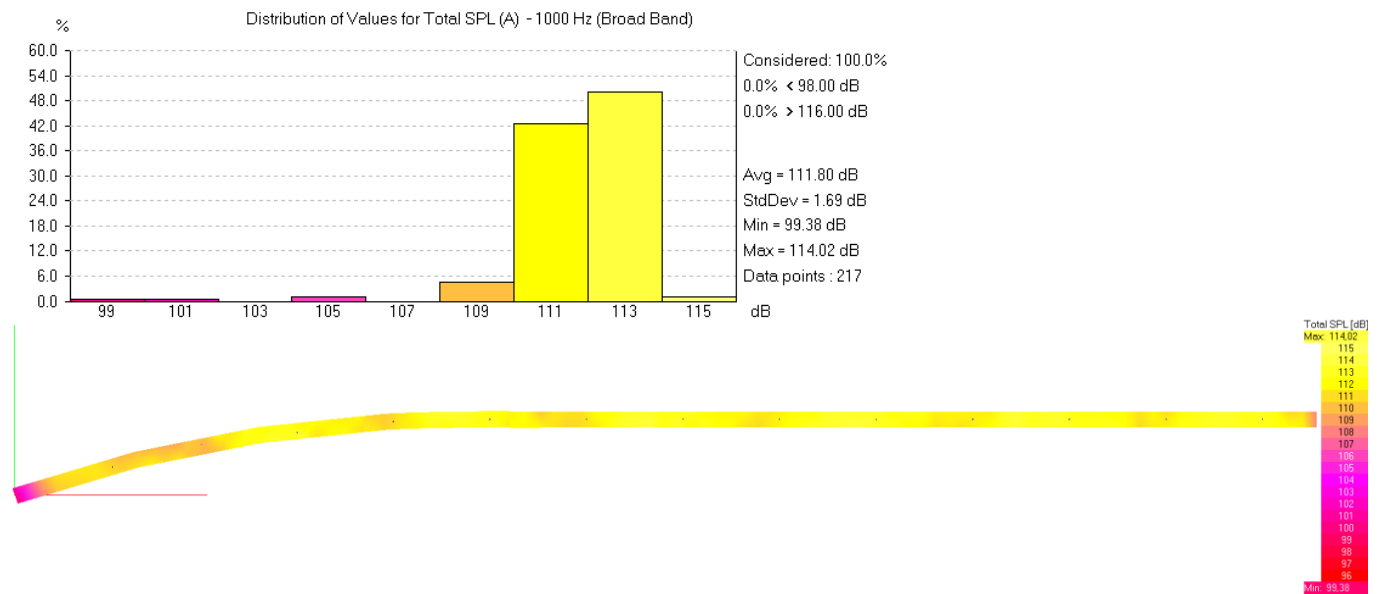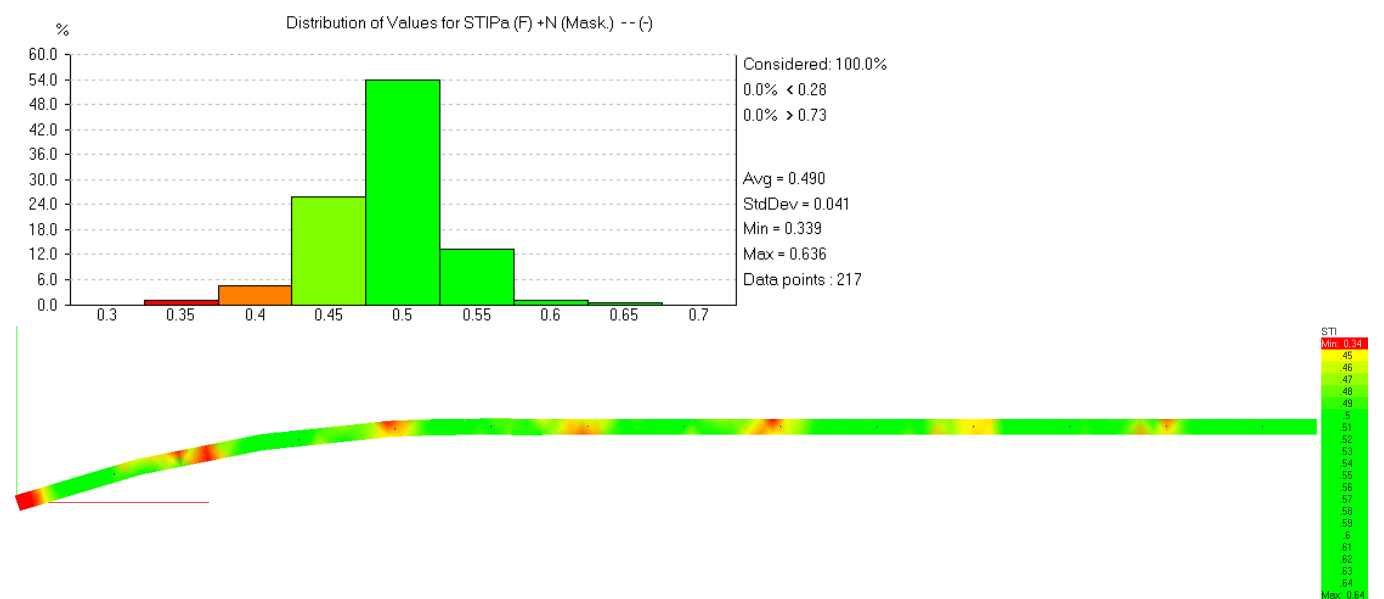*including masking and acoustic background (95 dBA)*

