TECHNICAL REPORT

ISO/TR 17534-4

First edition
2020-11

Acoustics — Software for the calculation of sound outdoors —

Part 4: Recommendations for a quality assured implementation of the COMMISSION DIRECTIVE (EU) 2015/996 in software according to ISO 17534-1

Acoustique — Logiciels de prévision de bruit dans l'environnement —

Partie 4: Recommandations pour l'assurance qualité de la mise en œuvre de la DIRECTIVE (UE) 2015/996 de la COMMISSION EUROPÉENNE dans les logiciels selon l'ISO 17534-1

Reference number
ISO/TR 17534-4:2020(E)

Contents

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 1, *Noise*.

A list of all parts in the ISO 17534 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The structure of the ISO 17534 series is shown in Figure 1. ISO 17534-1 describes the general approach of the ISO 17534 series, aiming to facilitate a standardized interpretation and a verifiably consistent software implementation of outdoor sound calculation methods. ISO/TR 17534-2 contains general recommendations for test cases and for a quality assurance interface. Further parts of the ISO 17534 series each address a specific outdoor sound calculation method for which they provide an agreed interpretation of ambiguous aspects, a set of illustrative test cases along with reference solutions, and an example of a template form for the declaration of conformity for software developers.

This document addresses the calculation method laid down in the COMMISSION DIRECTIVE (EU) 2015/996, hereafter referred to as CNOSSOS-EU:2015.

The European Commission developed Common NOise aSSessment methOdS (CNOSSOS-EU) for road, railway, aircraft and industrial noise for the purpose of strategic noise mapping. CNOSSOS-EU aims at improving the consistency and comparability of noise assessment results across the EU Member States which are performed on the basis of the data becoming available through the consecutive rounds of strategic noise mapping in Europe.

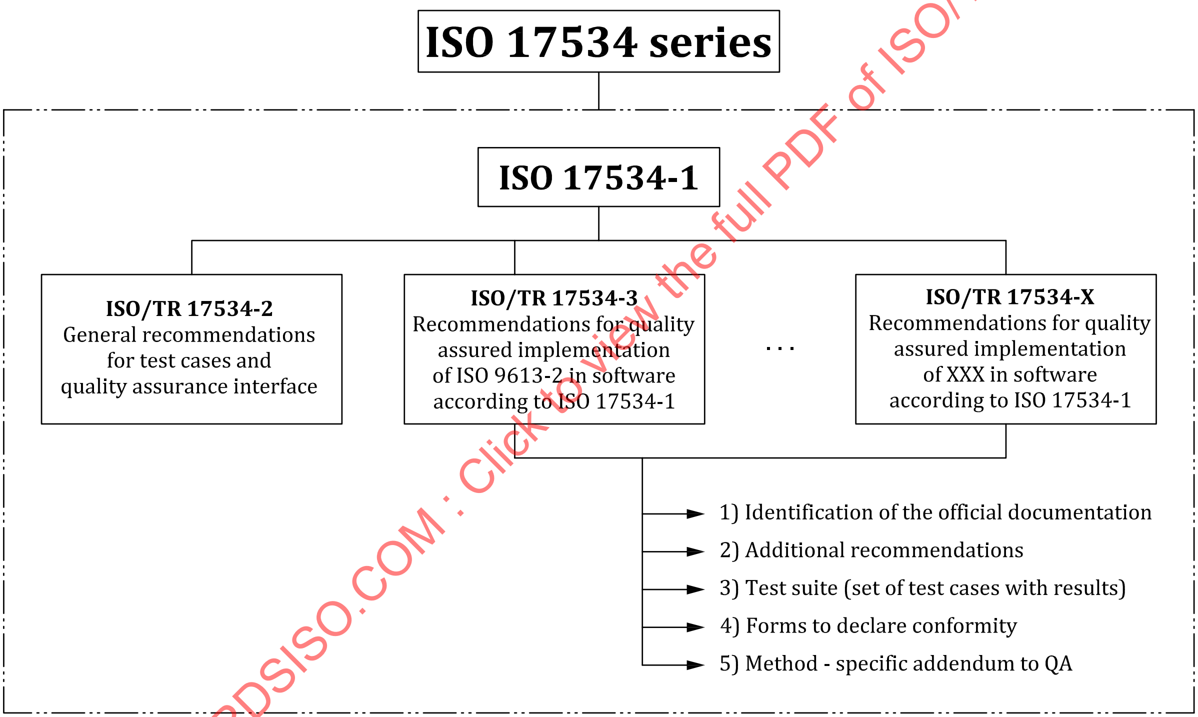


Figure 1 — Structure of the ISO 17534 series

Acoustics — Software for the calculation of sound outdoors —

Part 4: Recommendations for a quality assured implementation of the COMMISSION DIRECTIVE (EU) 2015/996 in software according to ISO 17534-1

1 Scope

This document facilitates a standardized interpretation and a verifiably consistent software implementation of the sound propagation part of the calculation method CNOSSOS-EU:2015 according to ISO 17534-1. Other parts of CNOSSOS-EU:2015, such as the source models or the calculation method for aircraft noise, are beyond the scope of this document. This document provides an agreed interpretation of ambiguous aspects of the sound propagation part of CNOSSOS-EU:2015, a set of illustrative test cases along with reference solutions, and an example of a template form for the declaration of conformity for software manufacturers.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 17534-1, *Acoustics — Software for the calculation of sound outdoors — Part 1: Quality requirements and quality assurance*

ISO/TR 17534-2, *Acoustics — Software for the calculation of sound outdoors — Part 2: General recommendations for test cases and quality assurance interface*

COMMISSION DIRECTIVE (EU) 2015/996 of 19 May 2015 establishing common noise assessment methods according to Directive 2002/49/EC of the European Parliament and of the Council, Official Journal of the European Union, L 168/1

3 Terms and definitions

For the purposes of this document, the terms and definitions given in CNOSSOS-EU:2015, ISO 17534-1, and ISO/TR 17534-2 apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

4 Identification of the official documentation

COMMISSION DIRECTIVE (EU) 2015/996 of 19 May 2015 establishing common noise assessment methods according to Directive 2002/49/EC of the European Parliament and of the Council, Official Journal of the European Union, L 168/1, herein referred to as CNOSSOS-EU:2015.

In its Chapter 2.5, “Calculation of noise propagation for road, railway, industrial sources”, CNOSSOS-EU: 2015 describes a method for calculating the attenuation of sound during propagation outdoors in order to predict the levels of environmental noise at a distance from a variety of sources.

5 Uniform and agreed interpretation of ambiguities

5.1 General

The propagation of sound outdoors in CNOSSOS-EU:2015 is calculated with a ray-based energetic model. Attenuations are calculated in eight octave bands, and separately for two idealized meteorological conditions labelled homogeneous and favourable. Finally, the A-weighted exposure level at a receiver position is given as the weighted energetic sum over all sources, paths, meteorological conditions, and octave bands.

Some aspects of the sound propagation model of CNOSSOS-EU:2015 are not described in sufficient detail to be unambiguous; in other aspects, in some part the official documentation is misleading. For each of these problematic topics, an agreed interpretation is given in 5.2 to 5.15 to allow for a standardized understanding of CNOSSOS-EU:2015.

The abbreviations are not explained when they are identical to those described in CNOSSOS-EU:2015.

Symbols are not defined when they are identical to those applied in CNOSSOS-EU:2015.

5.2 Sloping objects

Topic: CNOSSOS-EU:2015 states in subclause 2.5.1 that “obstacles sloping, when modelled, more than 15° in relation to the vertical are out of the scope of this calculation method”. This restriction does not constitute a general restriction of the method. Rather, it applies only to reflectors: obstacles sloping more than 15° in relation to the vertical are not considered as reflectors.

Agreed interpretation:

Objects sloping more than 15° in relation to the vertical are not considered as reflectors, but are taken into account in all other aspects of propagation such as ground effects and diffraction.

5.3 Equivalent heights

Topic: CNOSSOS-EU:2015 states in subclause 2.5.3, under the headline "Significant heights above the ground", that “If the equivalent height of a point becomes negative, i.e. if the point is located below the mean ground plane, a null height is retained, and the equivalent point is then identical with its possible image.” For points located below the mean ground plane, the equivalent height is set to zero in the calculation of A_{ground}. For the calculation of path length differences, it is irrelevant whether points lie above or below a mean ground plane, no points are shifted. For the calculation of $\Delta_{\text{ground(S,O)}}$ and $\Delta_{\text{ground(O,R)}}$ special care has to be taken in the case that one of the respective end points lies below the mean ground plane.

Agreed interpretation:

The first major step in the algorithm is to decide whether A_{ground} or A_{dif} must be calculated. The step is based on real coordinates, not equivalent heights. If a point lies below the mean ground plane, its equivalent height is set to zero in the calculation of A_{ground}. Equations (2.5.31) and (2.5.32) of CNOSSOS -EU:2015 apply only in the most common case that both S and R lay above the mean ground plane. If either S or R lies below the mean ground plane, the following simplified Equations apply:

$\Delta_{\text{ground(S,O)}} = A_{\text{ground(S,O)}}$ (CNOSSOS-EU:2015, 2.5.31)

$\Delta_{\text{ground(O,R)}} = A_{\text{ground(O,R)}}$ (CNOSSOS-EU:2015, 2.5.32)

For the calculation of path length differences, the original coordinates are used and no points are shifted, i.e. in the calculation of $\Delta_{\mathrm{dif(S,R)}}$ the original heights of S and R are used.

5.4 Alternative statistical approach

Topic: CNOSSOS-EU:2015 mentions in subclause 2.5.5, under the headline "Statistical approach inside urban areas for a path (S, R)", a statistical approach for calculations inside urban areas beyond the first line of buildings. This approach is not described in sufficient detail to be subjected to the quality assurance methodology of ISO 17534-1.

Agreed interpretation:

A statistical approach is not appropriate in the calculation of sound propagation beyond the first line of buildings.

5.5 Octave band centre frequency f_{m}

Topic: CNOSSOS-EU:2015 is somewhat ambiguous about whether nominal centre frequencies or exact centre frequencies should be used in the calculation of the atmospheric attenuation coefficient α_{atm}.

Agreed interpretation:

In the calculation of the atmospheric attenuation coefficient α_{atm}, ISO 9613-1 is followed, and exact centre frequencies are used. In all other calculations, the nominal centre frequency, denoted f_{m}, are used.

The tabulated values in ISO 9613-1 are based on the pressure at sea level.

5.6 Ground factor of the source area, G_{S}

Topic: CNOSSOS-EU:2015 introduces G_{S} in subclause 2.5.6 as the ground factor G of the source area. For industrial sources, it is left open how exactly G_{S} is to be calculated.

Agreed interpretation:

For industrial point sources, G_{S} is calculated as the average of the ground factor G over a distance of 1 m beginning at the vertical projection point below the source and proceeding along the direction source-receiver.

5.7 Distances in Figure 2.5.b of CNOSSOS-EU:2015

Topic: In CNOSSOS-EU:2015, it is unclear whether the distances d displayed in Figure 2.5.b are 3D-distances along the ground or 2D-projection onto a horizontal plane.