Results comparison

TABLE: **Results summary**

PARAMETER	14 loudspeakers tunnel ABT-100 TNL	7 loudspeakers tunnel ABT-100 TNL	14 loudspeakers tunnel ABT-TNL100 with boundary surface of 10 m × 2 m	7 loudspeakers tunnel ABT-TNL100 with boundary surface of 10 m × 2 m
Total SPL [dBA]	114,55	111,67	114,59	111,80
STIPa(F) + N(Mask)	0,47	0,46	0,49	**0,49**

As shown above, the optimal solution for achieving the highest speech intelligibility in a circular tunnel is the use of additional flat border surfaces directly above the loudspeakers. This allows the **STI to reach a value of 0.49**, which is very high for a space with such a long reverberation time without using costly acoustic treatment. The high efficiency and directionality of the ABT-TNL100 speakers allows you to achieve speech intelligibility at the same level when you place your speakers at 50 m and every 100 m. This reduces system cost and installation by half without lowering system performance.

Again, to ensure the best results verify the ABT-TNL100 speaker spacing by conducting a detailed acoustic analysis using simulations.

Dedicated Amplifier System

When designing voice evacuation systems in road tunnels, it is necessary to use dedicated tunnel loudspeakers, but also a dedicated system for amplifying the electroacoustic signal. **S4T – Safety for Tunnel** is a comprehensive solution for tunnels, which includes voice evacuation system control units also manufactured in Poland by Ambient System. **The heart of the system is the ABT-CU11LCD control unit with built-in DSP.** It is the manager of the system and the audio matrix at the same time and allows monitoring of key functions and all system components, such as memory cards, power amplifiers (e.g. switching to standby amplifiers), emergency power supply, loudspeaker lines, the connections to other systems, e.g. fire detection systems and many others. The unit allows you to control the loudspeaker line impedances with built-in adaptive measuring algorithm and to adjust tolerance for each loudspeaker. It provides redundancy of connections between control units and fireman's microphones through digital fibre-optic connection implemented in a ring topology, allowing the transmission of 45 audio channels

ABT-CU-11LCD / front panel

ABT-PA8160B / front panel

at 32-bit definition. With a built-in network card with SFP ports, there is no need to provide any external network switches. The matrix provides the ability to use an audio limiter on each loudspeaker line to prevent damage to the loudspeakers. The DSP allows for higher values of speech intelligibility through the use of a 3-band parametric EQ on every audio input and an 8-band parametric EQ on each audio output.

There is a built-in feedback eliminator and the ability to define the delay for each tunnel loudspeaker up to 30sec. The system also offers an intercom facility between the alarm and the zone microphones. Class D multi-channel power amplifiers allow you to provide adequate amplification of the acoustic signal and the use of a single channel for a standby amplifier.