Agreed interpretation:

Figure 2.5.b displays a 2D-projection onto the horizontal plane. The distances d used in the calculation of G_{path} are measured in this horizontal plane.

5.8 Equivalent heights in Equation (2.5.20) of CNOSSOS-EU:2015

Topic: CNOSSOS-EU:2015 explains that modified equivalent heights should be used in the calculation of $A_{\mathrm{ground,F}}$. But it is unclear whether these modified equivalent heights or unmodified equivalent heights should be used in the calculation of $A_{\mathrm{ground,F,min}}$ according to Equation (2.5.20) of CNOSSOS-EU:2015.

Agreed interpretation:

Unmodified equivalent heights are used in the calculation of $A_{\mathrm{ground,F,min}}$ according to Equation (2.5.20) of CNOSSOS-EU:2015.

5.9 Rayleigh's Criterion

Topic: CNOSSOS-EU:2015 states that no diffraction should be calculated if the ray path passes "high enough" over the diffraction edge. In this context, CNOSSOS-EU:2015 refers to Rayleigh's Criterion without providing details or formulae. The circumstances under which diffraction is calculated should be defined unambiguously.

Agreed interpretation:

In the unique vertical plane containing source and receiver, the line of sight from source to receiver is defined, under homogeneous conditions, as the straight line connecting source and receiver. Under favourable conditions, the line of sight is defined as the arc of radius Γ, given by Equation (2.5.24) of CNOSSOS-EU:2015, connecting source and receiver.

The decision whether diffraction must be calculated is made separately for homogeneous and favourable conditions respectively. If the line of sight is blocked, diffraction is always calculated. If the line of sight from source to receiver is unobstructed, Rayleigh's Criterion is employed as follows: first, that point D of the terrain profile including obstacles is identified, which gives the largest δ_D, i.e. the δ_D with the smallest absolute value. Then δ_D* is calculated as the path length difference from S' to R' via D, where S' and R' are the respective images of source and receiver constructed with the appropriate mean ground planes containing source or receiver. Diffraction is calculated only if $\delta_D > -\lambda/20$ and $\delta_D > \lambda/4 - \delta_D^*$ (Rayleigh's Criterion), where λ is the wavelength at the nominal centre frequency and calculated with a speed of sound of 340 m/s.

5.10 Parameter *e*

Topic: CNOSSOS-EU:2015 introduces the parameter *e* as the total distance along the path from the first to the last diffraction edge according to the "rubber band method". It is unclear how the parameter *e* is calculated for favourable propagation conditions.

Agreed interpretation:

The parameter *e* is defined as the total distance along the path from the first to the last diffraction edge. Under homogeneous conditions, straight lines are used as ray segments, while under favourable conditions, arcs of uniform radius are used as ray segments. Different diffraction edges may be relevant under homogeneous and favourable conditions respectively.

5.11 Diffraction under favourable conditions

Topic: CNOSSOS-EU:2015 explains diffraction under favourable propagation conditions. The text contains too little details to be unambiguous. In particular, the scale of Figure 2.5.f of CNOSSOS-EU: 2015 is chosen such that the ray segments appear to be straight lines while they should be arcs of radius Γ, given by Equation (2.5.24) of CNOSSOS-EU:2015.

Agreed interpretation:

Under favourable conditions, the propagation path in the vertical plane always consists of segments of a circle whose radius is given by the 3D-distance between source and receiver according to Equation (2.5.24) of CNOSSOS-EU:2015, i.e. all segments of a propagation path have the same radius of curvature. If the direct arc connecting source and receiver is blocked, the propagation path is defined as the shortest convex combination of arcs enveloping all obstacles. Convex in this context means that at each diffraction point, the outgoing ray segment is deflected downward with respect to the incoming ray segment (see ISO 9613-1).

To illustrate the principle of constructing the ray path with multiple diffractions under favourable conditions, Figure 2 is a slightly modified version of Figure 2.5.f of CNOSSOS-EU:2015, scaled such that the curvature of the rays is apparent.

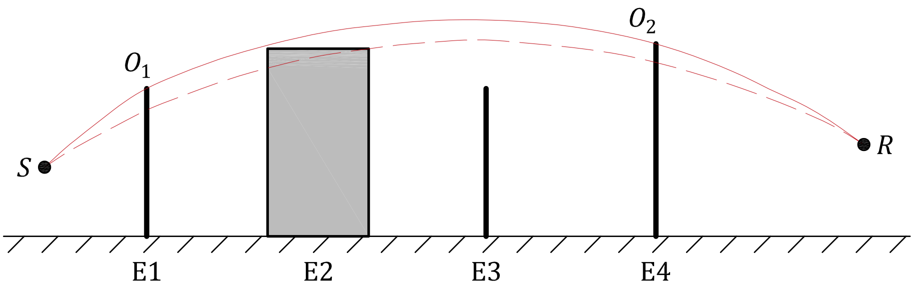


Figure 2 — Modified version of Figure 2.5.f of CNOSSOS-EU:2015 showing ray paths with easily visible curvature

5.12 Error in Figure 2.5.f and Equation (2.5.29) of CNOSSOS-EU:2015

Topic: Figure 2.5.f and Equation (2.5.29) of CNOSSOS-EU:2015 are erroneous.

Agreed interpretation:

Figure 2.5.f and Equation (2.5.29) of CNOSSOS-EU:2015 treat the point O_3 as a diffraction edge, even though it lies below the rubber band. This is incorrect. Given the geometry displayed in Figure 2.5.f of CNOSSOS-EU:2015, the right-hand edge of obstacle E2 cannot be treated as a diffraction edge. A corrected version of Figure 2.5.f of CNOSSOS-EU:2015 is displayed as Figure 3, with Equation (2.5.29) of CNOSSOS-EU:2015 reading: $\delta_F = \widehat{SO_1} + \widehat{O_1O_2} + \widehat{O_2O_3} + \widehat{O_3R} - \widehat{SR}$.

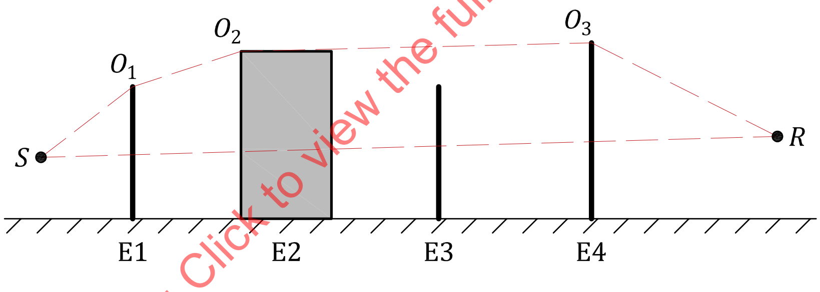


Figure 3 — Corrected version of Figure 2.5.f of CNOSSOS-EU:2015

5.13 Lateral diffraction

Topic: CNOSSOS-EU:2015 introduces lateral diffraction, i.e. diffraction on vertical edges. The description is too short to be unambiguous. In particular, it is left open exactly how laterally diffracted propagation paths are to be constructed.

Agreed interpretation:

As a general principle, lateral diffraction is considered only if the direct line of sight (see 5.9 above) between source and receiver is blocked and does not penetrate the terrain profile. In addition, the source must not be a mirror source due to reflection. This said, lateral diffraction edges are sought in the unique plane which contains both source and receiver, and which is also perpendicular to the vertical propagation plane. Obstacles are taken into account including adjoining obstacles. Obstacles which penetrate this plane form an area of intersection with that plane. An intersection area is only considered relevant if the corresponding obstacle is intersected by the direct line of sight. The diffraction edges of lateral paths are defined by a rubber band that stretches from source to receiver, left and right of the direct line of sight respectively, and encompasses all relevant intersection areas.

To calculate the ground attenuation for a laterally diffracted propagation path, a mean ground plane is calculated for the terrain profile vertically below the propagation path between source and receiver. This utilises a vertical X-Z auxiliary plane, whose Z coordinate corresponds to the absolute height, and whose X coordinate corresponds to the distance from the source point along the propagation path in the projection onto a horizontal plane. If a lateral propagation path in the projection onto a horizontal plane intersects the ground layout of a building, this building is taken into account in the calculation of G_{path} (usually with G=0) and in the calculation of the mean ground plane using its height. With respect to the calculation of the ground attenuation, a laterally diffracted propagation path is treated in the auxiliary X-Z plane as a propagation path with unblocked line of sight, and without diffraction.

5.14 Reflection on nearly vertical objects

Topic: CNOSSOS-EU:2015 explains reflection on (nearly) vertical objects. Further specifications are needed to formulate this aspect unambiguously.

Agreed interpretation:

Objects are considered as reflectors only if they slope less than 15° with respect to the vertical. For the calculation of reflected sound with a mirror image source propagation is only considered in a vertical propagation plane (i.e. not for laterally diffracted paths). The point of reflection, which lies on the reflecting object, is constructed assuming the reflecting surface is vertical. Ray paths are constructed for incident and reflected paths using straight lines under homogeneous conditions, and arcs under favourable conditions.

The height of the reflector, as viewed from the direction of the incident ray and measured through the point of reflection, is at least 0,5 m. The width of the reflector as viewed from the direction of the incident ray in a horizontal plane containing this reflection point is at least 0,5 m.

5.15 Retrodiffraction

Topic: CNOSSOS-EU:2015 describes the principle of retrodiffraction. It is unclear under which circumstances retrodiffraction is to be considered and how retrodiffraction is dealt with under favourable conditions.

Agreed interpretation:

Attenuation through retrodiffraction is calculated for every reflection.

The construction of the relevant path length difference δ' is shown in Figure 4 for homogeneous conditions. The upper edge of the reflector is used as fictitious diffraction edge and straight lines are used as ray segments. The resulting path length difference is $\delta' = \overline{S'O} - \overline{S'P} - \overline{PO}$.

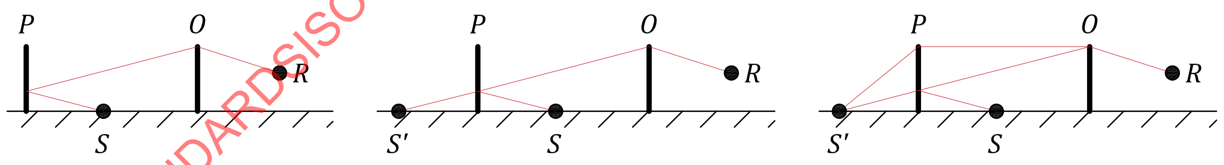


Figure 4 — Example for retrodiffraction under homogeneous conditions

Figure 5 depicts the same situation under favourable conditions. The construction is analogous to the homogeneous case but uses arcs for ray segments, instead of straight lines. In this example, the resulting path length difference becomes $\delta' = \widehat{S'O} + \widehat{OR} - \widehat{S'P} - \widehat{PR}$.