Delays of Loudspeaker Lines

In order to minimize unwanted echo effects that adversely affect speech intelligibility, each loudspeaker needs to be powered individually by a signal from a separate amplifier channel. The use of DSP is neces- sary, which processes each signal with EQ and a delay line. You need to understand and plan for the time that the acoustic wave that takes to go the long distances between the loudspeakers. Time synchronization of the sound signal coming from each previous loudspeaker with each next loudspeaker is really important. Our conducted tests have proven that with the right tuning and using the built-in EQ and precise setting of the delay, it is possible to increase the speech intelligibility index, the STI by 0.1.
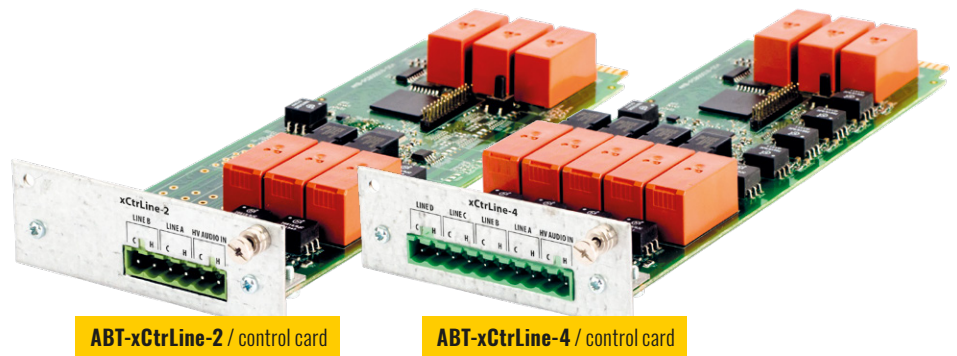

ABT-DMS-LCD / zone microphone

System architecture

The S4T system is based on a digital fibre-optic connection between the ABT-CU-11LCD control units and the ABT- DFMS fireman microphone. Communication with control units is performed over Ethernet networks with 1000BASE-X or 10/100 / 1000BASE-T / TX fibre-optic links. Transmitted digitally, without interference and distortion, audio signals do not lose quality. The ABT-CU-11LCD control unit combines function of audio inputs and out-puts, matrix, DSPs, loudspeaker controllers, and a network switch in one device. It is also responsible for providing automatic evacuation and warning messages triggered by the fire detection system using the ABT-xLogIN-8f logic input board.

One ABT-CU-11LCD unit can handle up to 10 ABT-TNL100 tunnel speakers, fed with individual audio signals. DSP enables detailed processing of time and frequency signals for a very precise setting of the time delay individually for each speaker depending on the distance between them. Thanks to the parametric equaliser functions, it is possible to adjust the frequency response of each speaker to best suit the acoustical conditions of different architectural interiors of tunnels.

ABT-xCtrLine-4 and ABT-xCtrLine-2 control cards, which are responsible for monitoring the loudspeaker line continuity and signalling the correct working of each ABT-TNL100 speaker. In case of failure, they can enable the switching of the faulty amplifier channels to standby backup amplifiers. The eight-channel (ABT-PA8160B) and four-channel amplifiers deliver 160W

ABT-xCtrLine-2 / control card   **ABT-xCtrLine-4** / control card

ABT-DFMS / fireman microphone + extension

of power per each channel. They use 100V line technology, so it is possible to transmit already amplified audio signal over very long distances with minimal power loss. In the event of a mains power failure, the S4T system will continue to function uninterruptedly by using emergency power. The ABT-PSM48 Power Manager is responsible for distribution and switching power. It simultaneously manages the charging of 48V batteries and distributes power to all system devices. As a source for the VES power supply system, the manager uses the power modules of the 48V power supply 800W (ABT-PS48800) and batteries up to 200Ah.

Fireman's microphones and zone microphones are used to broadcast voice messages. The ABT-DFMS and ABT-DFMS BOX are designed for use by emergency services (with built-in emergency power supply and touch LCD screen), and are most often installed at entrances at the ends of the tunnel and in service buildings. ABT-DFMS has programmable function keys that can be assigned to selected functions in any way. It also has the ability to add up to 5 ABT-EKB-20M extensions with additional function keys.