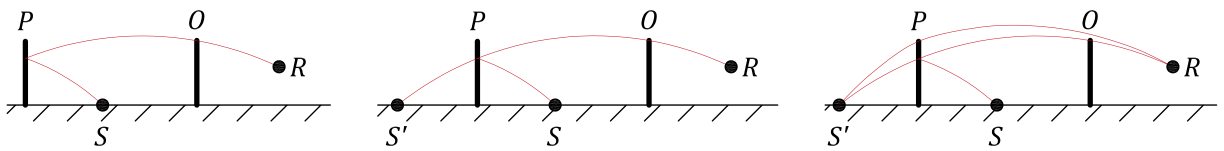


Figure 5 — Example for retrodiffraction under favourable conditions

6 Test cases

6.1 General

The test cases are based on the series proposed with ISO/TR 17534-2, but extended to address special aspects of CNOSSOS-EU:2015. As mentioned in 5.13, diffraction on vertical edges is not described in sufficient detail to be unambiguous in the official documentation. The sentence "Equation (2.5.21) may be used to calculate the diffractions on vertical edges (lateral diffractions) in case of industrial noise" opens many possibilities to treat this issue. According to the general requirements of Quality Assurance in ISO 17534-1 it was necessary to provide a detailed specification – this is given in 5.13 above. Lateral diffraction is restricted to industrial sources and ensures a continuous transition from the screened to the unscreened position when the receiver moves horizontally behind the objects blocking the direct line of sight. Unfortunately, lateral diffraction requires a lot of additional calculation steps.

Independent from the different national specifications (in which cases lateral diffraction is taken into account) lateral diffraction is included in all test cases where it influences the result if the point source is assumed to be an industrial facility, thus allowing for the certification of a correct implementation in all cases. The test cases are complete in the sense that all data necessary to perform the calculations are given.

Intermediate and final results are shown separately for the propagation in the vertical plane and for the propagation around vertical edges – when only road-traffic and railway are of concern, the validation of a quality assured implementation in accordance with ISO 17534-1 can be restricted to the propagation in the vertical plane.

When testing a software implementation, the calculated A-weighted long-term sound pressure levels, referred to as final results, are compared with the reference results given in 6.3 in Table 362 and Table 363. A software implementation of CNOSSOS-EU:2015 is considered quality assured in accordance with ISO 17534-1 if – for all test cases – the deviation of the calculated final results from the reference results does not exceed ±0,1 dB in any octave band. If some of the final results differ too much from the reference results, the implementation is considered flawed. Intermediate results are provided – mostly to two decimal places – to facilitate the necessary search for the deficiency of the implementation. Test results and tolerances are based on experience with calculations made with different software platforms.

Unless stated otherwise, the input parameters shown in Tables 1 and 2 apply to all test cases.

Table 1 — Input parameters identical for all test cases

p %	50
Relative humidity %	70
T °C	10

Table 2 — Linear octave-band sound power levels and A-weighting correction values

Value	Octave-band centre frequency in Hz							
	63	125	250	500	1 000	2 000	4 000	8 000
Sound power level L_W in dB	93	93	93	93	93	93	93	93
A-weighting correction value in dB	−26,2	−16,1	−8,6	−3,2	0,0	1,2	1,0	−1,1

In the Tables containing the parameters of the mean ground plane (MGP) and the heights *z* above this MGP, the two abbreviations z_1 and z_2 are used. Their correspondence to the notation in CNOSSOS-EU: 2015 is shown in Table 3.

Table 3 — Correspondence between z_1 and z_2, used in some Tables such as Table 18, and z_s, $z_{o,s}$, $z_{o,r}$, z_r

	S -> R	S -> O_1	O_n -> R
z_1	z_s	z_s	$z_{o,r}$
z_2	z_r	$z_{o,s}$	z_r

6.2 Test cases with intermediate and final results

6.2.1 TC01-TC03 — Flat ground with homogeneous acoustic properties

The test cases to check free sound propagation with different conditions are shown in Figure 6.

Key

S source

R receiver

Figure 6 — Test cases TC01-TC03 to check free sound propagation with different conditions

With the first three test cases, the correct consideration of the ground factor G is checked. The terrain is flat. Table 4 shows the coordinates of source and receiver which is identical for all three test cases.

Table 4 — Coordinates of source S and receiver R

Point	x (m)	y (m)	z (m)
S	10	10	1
R	200	50	4

6.2.2 TC01 — Reflecting ground (G = 0)

Tables 5 and 6 contain the intermediate and the final results.

Table 5 — Ground attenuation (in frequency bands where no diffraction is relevant)

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000
w (H)[a]	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
C_f (H)	194,16	194,16	194,16	194,16	194,16	194,16	194,16	194,16
$A_{ground,H}$ in dB	-3,00	-3,00	-3,00	-3,00	-3,00	-3,00	-3,00	-3,00
w (F)[b]	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
C_f (F)	194,16	194,16	194,16	194,16	194,16	194,16	194,16	194,16
$A_{ground,F}$ in dB	-4,36	-4,36	-4,36	-4,36	-4,36	-4,36	-4,36	-4,36

[a] (H) – homogeneous

[b] (F) – favourable

Table 6 — Step by step and final results related to the propagation in the vertical plane

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000	
L_W in dB	93	93	93	93	93	93	93	93	
α_{atm}	0,12	0,41	1,04	1,93	3,66	9,66	32,77	116,88	
A_{atm} in dB	0,02	0,08	0,20	0,37	0,71	1,88	6,36	22,70	
A_{div} in dB	56,76	56,76	56,76	56,76	56,76	56,76	56,76	56,76	
$A_{boundary,H}$ in dB	-3,00	-3,00	-3,00	-3,00	-3,00	-3,00	-3,00	-3,00	
$A_{boundary,F}$ in dB	-4,36	-4,36	-4,36	-4,36	-4,36	-4,36	-4,36	-4,36	**Total**
L_H in dB	39,21	39,16	39,03	38,86	38,53	37,36	32,87	16,54	46,70
L_F in dB	40,58	40,52	40,40	40,23	39,89	38,72	34,24	17,90	48,07
L in dB	39,95	39,89	39,77	39,60	39,26	38,09	33,61	17,27	47,44
A-weighting in dB	-26,2	-16,1	-8,6	-3,2	0,0	1,2	1,0	-1,1	
L_A in dB	13,75	23,79	31,17	36,40	39,26	39,29	34,61	16,17	44,12

6.2.3 TC02 — Mixed ground (G = 0,5)

Tables 7 and 8 contain the intermediate and the final results.

Table 7 — Ground attenuation (in frequency bands where no diffraction is relevant)

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000
w (H)	8,2E-05	4,5E-04	2,5E-03	0,01	0,08	0,41	2,10	10,13
C_f (H)	199,17	213,44	225,43	134,05	23,76	2,49	0,47	0,10
$A_{ground,H}$ in dB	-1,50	-1,50	-1,50	0,85	5,71	-1,50	-1,50	-1,50
w (F)	0,00	0,00	0,00	0,01	0,08	0,41	2,10	10,13
C_f (F)	199,17	213,44	225,43	134,05	23,76	2,49	0,47	0,10
$A_{ground,F}$ in dB	-2,18	-2,18	-2,18	-2,18	-0,93	-2,18	-2,18	-2,18

Table 8 — Step by step and final results related to the propagation in the vertical plane

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000
L_W in dB	93	93	93	93	93	93	93	93
α_{atm}	0,12	0,41	1,04	1,93	3,66	9,66	32,77	116,88
A_{atm} in dB	0,02	0,08	0,20	0,37	0,71	1,88	6,36	22,70
A_{div} in dB	56,76	56,76	56,76	56,76	56,76	56,76	56,76	56,76
$A_{boundary,H}$ in dB	-1,50	-1,50	-1,50	0,85	5,71	-1,50	-1,50	-1,50

Table 8 *(continued)*

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000	
$A_{\mathrm{boundary,F}}$ in dB	-2,18	-2,18	-2,18	-2,18	-0,93	-2,18	-2,18	-2,18	**Total**
L_{H} in dB	37,71	37,66	37,53	35,01	29,82	35,86	31,37	15,04	44,28
L_{F} in dB	38,39	38,34	38,22	38,04	36,45	36,54	32,05	15,72	45,72
L in dB	38,07	38,01	37,89	36,79	34,29	36,21	31,73	15,39	45,06
A-weighting in dB	-26,2	-16,1	-8,6	-3,2	0,0	1,2	1,0	-1,1	
L_{A} in dB	11,87	21,91	29,29	33,59	34,29	37,41	32,73	14,29	41,27

6.2.4 TC03 — Porous ground (G = 1)

Tables 9 and 10 contain the intermediate and the final results.

Table 9 — Ground attenuation (in frequency bands where no diffraction is relevant)

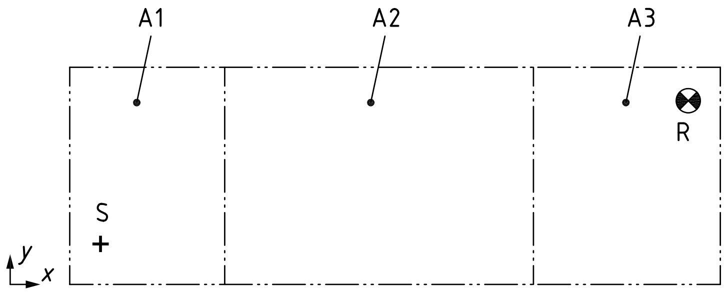
f in Hz	63	125	250	500	1 000	2 000	4 000	8 000
w (H)	4,9E-04	2,7E-03	1,5E-02	0,08	0,41	2,02	9,06	35,59
C_f (H)	214,47	224,67	130,15	22,76	2,48	0,49	0,11	0,03
$A_{\mathrm{ground,H}}$ in dB	0,00	0,00	1,59	9,67	5,03	0,00	0,00	0,00
w (F)	0,00	0,00	0,01	0,08	0,41	2,02	9,06	35,59
C_f (F)	214,47	224,67	130,15	22,76	2,48	0,49	0,11	0,03
$A_{\mathrm{ground,F}}$ in dB	0,00	0,00	0,00	4,23	0,00	0,00	0,00	0,00

Table 10 — Step by step and final results related to the propagation in the vertical plane

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000	
L_W in dB	93	93	93	93	93	93	93	93	
α_{atm}	0,12	0,41	1,04	1,93	3,66	9,66	32,77	116,88	
A_{atm} in dB	0,02	0,08	0,20	0,37	0,71	1,88	6,36	22,70	
A_{div} in dB	56,76	56,76	56,76	56,76	56,76	56,76	56,76	56,76	
$A_{\mathrm{boundary,H}}$ in dB	0,00	0,00	1,59	9,67	5,03	0,00	0,00	0,00	
$A_{\mathrm{boundary,F}}$ in dB	0,00	0,00	0,00	4,23	0,00	0,00	0,00	0,00	**Total**
L_{H} in dB	36,21	36,16	34,45	26,19	30,49	34,36	29,87	13,54	42,14
L_{F} in dB	36,21	36,16	36,03	31,63	35,53	34,36	29,87	13,54	43,24
L in dB	36,21	36,16	35,31	29,71	33,70	34,36	29,87	13,54	42,72
A-weighting in dB	-26,2	-16,1	-8,6	-3,2	0,0	1,2	1,0	-1,1	
L_{A} in dB	10,01	20,06	26,71	26,51	33,70	35,56	30,87	12,44	39,14

6.2.5 TC04 — Flat ground with spatially varying acoustic properties

The aim of this test case is to check the correct consideration and averaging of varying ground factors G. This test case is shown in Figure 7.