The "CPU-OFF" switch enables imme- diate and direct transmission of messages to all zones without the control system (even during central processor failure). Microphones have automatic detection and signalling of buttons and audio path damage from the microphone capsule

through to the control unit. The built-in BLACK BOX will record all the alarm communication sent during any period when the system is in alarm mode. The ABT-DMS-LCD zone microphone is typically installed in tunnel maintenance buildings. Used to call general purpose messages, select individual zones, and broadcast live voice messages. The microphone has a local monitor loudspeaker to listen to any one of the zones. It also has the ability to add up to 5 ABT-EKB-20M extensions with additional function keys. The ABT-DMS-LCD has additional audio outputs that allow to connect an external recorder and a radio broadcasting systems in the service building. In addition, all microphones in the S4T system provide intercom functionality – two-way communication between microphones.

A key function also offered by the S4T system is automatic gain control driven by ABT-AMBN-MIC background microphones. Thanks to this, it is possible for the system to automatically adjust the level of the message to compensate for the level of tunnel noise.

The S4T system also provides options for additional MCR-SMSP20 fire loudspeakers in evacuation passages and technical rooms and ABT-W6 wall-mounted fire loudspeakers in the service building.
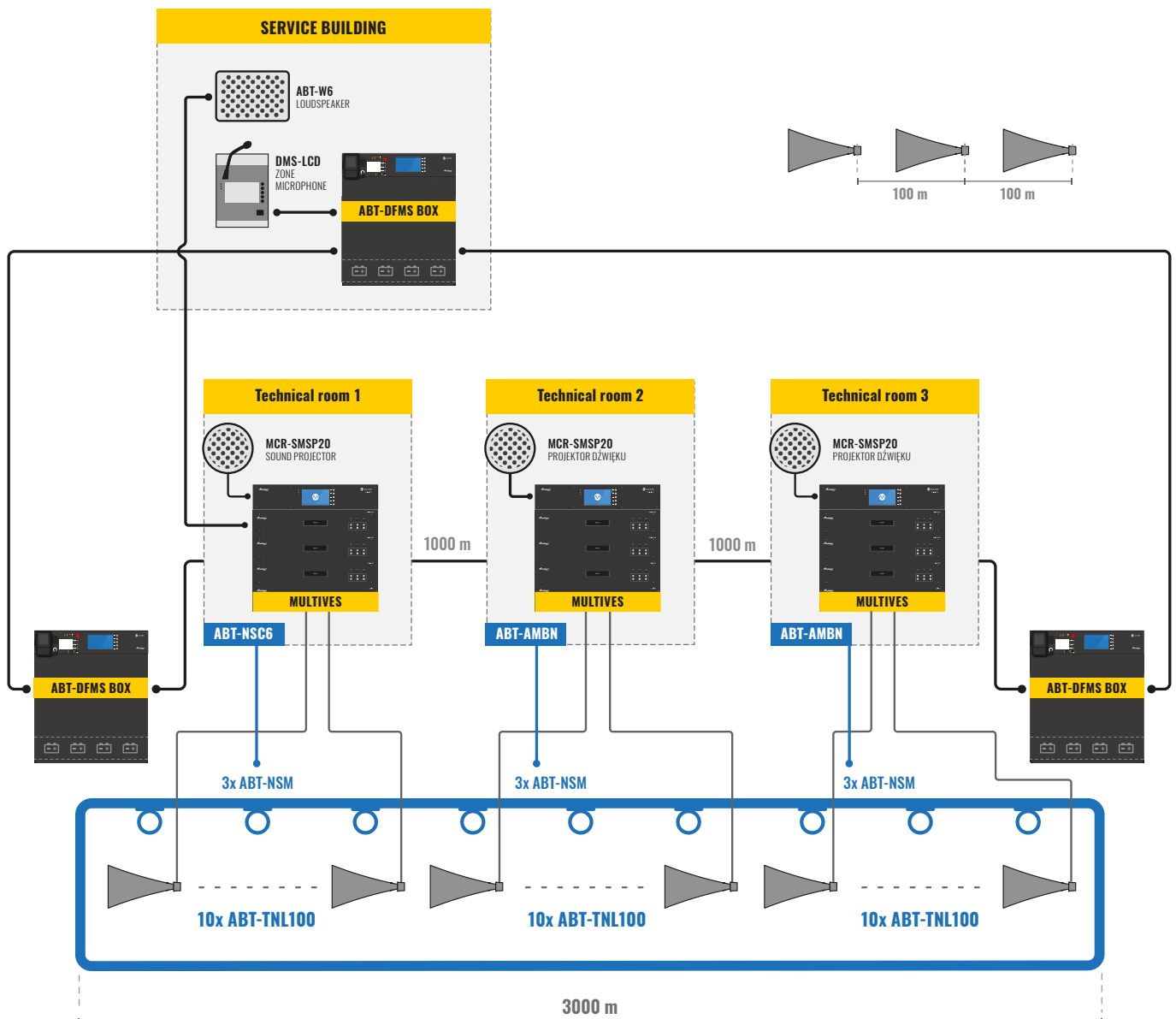
Examples of system configuration

Depending on the tunnel architecture and design guidelines, thanks to the modular structure of the S4T system, configurations are possible to meets any requirement.