Key

S source
R receiver
A1 area with G = 0,2
A2 area with G = 0,5
A3 area with G = 0,9

Figure 7 — Flat ground with different ground factors *G*

Table 11 contains the parameters of the areas with constant ground factor *G*, and Tables 12 to 14 show the detailed intermediate and the final results.

Table 11 — Rectangular areas with constant ground factor *G*

G	*x* (m)		*y* (m)	
	min	max	min	max
0,2	0,0	50,0	-20,0	80,0
0,5	50,0	150,0	-20,0	80,0
0,9	150,0	225,0	-20,0	80,0

Table 12 — *G*-profile (ground factor) along the propagation path

***G*-profile** S -> R			
from (m)	to (m)	length (m)	*G*
0,00	40,88	40,88	0,2
40,88	143,07	102,19	0,5
143,07	194,16	51,09	0,9

Table 13 — Ground attenuation (in frequency bands where no diffraction is relevant)

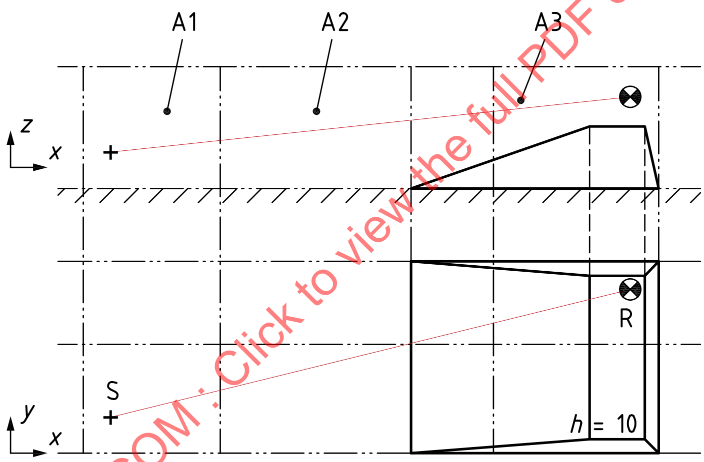
f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**
w (H)	1,0E-04	5,6E-04	3,1E-03	0,02	0,09	0,50	2,53	11,96
C_f (H)	200,18	216,12	221,91	116,87	17,87	2,02	0,39	0,08
$A_{\text{ground,H}}$ in dB	-1,37	-1,37	-1,37	1,77	6,23	-1,37	-1,37	-1,37
w (F)	0,00	0,00	0,00	0,02	0,09	0,50	2,53	11,96
C_f (F)	200,18	216,12	221,91	116,87	17,87	2,02	0,39	0,08
$A_{\text{ground,F}}$ in dB	-2,00	-2,00	-2,00	-2,00	-0,95	-2,00	-2,00	-2,00

Table 14 — Step by step and final results related to the propagation in the vertical plane

f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**	
L_W in dB	93	93	93	93	93	93	93	93	
α_{atm}	0,12	0,41	1,04	1,93	3,66	9,66	32,77	116,88	
A_{atm} in dB	0,02	0,08	0,20	0,37	0,71	1,88	6,36	22,70	
A_{div} in dB	56,76	56,76	56,76	56,76	56,76	56,76	56,76	56,76	
$A_{boundary,H}$ in dB	-1,37	-1,37	-1,37	1,77	6,23	-1,37	-1,37	-1,37	
$A_{boundary,F}$ in dB	-2,00	-2,00	-2,00	-2,00	-0,95	-2,00	-2,00	-2,00	**Total**
L_H in dB	37,59	37,53	37,41	34,10	29,29	35,73	31,25	14,91	44,05
L_F in dB	38,21	38,15	38,03	37,86	36,48	36,36	31,87	15,54	45,56
L in dB	37,91	37,85	37,73	36,37	34,23	36,06	31,57	15,24	44,87
A-weighting in dB	-26,2	-16,1	-8,6	-3,2	0,0	1,2	1,0	-1,1	
L_A in dB	11,71	21,75	29,13	33,17	34,23	37,26	32,57	14,14	41,09

6.2.6 TC05 — Ground with spatially varying heights and acoustic properties

This test case is to check the correct averaging of ground factors G in combination with varying ground heights. This test case is shown in Figures 8 and 9.



Key

S source

R receiver

A1 area with G = 0,9

A2 area with G = 0,5

A3 area with G = 0,2

Figure 8 — Ground with spatially varying heights and acoustic properties

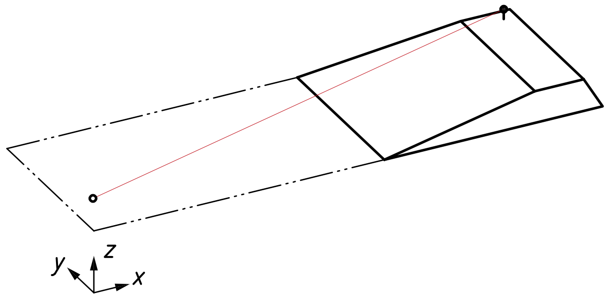


Figure 9 — 3D-presentation of scenario TC05

Tables 15 to 17 contain the modified and additional input parameters, Tables 18 to 20 the intermediate and the final results.

Table 15 — Coordinates of source S and receiver R

Point	x (m)	y (m)	z (m)
S	10	10	1
R	200	50	14

Table 16 — Contour lines to describe the shape of the ground surface

No	x_1 (m)	y_1 (m)	z_1 (m)	x_2 (m)	y_2 (m)	z_2 (m)
1	0	80	0	225	80	0
2	225	80	0	225	-20	0
3	225	-20	0	0	-20	0
4	0	-20	0	0	80	0
5	120	-20	0	120	80	0
6	185	-5	10	205	-5	10
7	205	-5	10	205	75	10
8	205	75	10	185	75	10
9	185	75	10	185	-5	10

Table 17 — Rectangular areas with constant ground factor *G*

G	x (m)		y (m)	
	min	max	min	max
0,9	0	50	-20	80
0,5	50	150	-20	80
0,2	150	225	-20	80

Table 18 — Mean ground plane MGP and averaged ground factors

Parameter	S -> R
a (MGP)	0,05
b (MGP) in m	-2,83
z_1 in m	3,83

Table 18 *(continued)*

Parameter	S -> R
z_2 in m	6,16
d_p in m	194,59
G_{path}	0,51
G'_{path}	0,64

Table 19 — Ground attenuation (in frequency bands where no diffraction is relevant)

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000
w (H)	1,6E-04	8,7E-04	4,8E-03	0,03	0,14	0,75	3,70	16,77
C_f (H)	203,37	222,35	207,73	82,09	9,63	1,33	0,27	0,06
$A_{ground,H}$ in dB	-1,07	-1,07	-1,07	-1,07	-1,07	-1,07	-1,07	-1,07
w (F)	0,00	0,00	0,00	0,01	0,08	0,42	2,16	10,35
C_f (F)	199,73	214,27	225,54	131,93	22,89	2,42	0,46	0,10
$A_{ground,F}$ in dB	-1,07	-1,07	-1,07	-1,07	-1,07	-1,07	-1,07	-1,07

Table 20 — Step by step and final results related to the propagation in the vertical plane

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000	
L_W in dB	93	93	93	93	93	93	93	93	
α_{atm}	0,12	0,41	1,04	1,93	3,66	9,66	32,77	116,88	
A_{atm} in dB	0,02	0,08	0,20	0,38	0,71	1,88	6,38	22,75	
A_{div} in dB	56,78	56,78	56,78	56,78	56,78	56,78	56,78	56,78	
$A_{boundary,H}$ in dB	-1,07	-1,07	-1,07	-1,07	-1,07	-1,07	-1,07	-1,07	
$A_{boundary,F}$ in dB	-1,07	-1,07	-1,07	-1,07	-1,07	-1,07	-1,07	-1,07	**Total**
L_H in dB	37,26	37,21	37,08	36,91	36,57	35,41	30,91	14,54	44,75
L_F in dB	37,26	37,21	37,08	36,91	36,57	35,41	30,91	14,54	44,75
L in dB	37,26	37,21	37,08	36,91	36,57	35,41	30,91	14,54	44,75
A-weighting in dB	-26,2	-16,1	-8,6	-3,2	0,0	1,2	1,0	-1,1	
L_A in dB	11,06	21,11	28,48	33,71	36,57	36,61	31,91	13,44	41,43

6.2.7 TC06 — Reduced receiver height to include diffraction in some frequency bands

This test case is identical to TC05 with the exception of a lower receiver height. The aim is to get diffraction in some frequency bands due to a negative path length difference. Figure 10 shows a cross section containing source and receiver.

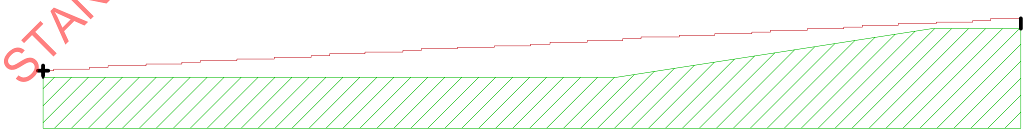


Figure 10 — Cross section containing S and R with ray S->R

Table 21 contains the modified receiver height, and Tables 22 to 30 present the intermediate and the final results. The detailed calculation steps show that diffraction occurs, but due to the Rayleigh-Criterion this diffraction is not relevant for the bands 63 Hz, 125 Hz and 250 Hz (see Tables 27 and 28). Diffraction is only relevant for homogeneous conditions in the octave bands 500 Hz and 1 000 Hz.

Table 21 — Coordinates of source S and receiver R

Point	x (m)	y (m)	z (m)
S	10	10	1
R	200	50	11,5

Table 22 — Ground attenuation (in frequency bands where no diffraction is relevant)

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000
w (H)	1,1E-04	6,0E-04	3,4E-03	-	-	0,53	2,70	12,70
C_f (H)	200,89	217,45	220,41	-	-	1,88	0,37	0,08
$A_{\text{ground,H}}$ in dB	-1,32	-1,32	-1,32	-	-	-1,32	-1,32	-1,32
w (F)	0,00	0,00	0,00	0,01	0,08	0,42	2,16	10,35
C_f (F)	199,59	214,11	225,39	131,90	22,89	2,42	0,46	0,10
$A_{\text{ground,F}}$ in dB	-1,32	-1,32	-1,29	-1,05	-1,32	-1,32	-1,32	-1,32

Table 23 — z-profile (ground height) along the propagation path

z-profile S-R		
No	u (m)	v (m)
1	0,00	0,00
2	112,41	0,00
3	178,84	10,00
4	194,16	10,00

Table 24 — Mean ground plane MGP and averaged ground factors (homogeneous)

Parameter	S -> R	S -> O1	On -> R
a (MGP)	0,05	0,05	0,00
b (MGP) in m	-2,83	-2,33	10,00
z_1 in m	3,83	3,33	0,00
z_2 in m	3,66	3,95	1,50
d_p in m	194,45	179,06	15,33
G_{path}	0,51	0,53	0,20
G'_{path}	0,56	0,60	

Table 25 — Coordinates of mirror points (homogeneous)

Mirror points	u (m)	v (m)
S' (S -> O)	0,31	-5,65
R' (O -> R)	194,16	8,50

Table 26 — Calculation of the path length differences

Parameter	S->R		S'->R		S->R'	
	(H)	(F)	(H)	(F)	(H)	(F)
No(O$_1$)	3	3	3	-	3	-
No(O$_n$)	3	3	3	-	3	-
d	194,45	194,58	194,61	-	194,31	-

Table 26 *(continued)*

Parameter	S->R		S'->R		S->R'	
	(H)	(F)	(H)	(F)	(H)	(F)
d_{ss}	179,06	179,16	179,21	-	179,06	-
d_{sr}	15,40	15,40	15,40	-	15,40	-
e	0,00	0,00	0,00	-	0,00	-
δ	-0,02	-0,04	0,00	-	0,15	-

Table 27 — Check of the "Rayleigh-Criterion" (homogeneous)

Parameter	Homogeneous							
	63	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**
O (No of edge in z-profile)	3,00	3,00	3,00	-	-	-	-	-
$-\lambda/20$	-0,27	-0,14	-0,07	-	-	-	-	-
S-R	194,45	194,45	194,45	-	-	-	-	-
d_{ss} (S-D-R)	179,06	179,06	179,06	-	-	-	-	-
d_{sr} (S-D-R)	15,40	15,40	15,40	-	-	-	-	-
δ_D	-0,02	-0,02	-0,02	-	-	-	-	-
$\delta_D > -\lambda/20$?	yes	yes	yes	-	-	-	-	-
S*-R*	194,37	194,37	194,37	-	-	-	-	-
d_{ss} (S*-D-R*)	179,21	179,21	179,21	-	-	-	-	-
d_{sr} (S*-D-R*)	15,40	15,40	15,40	-	-	-	-	-
$\delta_D{}^*$	0,24	0,24	0,24	-	-	-	-	-
$\lambda/4-\delta_D{}^*$	1,11	0,44	0,10	-	-	-	-	-
$\delta_D > (\lambda/4 - \delta_D{}^*)$?	no	no	no	-	-	-	-	-
R- Criterion OK?	no	no	no	-	-	-	-	-

Table 28 — Check of the "Rayleigh-Criterion" (favourable)

Parameter	Favourable							
	63	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**
O (No of edge in z-profile)	3,00	3,00	3,00	-	-	-	-	-
$-\lambda/20$	-0,27	-0,14	-0,07	-	-	-	-	-
S-R	194,58	194,58	194,58	-	-	-	-	-
d_{ss} (S-D-R)	179,16	179,16	179,16	-	-	-	-	-
d_{sr} (S-D-R)	15,40	15,40	15,40	-	-	-	-	-
δ_D	-0,04	-0,04	-0,04	-	-	-	-	-
$\delta_D > -\lambda/20$?	yes	yes	yes	-	-	-	-	-
S*-R*	194,50	194,50	194,50	-	-	-	-	-
d_{ss} (S*-D-R*)	179,31	179,31	179,31	-	-	-	-	-
d_{sr} (S*-D-R*)	15,40	15,40	15,40	-	-	-	-	-
$\delta_D{}^*$	0,21	0,21	0,21	-	-	-	-	-
$\lambda/4-\delta_D{}^*$	1,13	0,47	0,13	-	-	-	-	-
$\delta_D > (\lambda/4 - \delta_D{}^*)$?	no	no	no	-	-	-	-	-
R-Criterion OK?	no	no	no	-	-	-	-	-

Table 29 — Determination of $A_{boundary,H}$

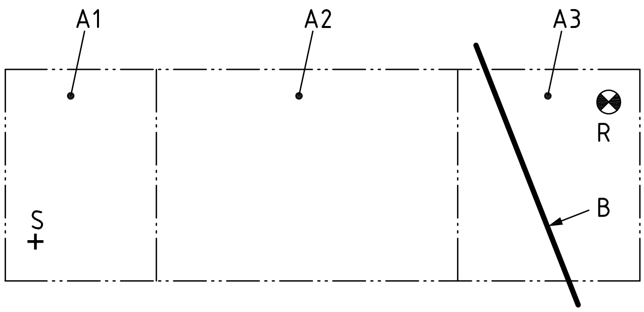
f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**
$A_{dif(S,R)}$	0,00	0,00	0,00	3,16	0,56	0,00	0,00	0,00
$A_{ground,(S,O)}$	-	-	-	2,74	-1,21	-	-	-
$A_{ground,(O,R)}$	-	-	-	-2,40	-2,40	-	-	-
$A_{dif(S',R)}$	-	-	-	4,71	4,65	-	-	-
$A_{dif(S,R')}$	-	-	-	10,83	13,26	-	-	-
$A_{ground(S,O)}$	-	-	-	2,23	-0,77	-	-	-
$A_{ground(O,R)}$	-	-	-	-1,07	-0,62	-	-	-
A_{dif}	-	-	-	4,31	-0,83	-	-	-
$A_{ground(S,R)}$	-1,32	-1,32	-1,32	-	-	-1,32	-1,32	-1,32
$A_{boundary,H}$	-1,32	-1,32	-1,32	4,31	-0,83	-1,32	-1,32	-1,32

Table 30 — Step by step and final results related to the propagation in the vertical plane

f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**	
L_W in dB	93	93	93	93	93	93	93	93	
α_{atm}	0,12	0,41	1,04	1,93	3,66	9,66	32,77	116,88	
A_{atm} in dB	0,02	0,08	0,20	0,37	0,71	1,88	6,37	22,73	
A_{div} in dB	56,78	56,78	56,78	56,78	56,78	56,78	56,78	56,78	
$A_{boundary,H}$ in dB	-1,32	-1,32	-1,32	4,31	-0,83	-1,32	-1,32	-1,32	
$A_{boundary,F}$ in dB	-1,32	-1,32	-1,29	-1,05	-1,32	-1,32	-1,32	-1,32	**Total**
L_H in dB	37,53	37,47	37,35	31,54	36,34	35,67	31,18	14,82	44,38
L_F in dB	37,53	37,47	37,31	36,89	36,84	35,67	31,18	14,82	44,97
L in dB	37,53	37,47	37,33	34,99	36,60	35,67	31,18	14,82	44,68
A-weighting in dB	-26,2	-16,1	-8,6	-3,2	0,0	1,2	1,0	-1,1	
L_A in dB	11,33	21,37	28,73	31,79	36,60	36,87	32,18	13,72	41,31

6.2.8 TC07 — Flat ground with spatially varying acoustic properties and long barrier

The aim of this test case is to check the correct calculation of diffraction with one single diffracting edge. The areas of constant ground factor G are the same as in TC05 (Table 17). The scenario is shown in Figures 11 and 12.



Key

S source

R receiver

B barrier

A1 area with G = 0,9

A2 area with G = 0,5

A3 area with G = 0,2

Figure 11 — Areas with different ground factors and long barrier

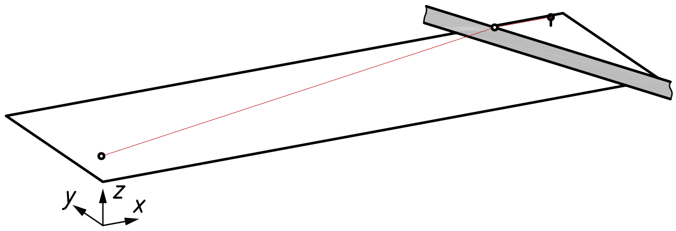


Figure 12 — 3D-presentation of scenario TC07

Tables 31 and 32 contain the modified and the additional input parameters, and Tables 33 to 39 show the intermediate and the final results.

Table 31 — Coordinates of source S and receiver R

Point	*x* (m)	*y* (m)	*z* (m)
S	10	10	1
R	200	50	4

Table 32 — Coordinates of screens (upper edges)

Screen No	*x* (m)	*y* (m)	*z* (m)
1	100	240	6
1	265	-180	6

Table 33 — *z*-profile (ground height) along the propagation path

No	*z*-profile S-R	
	u (m)	*v* (m)
1	0,00	0,00
2	170,23	0,00
3	170,23	6,00
4	170,23	0,00
5	194,16	0,00

Table 34 — Coordinates of mirror points (homogeneous)

Mirror points	*u* (m)	*v* (m)
S' (S -> O)	0,00	-1,00
R' (O -> R)	194,16	-4,00

Table 35 — Mean ground plane MGP and averaged ground factors (homogeneous)

Parameter	S -> O_1	O_n -> R
a (MGP)	0,00	0,00
b (MGP) in m	0,00	0,00
z_1 in m	1,00	6,00
z_2 in m	6,00	4,00
d_p in m	170,23	23,93

Table 35 *(continued)*

Parameter	S -> O_1	O_n -> R
G_{path}	0,55	0,20
G'_{path}	0,61	

Table 36 — Calculation of the path length differences δ

Parameter	S->R		S'->R		S->R'	
	(H)	(F)	(H)	(F)	(H)	(F)
No(O_1)	3	3	3	3	3	3
No(O_n)	3	3	3	3	3	3
d	194,19	194,31	194,23	194,36	194,23	194,36
d_{ss}	170,30	170,39	170,38	170,46	170,30	170,39
d_{sr}	24,02	24,02	24,02	24,02	25,94	25,94
e	0,00	0,00	0,00	0,00	0,00	0,00
δ	0,13	0,09	0,16	0,12	2,01	1,97

Table 37 — Determination of $A_{\mathrm{boundary,H}}$

f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**
$A_{\mathrm{dif(S,R)}}$	6,01	6,96	8,41	10,36	12,72	15,37	18,19	21,10
$A_{\mathrm{ground,(S,O)}}$	-1,16	-1,16	-1,16	-1,16	1,45	-1,16	-1,16	-1,16
$A_{\mathrm{ground,(O,R)}}$	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40
$A_{\mathrm{dif(S',R)}}$	6,24	7,32	8,92	11,00	13,46	16,16	19,01	21,94
$A_{\mathrm{dif(S,R')}}$	12,54	15,13	17,94	20,85	23,80	26,78	29,78	32,78
$A_{\mathrm{ground(S,O)}}$	-1,13	-1,11	-1,09	-1,08	1,32	-1,06	-1,06	-1,06
$A_{\mathrm{ground(O,R)}}$	-1,22	-1,02	-0,88	-0,79	-0,74	-0,71	-0,70	-0,69
A_{dif}	3,67	4,83	6,44	8,49	13,30	13,60	16,43	19,35
$A_{\mathrm{ground(S,R)}}$	-	-	-	-	-	-	-	-
$A_{\mathrm{boundary,H}}$	3,67	4,83	6,44	8,49	13,30	13,60	16,43	19,35