EXAMPLE 1

The following is an example of the typical connection pattern of a S4T application in a tunnel 3 km long with the placement of ABT-TNL100 tunnel speakers placed every 100 m. The technical rooms, in which the S4T units are located are spaced 1000 m apart. ABT-DFMS BOX fireman's microphones are located at the entrance to the tunnels and in the service building, which also includes a zone microphone. In addition it was decided to use the MCR-SMSP20 projector fire speakers in technical rooms and the ABT-W6 wall-mounted fire speakers in services building. Background microphones are located every 330 m.
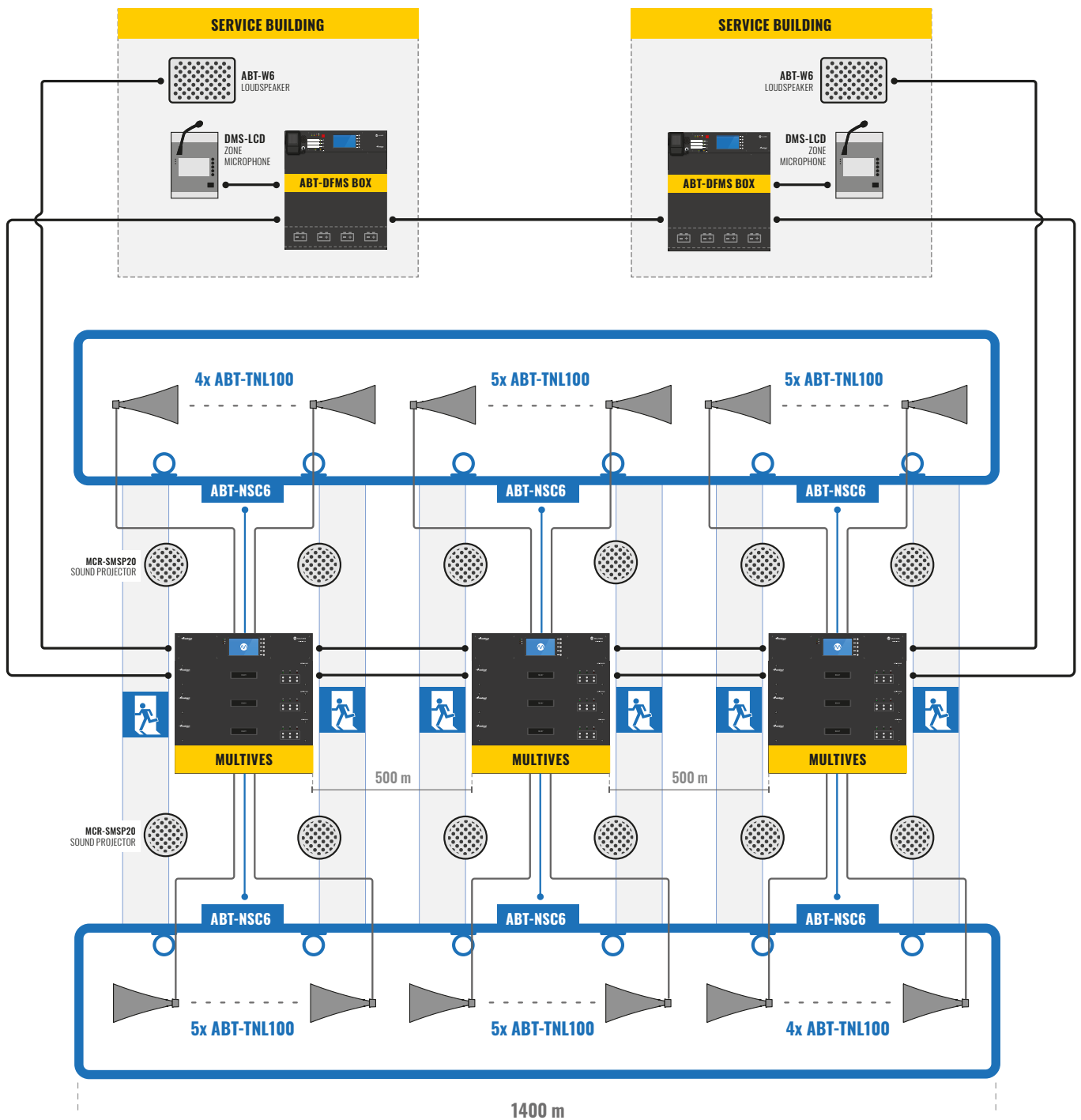
EXAMPLE 2