Table 38 — Determination of $A_{\mathrm{boundary,F}}$

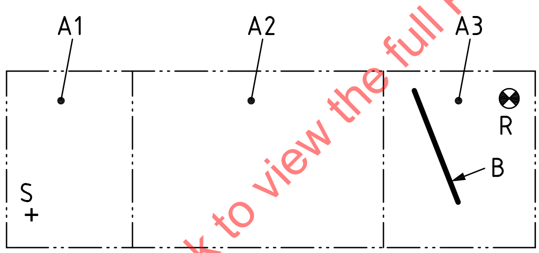
f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**
$A_{\mathrm{dif(S,R)}}$	5,67	6,40	7,58	9,27	11,43	13,94	16,68	19,55
$A_{\mathrm{ground,(S,O)}}$	-1,16	-1,16	-1,16	-1,16	-1,16	-1,16	-1,16	-1,16
$A_{\mathrm{ground,(O,R)}}$	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40
$A_{\mathrm{dif(S',R)}}$	5,91	6,81	8,19	10,07	12,39	15,01	17,81	20,71
$A_{\mathrm{dif(S,R')}}$	12,46	15,05	17,86	20,76	23,71	26,70	29,69	32,70
$A_{\mathrm{ground(S,O)}}$	-1,12	-1,11	-1,08	-1,06	-1,04	-1,03	-1,02	-1,02
$A_{\mathrm{ground(O,R)}}$	-1,18	-0,96	-0,81	-0,71	-0,65	-0,61	-0,60	-0,59
A_{dif}	3,36	4,33	5,69	7,50	9,74	12,30	15,06	17,94
$A_{\mathrm{ground(S,R)}}$	-	-	-	-	-	-	-	-
$A_{\mathrm{boundary,F}}$	3,36	4,33	5,69	7,50	9,74	12,30	15,06	17,94

Table 39 — Step by step and final results related to the propagation in the vertical plane

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000	
L_W in dB	93	93	93	93	93	93	93	93	
α_{atm}	0,12	0,41	1,04	1,93	3,66	9,66	32,77	116,88	
A_{atm} in dB	0,02	0,08	0,20	0,37	0,71	1,88	6,36	22,70	
A_{div} in dB	56,76	56,76	56,76	56,76	56,76	56,76	56,76	56,76	
$A_{\mathrm{boundary,H}}$ in dB	3,67	4,83	6,44	8,49	13,30	13,60	16,43	19,35	
$A_{\mathrm{boundary,F}}$ in dB	3,36	4,33	5,69	7,50	9,74	12,30	15,06	17,94	**Total**
L_{H} in dB	32,54	31,32	29,60	27,37	22,22	20,76	13,44	-5,81	36,92
L_{F} in dB	32,85	31,83	30,35	28,36	25,78	22,06	14,81	-4,41	37,63
L in dB	32,70	31,58	29,99	27,89	24,36	21,46	14,18	-5,05	37,29
A-weighting in dB	-26,2	-16,1	-8,6	-3,2	0,0	1,2	1,0	-1,1	
L_{A} in dB	6,50	15,48	21,39	24,69	24,36	22,66	15,18	-6,15	29,83

6.2.9 TC08 — Flat ground with spatially varying acoustic properties and short barrier

The aim of this test case is to check the correct consideration of laterally diffracted sound. The areas of constant ground factor G are the same as in TC05 (Table 17). The scenario is shown in Figures 13 and 14.



Key

S source

R receiver

B barrier

A1 area with G = 0,9

A2 area with G = 0,5

A3 area with G = 0,2

Figure 13 — Areas with different ground factors and long barrier

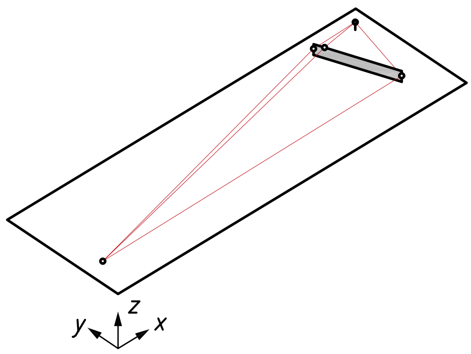


Figure 14 — 3D-presentation of scenario TC07

Table 40 contains the barrier geometry as input parameters, and Tables 41 to 53 show the detailed intermediate and the final results.

Table 40 — Coordinates of screens (upper edges)

Screen No	x (m)	y (m)	z (m)
1	175	50	6
1	190	10	6

Table 41 — z-profile (ground height) along the propagation path

z-profile S-R		
No	u (m)	v (m)
1	0,00	0,00
2	170,49	0,00
3	170,49	6,00
4	170,49	0,00
5	194,16	0,00

Table 42 — Coordinates of mirror points (homogeneous)

Mirror points	u (m)	v (m)
S' (S -> O)	0,00	-1,00
R' (O -> R)	194,16	-4,00

Table 43 — Mean ground plane MGP and averaged ground factors (homogeneous)

Parameter	S -> O_1	O_n -> R	S->R right	S->R left
a (MGP)	0,00	0,00	0,00	0,00
b (MGP) in m	0,00	0,00	0,00	0,00
z_1 in m	1,00	6,00	1,00	1,00
z_2 in m	6,00	4,00	4,00	4,00
d_p in m	170,49	23,68	221,23	194,78
G_{path}	0,55	0,20	0,46	0,51
G'_{path}	0,61		0,46	0,51

Table 44 — Calculation of the path length differences δ

Parameter	S->R		S'->R		S->R'		Lateral right		Lateral left	
	(H)	(F)	(H)	(F)	(H)	(F)	(H)	(F)	(H)	(F)
No(O_1)	3	3	3	3	3	3	-	-	-	-
No(O_n)	3	3	3	3	3	3	-	-	-	-
d	194,19	194,31	194,23	194,36	194,23	194,36	194,19	194,19	194,19	194,19
d_{ss}	170,56	170,65	170,63	170,72	170,56	170,65	180,02	180,02	169,80	169,80
d_{sr}	23,76	23,76	23,76	23,76	25,70	25,70	41,23	41,23	25,00	25,00
e	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
δ	0,13	0,09	0,16	0,12	2,03	1,99	27,07	27,07	0,61	0,61

Table 45 — Determination of $A_{boundary,H}$

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000
$\Delta_{dif(S,R)}$	6,02	6,97	8,42	10,38	12,75	15,40	18,21	21,12
$A_{ground,(S,O)}$	-1,16	-1,16	-1,16	-1,16	1,46	-1,16	-1,16	-1,16
$A_{ground,(O,R)}$	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40
$\Delta_{dif(S',R)}$	6,25	7,33	8,93	11,01	13,47	16,18	19,03	21,96
$\Delta_{dif(S,R')}$	12,57	15,17	17,98	20,89	23,84	26,83	29,82	32,83
$\Delta_{ground(S,O)}$	-1,13	-1,11	-1,10	-1,08	1,33	-1,06	-1,06	-1,06
$\Delta_{ground(O,R)}$	-1,21	-1,01	-0,87	-0,79	-0,74	-0,71	-0,70	-0,69
A_{dif}	3,68	4,84	6,45	8,51	13,34	13,62	16,46	19,38
$A_{ground(S,R)}$	-	-	-	-	-	-	-	-
$A_{boundary,H}$	3,68	4,84	6,45	8,51	13,34	13,62	16,46	19,38

Table 46 — Determination of $A_{boundary,F}$

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000
$\Delta_{dif(S,R)}$	5,68	6,41	7,60	9,30	11,47	13,99	16,73	19,60
$A_{ground,(S,O)}$	-1,16	-1,16	-1,16	-1,16	-1,16	-1,16	-1,16	-1,16
$A_{ground,(O,R)}$	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40
$\Delta_{dif(S',R)}$	5,92	6,82	8,21	10,10	12,42	15,04	17,84	20,75
$\Delta_{dif(S,R')}$	12,50	15,09	17,90	20,80	23,76	26,74	29,74	32,74
$\Delta_{ground(S,O)}$	-1,13	-1,11	-1,09	-1,06	-1,05	-1,03	-1,03	-1,02
$\Delta_{ground(O,R)}$	-1,18	-0,96	-0,81	-0,71	-0,65	-0,61	-0,60	-0,59
A_{dif}	3,37	4,34	5,71	7,53	9,78	12,34	15,11	17,99
$A_{ground(S,R)}$	-	-	-	-	-	-	-	-
$A_{boundary,F}$	3,37	4,34	5,71	7,53	9,78	12,34	15,11	17,99

Table 47 — Step by step and final results related to the propagation in the vertical plane

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000	
L_W in dB	93	93	93	93	93	93	93	93	
α_{atm}	0,12	0,41	1,04	1,93	3,66	9,66	32,77	116,88	
A_{atm} in dB	0,02	0,08	0,20	0,37	0,71	1,88	6,36	22,70	
A_{div} in dB	56,76	56,76	56,76	56,76	56,76	56,76	56,76	56,76	
$A_{boundary,H}$ in dB	3,68	4,84	6,45	8,51	13,34	13,62	16,46	19,38	
$A_{boundary,F}$ in dB	3,37	4,34	5,71	7,53	9,78	12,34	15,11	17,99	**Total**
L_H in dB	32,54	31,31	29,58	27,35	22,19	20,74	13,42	-5,84	36,91
L_F in dB	32,84	31,81	30,32	28,33	25,74	22,02	14,76	-4,45	37,61
L in dB	32,69	31,57	29,97	27,87	24,32	21,42	14,14	-5,09	37,27
A-weighting in dB	-26,2	-16,1	-8,6	-3,2	0,0	1,2	1,0	-1,1	
L_A in dB	6,49	15,47	21,37	24,67	24,32	22,62	15,14	-6,19	29,80

Table 48 — Ground attenuation related to lateral propagation paths

f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**
Lateral right								
w (H)	0,00	0,00	0,00	0,01	0,06	0,34	1,76	8,58
C_f (H)	226,58	242,17	257,73	159,33	29,64	3,03	0,57	0,12
$A_{ground,H}$ in dB	-1,61	-1,61	-1,61	0,75	6,25	-0,39	-1,61	-1,61
w (F)	0,00	0,00	0,00	0,01	0,06	0,34	1,76	8,58
C_f (F)	226,58	242,17	257,73	159,33	29,64	3,03	0,57	0,12
$A_{ground,F}$ in dB	-2,65	-2,65	-2,65	-2,65	-1,30	-2,65	-2,65	-2,65
lateral left								
w (H)	0,00	0,00	0,00	0,01	0,08	0,42	2,17	10,40
C_f (H)	199,96	214,57	225,67	131,50	22,70	2,41	0,46	0,10
$A_{ground,H}$ in dB	-1,48	-1,48	-1,48	1,01	5,84	-1,48	-1,48	-1,48
w (F)	0,00	0,00	0,00	0,01	0,08	0,42	2,17	10,40
C_f (F)	199,96	214,57	225,67	131,50	22,70	2,41	0,46	0,10
$A_{ground,F}$ in dB	-2,16	-2,16	-2,16	-2,16	-0,92	-2,16	-2,16	-2,16

Table 49 — Calculation of the linear partial levels related to the right lateral path (homogeneous)

Lateral right (H)									
f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**	
L_W in dB	93	93	93	93	93	93	93	93	
α_{atm}(10°,70%)	0,12	0,41	1,04	1,93	3,66	9,66	32,77	116,88	
A_{atm} in dB	0,03	0,09	0,23	0,43	0,81	2,14	7,25	25,86	
A_{div} in dB	56,76	56,76	56,76	56,76	56,76	56,76	56,76	56,76	
$A_{ground,H}$ in dB	-1,61	-1,61	-1,61	0,75	6,25	-0,39	-1,61	-1,61	
$\Delta_{dif,H}$ in dB	23,09	26,03	29,03	32,03	35,03	38,04	41,05	44,06	
A_H in dB	78,27	81,27	84,41	89,97	98,86	96,56	103,45	125,07	**Total**
L_H in dB	14,73	11,73	8,59	3,03	-5,86	-3,56	-10,45	-32,07	17,38

Table 50 — Calculation of the linear partial levels related to the right lateral path (favourable)

Lateral right (F)									
f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**	
L_W in dB	93	93	93	93	93	93	93	93	
α_{atm} (10°,70%)	0,12	0,41	1,04	1,93	3,66	9,66	32,77	116,88	
A_{atm} in dB	0,03	0,09	0,23	0,43	0,81	2,14	7,25	25,86	
A_{div} in dB	56,76	56,76	56,76	56,76	56,76	56,76	56,76	56,76	
$A_{ground,F}$ in dB	-2,65	-2,65	-2,65	-2,65	-1,30	-2,65	-2,65	-2,65	
$\Delta_{dif,F}$ in dB	23,09	26,03	29,03	32,03	35,03	38,04	41,05	44,06	
A_F in dB	77,23	80,23	83,37	86,57	91,31	94,29	102,41	124,03	**Total**
L_F in dB	15,77	12,77	9,63	6,43	1,69	-1,29	-9,41	-31,03	18,61

Table 51 — Calculation of the linear partial levels related to the left lateral path (homogeneous)

Lateral left (H)									
f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**	
L_W in dB	93	93	93	93	93	93	93	93	
α_{atm} (10°,70%)	0,12	0,41	1,04	1,93	3,66	9,66	32,77	116,88	
A_{atm} in dB	0,02	0,08	0,20	0,38	0,71	1,88	6,38	22,77	
A_{div} in dB	56,76	56,76	56,76	56,76	56,76	56,76	56,76	56,76	
$A_{ground,H}$ in dB	-1,48	-1,48	-1,48	1,01	5,84	-1,48	-1,48	-1,48	
$\Delta_{dif,H}$ in dB	8,78	10,81	13,24	15,93	18,77	21,69	24,66	27,64	
A_H in dB	64,09	66,17	68,72	74,08	82,08	78,86	86,32	105,70	**Total**
L_H in dB	28,91	26,83	24,28	18,92	10,92	14,14	6,68	-12,70	32,17

Table 52 — Calculation of the linear partial levels related to the left lateral path (favourable)

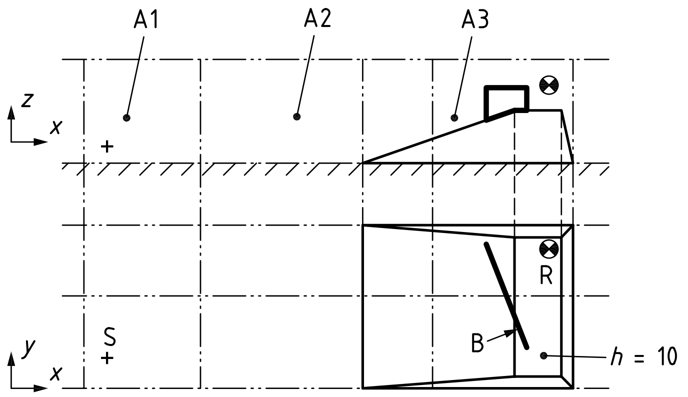
Lateral left (F)									
f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**	
L_W in dB	93	93	93	93	93	93	93	93	
α_{atm} (10°,70%)	0,12	0,41	1,04	1,93	3,66	9,66	32,77	116,88	
A_{atm} in dB	0,02	0,08	0,20	0,38	0,71	1,88	6,38	22,77	
A_{div} in dB	56,76	56,76	56,76	56,76	56,76	56,76	56,76	56,76	
$A_{ground,F}$ in dB	-2,16	-2,16	-2,16	-2,16	-0,92	-2,16	-2,16	-2,16	
$\Delta_{dif,F}$ in dB	8,78	10,81	13,24	15,93	18,77	21,69	24,66	27,64	
A_F in dB	63,41	65,49	68,04	70,91	75,32	78,18	85,64	105,02	**Total**
L_F in dB	29,59	27,51	24,96	22,09	17,68	14,82	7,36	-12,02	33,10

Table 53 — Partial and total sound pressure levels for all three propagation paths

f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**	**Total**
L_A in dB over top	6,49	15,47	21,37	24,67	24,32	22,62	15,14	-6,19	29,80
L_A in dB right	-10,92	-3,82	0,54	1,86	-0,61	-1,08	-8,90	-32,62	6,94
L_A in dB left	3,06	11,08	16,03	17,59	15,50	15,70	8,03	-13,44	22,82
L_A in dB	8,17	16,86	22,51	25,46	24,87	23,44	15,93	-5,43	30,62

6.2.10 TC09 — Ground with spatially varying heights and and acoustic properties and short barrier

This test case is to check the correct consideration of laterally diffracted sound with uneven ground. Contour lines and areas of constant ground factor G are the same as in TC05 (Tables 16 and 17). The scenario is shown in Figures 15 and 16.



Key

S source

R receiver

B barrier

A1 area with G = 0,9

A2 area with G = 0,5

A3 area with G = 0,2

Figure 15 — Areas with different ground factors, varying ground height and short barrier

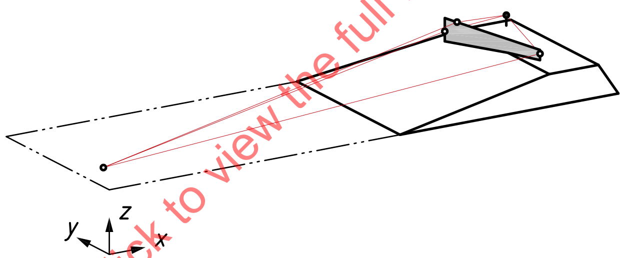


Figure 16 — 3D-presentation of scenario TC09

Tables 54 to 55 contain the modified and additional input parameters, and Tables 56 to 71 show the intermediate and final results.

Table 54 — Coordinates of source S and receiver R

Point	x (m)	y (m)	z (m)
S	10	10	1
R	200	50	14

Table 55 — Coordinates of screens (upper edges)

Screen	x	y	z
No	(m)	(m)	(m)
1	175	50	17
1	190	10	14

Table 56 — Determination of G_{path} (homogeneous)

G-profile S -> O				*G*-profile O -> R			
from (m)	to (m)	length (m)	G	from (m)	to (m)	length (m)	G
0,00	40,88	40,88	0,9	0,00	23,68	23,68	0,2
40,88	143,07	102,19	0,5			G_{path}	0,20
143,07	170,49	27,42	0,20				
		G_{path}	0,55				

Table 57 — *G*-profile along the two lateral paths (homogeneous)

G-profile lateral right				*G*-profile lateral left			
from (m)	to (m)	length (m)	*G*	from (m)	to (m)	length (m)	*G*
0,00	40,00	40,00	0,9	0,00	41,16	41,16	0,9
40,00	140,00	100,00	0,5	41,16	144,06	102,90	0,5
140,00	180,00	40,00	0,2	144,06	169,78	25,72	0,2
180,00	221,24	41,24	0,2	169,78	194,78	25,00	0,2
		G_{path}	0,46			G_{path}	0,51

Table 58 — Height profiles along the direct and the two lateral paths (homogeneous)

z-profile S-O		*z*-profile O-R		*z*-profile right		*z*-profile left	
u (m)	*z* (m)	*u* (m)	*z* (m)	*u* (m)	*z* (m)	*u* (m)	*z* (m)
0,00	0,00	170,49	8,74	0,00	0,00	0,00	0,00
112,41	0,00	178,84	10,00	110,00	0,00	113,19	0,00
170,49	8,74	194,16	10,00	175,00	10,00	169,78	8,46
				180,00	10,00	179,78	10,00
				221,24	10,00	194,78	10,00

Table 59 — *z*-profile (ground height) along the propagation path

z-profile S-R		
No	*u* (m)	*v* (m)
1	0,00	0,00
2	112,41	0,00
3	170,49	8,74
4	170,49	16,63
5	170,49	8,74
6	178,84	10,00
7	194,16	10,00

Table 60 — Mean ground plane MGP and averaged ground factors (homogeneous)

Parameter	S -> O_1	O_n -> R	S->R right	S->R left
a (MGP)	0,04	0,04	0,06	0,05
b (MGP) in m	-1,96	1,94	-3,10	-2,82

Table 60 *(continued)*

Parameter	S -> O_1	O_n -> R	S->R right	S->R left
z_1 in m	2,96	7,36	4,09	3,81
z_2 in m	11,68	3,71	3,77	6,23
d_p in m	170,98	23,54	221,62	195,20
G_{path}	0,55	0,20	0,46	0,51
G'_{path}	0,76		0,49	0,64

Table 61 — Coordinates of mirror points (homogeneous)

Mirror points	*u* (m)	*v* (m)
S' (S -> O)	0,24	-4,92
R' (O -> R)	194,48	6,59

Table 62 — Calculation of the path length differences δ

Parameter	S->R		S'->R		S->R'		Lateral right		Lateral left	
	(H)	(F)	(H)	(F)	(H)	(F)	(H)	(F)	(H)	(F)
No(O_1)	4	4	4	4	4	4	-	-	-	-
No(O_n)	4	4	4	4	4	4	-	-	-	-
d	194,60	194,73	194,85	194,97	194,56	194,69	194,60	194,60	194,60	194,60
d_{ss}	171,20	171,29	171,61	171,69	171,20	171,29	180,39	180,39	170,16	170,16
d_{sr}	23,82	23,82	23,82	23,82	26,01	26,01	41,26	41,26	25,05	25,05
e	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
δ	0,43	0,39	0,58	0,54	2,65	2,61	27,04	27,04	0,62	0,62