This example shows an 1800 m long tunnel with two paths with two-way traffic direction. The ABT-TNL100 speakers are spaced every 100 m. The technical rooms, where the S4T units are located, are 500 m apart. ABT-DFMS BOX fireman's microphones are located at the entrance to the tunnels and in the service building, which also includes a zone microphone. In addition, it was decided to include the MCR-SMSP20 projector fire speakers in evacuation passages and technical rooms, and the ABT-W6 wall-mounted fire speakers in services building. Background microphones are located every 330 m.

The following is a typical set of devices in one location that supports 10 tunnel speakers:

ABT-CU-11LCD	Control unit with LCD (11 Control slots)	1
ABT-xCtrLine-4	4 loudspeaker line control card	1
ABT-xCtrLine-2	2 loudspeaker line control card	9
ABT-ISLE	Audio / RS485 interface	3
ABT-PA8160B	Power amplifier 8 × 160 W (class D)	1
ABT-PA4160B	Power amplifier 4 × 160 W (class D)	1
ABT-PSM48	Power supply manager	1
ABT-PS48800	Power supply	2
ABT-PF4	System power supply frame	1
AKU 65-12	Battery 12 V 65 Ah	4
RACK 19" 24U	RACK 24U (600 × 800 mm)	1
ABT-TNL100	Tunnel Loudspeaker 100 W, 100 V	10
SF-MM31002D-GP	Module SFP, 1.25 Gbps SX + 1350 nm LC DDM MMF 2 km	2

Additional equipment that needs to be included in the tunnel design, depending on functional requirements and design guidelines:

ABT-xLogIN-8f	Logical 8 input card for function slot
ABT-DFMS	Fireman microphone
ABT-DFMS BOX	Fireman microphone with built-in emergency power supply
ABT-DMS-LCD	Zone microphone (LCD)
ABT-NSM	Noise sensing microphone
ABT-NSC6	Noise sensing controller
ABT-EKB-20M	Microphone keyboard extension (20 buttons)
MCR-SMSP20	Fire Sound Projector 20 W, 100 V
ABT-W6	Wall-mounted, aesthetic Loudspeaker: 6 W, 100 V
GS18E48-P1J	Zone microphone power supply 48 VDC, 0,375 A,18 W, plug: EU

The choice and number of devices may be different depending on the tunnel architecture and design guidelines. Each project should be considered individually and preceded by detailed analysis and acoustic simulation.

SAFETY FOR TUNNEL

ADVANCED VES FOR
ROAD TUNNELS APPLICATION

S4T

Safety for Tunnel

Ambient System — manufacturer of **MULTIVES** and **miniVES** digital voice evacuation systems, fully compliant with current standards EN 54-16 and EN 54-4, has extensive experience in providing comprehensive solutions for sounding system and voice evacuation systems for acoustically challenging facilities, where the very high quality of sound reproduction and obtaining the highest degree of speech intelligibility are the paramount. We successfully deliver sound systems for sports facilities, airports, train stations, museums, multi-storey shopping malls and road tunnels.

S4T – Safety for Tunnel offers the most effective solution that combines a dedicated Voice Evacuation System and specially designed ABT-TNL100 tunnel loudspeakers.

The system fully meets the requirements of the RABT Edition 2006. In contrast to conventional solutions based on the use of horn loudspeakers, it allows for clear reception of broadcast voice messages. The S4T achieves very high STI speech intelligibility which is unachievable for other speaker systems in the difficult acoustic conditions found in tunnels

ambient SYSTEM

We make everyday life safer

EN / 08.2020