Table 63 — Determination of $A_{boundary,H}$

f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**
$A_{dif(S,R)}$	7,90	9,67	11,92	14,49	17,26	20,15	23,09	26,07
$A_{ground,(S,O)}$	-0,71	-0,71	-0,71	-0,71	-0,71	-0,71	-0,71	-0,71
$A_{ground,(O,R)}$	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40
$A_{dif(S',R)}$	8,65	10,64	13,05	15,72	18,56	21,48	24,44	27,43
$A_{dif(S,R')}$	13,55	16,23	19,09	22,01	24,98	27,97	30,97	33,98
$A_{ground(S,O)}$	-0,65	-0,64	-0,63	-0,62	-0,62	-0,61	-0,61	-0,61
$A_{ground(O,R)}$	-1,33	-1,21	-1,13	-1,09	-1,07	-1,06	-1,05	-1,05
A_{dif}	5,91	7,82	10,16	12,78	15,58	18,48	21,43	23,34
$A_{ground(S,R)}$	-	-	-	-	-	-	-	-
$A_{boundary,H}$	5,91	7,82	10,16	12,78	15,58	18,48	21,43	23,34

Table 64 — Determination of $A_{boundary,F}$

f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**
$A_{dif(S,R)}$	7,68	9,39	11,57	14,10	16,85	19,73	22,67	25,64
$A_{ground,(S,O)}$	-0,71	-0,71	-0,71	-0,71	-0,71	-0,71	-0,71	-0,71
$A_{ground,(O,R)}$	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40
$A_{dif(S',R)}$	8,47	10,41	12,79	15,44	18,26	21,17	24,13	27,12
$A_{dif(S,R')}$	13,50	16,17	19,02	21,95	24,92	27,91	30,91	33,91
$A_{ground(S,O)}$	-0,65	-0,63	-0,62	-0,61	-0,61	-0,61	-0,60	-0,60

Table 64 *(continued)*

f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**
$A_{ground(O,R)}$	-1,31	-1,18	-1,10	-1,05	-1,03	-1,02	-1,01	-1,01
A_{dif}	5,72	7,57	9,85	12,44	15,22	18,11	21,05	23,39
$A_{ground(S,R)}$	-	-	-	-	-	-	-	-
$A_{boundary,F}$	5,72	7,57	9,85	12,44	15,22	18,11	21,05	23,39

Table 65 — Step by step and final results related to the propagation in the vertical plane

f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**	
L_W in dB	93	93	93	93	93	93	93	93	
α_{atm}	0,12	0,41	1,04	1,93	3,66	9,66	32,77	116,88	
A_{atm} in dB	0,02	0,08	0,20	0,38	0,71	1,88	6,38	22,75	
A_{div} in dB	56,78	56,78	56,78	56,78	56,78	56,78	56,78	56,78	
$A_{boundary,H}$ in dB	5,91	7,82	10,16	12,78	15,58	18,48	21,43	23,34	
$A_{boundary,F}$ in dB	5,72	7,57	9,85	12,44	15,22	18,11	21,05	23,39	**Total**
L_H in dB	30,28	28,31	25,86	23,07	19,93	15,86	8,41	-9,87	33,94
L_F in dB	30,47	28,57	26,16	23,40	20,29	16,23	8,79	-9,92	34,19
L in dB	30,38	28,44	26,01	23,24	20,11	16,05	8,60	-9,89	34,07
A-weighting in dB	-26,2	-16,1	-8,6	-3,2	0,0	1,2	1,0	-1,1	
L_A in dB	4,18	12,34	17,41	20,04	20,11	17,25	9,60	-10,99	25,32

Table 66 — Ground attenuation related to lateral propagation paths

f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**
Lateral right								
w (H)	0,00	0,00	0,00	0,01	0,07	0,39	2,00	9,66
C_f (H)	227,72	244,70	256,12	145,81	24,37	2,61	0,50	0,10
$A_{ground,H}$ in dB	-1,53	-1,53	-1,53	2,33	-1,53	-1,53	-1,53	-1,53
w (F)	0,00	0,00	0,00	0,01	0,06	0,34	1,76	8,58
C_f (F)	226,99	242,62	258,17	159,45	29,63	3,03	0,57	0,12
$A_{ground,F}$ in dB	-1,53	-1,38	-1,35	-1,53	-1,53	-1,53	-1,53	-1,53
lateral left								
w (H)	0,00	0,00	0,00	0,03	0,14	0,75	3,72	16,84
C_f (H)	204,07	223,16	208,01	81,73	9,55	1,33	0,27	0,06
$A_{ground,H}$ in dB	-1,07	-1,07	-1,07	-1,07	-1,07	-1,07	-1,07	-1,07
w (F)	0,00	0,00	0,00	0,01	0,08	0,42	2,17	10,40
C_f (F)	200,40	215,06	226,13	131,61	22,68	2,41	0,46	0,10
$A_{ground,F}$ in dB	-1,07	-1,07	-1,07	-1,07	-1,07	-1,07	-1,07	-1,07

Table 67 — Calculation of the linear partial levels related to the right lateral path (homogeneous)

Lateral right (H)								
f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**
L_W in dB	93	93	93	93	93	93	93	93
α_{atm} (10°,70%)	0,12	0,41	1,04	1,93	3,66	9,66	32,77	116,88
A_{atm} in dB	0,03	0,09	0,23	0,43	0,81	2,14	7,26	25,91

Table 67 *(continued)*

Lateral right (H)									
f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**	
A_{div} in dB	56,78	56,78	56,78	56,78	56,78	56,78	56,78	56,78	
$A_{ground,H}$ in dB	-1,53	-1,53	-1,53	2,33	-1,53	-1,53	-1,53	-1,53	
$\Delta_{dif,H}$ in dB	23,08	26,03	29,02	32,02	35,03	38,04	41,05	44,06	
A_H in dB	78,36	81,37	84,50	91,56	91,09	95,43	103,56	125,21	**Total**
L_H in dB	14,64	11,63	8,50	1,44	1,91	-2,43	-10,56	-32,21	17,35

Table 68 — Calculation of the linear partial levels related to the right lateral path (favourable)

Lateral right (F)									
f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**	
L_W in dB	93	93	93	93	93	93	93	93	
α_{atm} (10°,70%)	0,12	0,41	1,04	1,93	3,66	9,66	32,77	116,88	
A_{atm} in dB	0,03	0,09	0,23	0,43	0,81	2,14	7,26	25,91	
A_{div} in dB	56,78	56,78	56,78	56,78	56,78	56,78	56,78	56,78	
$A_{ground,F}$ in dB	-1,53	-1,38	-1,35	-1,53	-1,53	-1,53	-1,53	-1,53	
$\Delta_{dif,F}$ in dB	23,08	26,03	29,02	32,02	35,03	38,04	41,05	44,06	
A_F in dB	78,36	81,52	84,69	87,70	91,09	95,43	103,56	125,21	**Total**
L_F in dB	14,64	11,48	8,31	5,30	1,91	-2,43	-10,56	-32,21	17,45

Table 69 — Calculation of the linear partial levels related to the left lateral path (homogeneous)

Lateral left (H)									
f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**	
L_W in dB	93	93	93	93	93	93	93	93	
α_{atm} (10°,70%)	0,12	0,41	1,04	1,93	3,66	9,66	32,77	116,88	
A_{atm} in dB	0,02	0,08	0,20	0,38	0,71	1,89	6,40	22,82	
A_{div} in dB	56,78	56,78	56,78	56,78	56,78	56,78	56,78	56,78	
$A_{ground,H}$ in dB	-1,07	-1,07	-1,07	-1,07	-1,07	-1,07	-1,07	-1,07	
$\Delta_{dif,H}$ in dB	8,79	10,81	13,24	15,93	18,77	21,70	24,66	27,65	
A_H in dB	64,53	66,61	69,16	72,03	75,21	79,30	86,78	106,19	**Total**
L_H in dB	28,47	26,39	23,84	20,97	17,79	13,70	6,22	-13,19	32,03

Table 70 — Calculation of the linear partial levels related to the left lateral path (favourable)

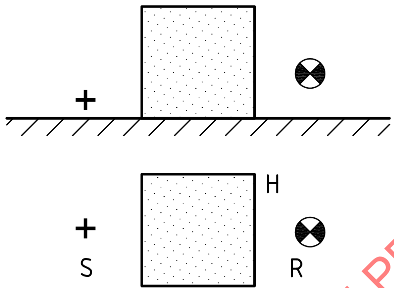
Lateral left (F)									
f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**	
L_W in dB	93	93	93	93	93	93	93	93	
α_{atm} (10°,70%)	0,12	0,41	1,04	1,93	3,66	9,66	32,77	116,88	
A_{atm} in dB	0,02	0,08	0,20	0,38	0,71	1,89	6,40	22,82	
A_{div} in dB	56,78	56,78	56,78	56,78	56,78	56,78	56,78	56,78	
$A_{ground,F}$ in dB	-1,07	-1,07	-1,07	-1,07	-1,07	-1,07	-1,07	-1,07	
$\Delta_{dif,F}$ in dB	8,79	10,81	13,24	15,93	18,77	21,70	24,66	27,65	
A_F in dB	64,53	66,61	69,16	72,03	75,21	79,30	86,78	106,19	**Total**
L_F in dB	28,47	26,39	23,84	20,97	17,79	13,70	6,22	-13,19	32,03

Table 71 — Partial and total sound pressure levels for all three propagation paths

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000	Total
L_A in dB over top	4,18	12,34	17,41	20,04	20,11	17,25	9,60	-10,99	25,32
L_A in dB right	-11,56	-4,54	-0,19	0,58	1,91	-1,23	-9,56	-33,31	6,94
L_A in dB left	2,27	10,29	15,24	17,77	17,79	14,90	7,22	-14,29	23,05
L_A in dB	6,41	14,50	19,52	22,09	22,16	19,28	11,62	-9,31	27,39

6.2.11 TC10 — Flat ground with homogeneous acoustic properties and cubic building — Receiver at low height

The aim of this test case is to check the correct consideration of objects like buildings in the diffraction calculation. The ground factor is spatially constant with G = 0,5. The scenario is shown in Figures 17 and 18.



Key

S source

R receiver

H object

Figure 17 — Screening cubic building between source and receiver at low height

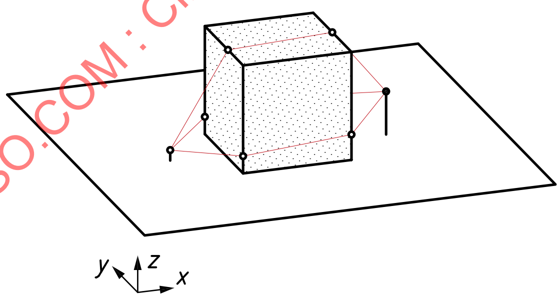


Figure 18 — 3D-presentation of scenario TC10

Tables 72 and 73 contain the modified and additional input parameters, and Tables 74 to 83 show the intermediate and final results.

Table 72 — Coordinates of source S and receiver R

Point	x (m)	y (m)	z (m)
S	50	10	1
R	70	10	4

Table 73 — Coordinates of acoustically opaque objects (buildings)

Object No	Edge No	x (m)	y (m)	z (m)
1	1	55	5	10
1	2	65	5	10
1	3	65	15	10
1	4	55	15	10

Table 74 — z-profile (ground height) along the propagation path

z-profile S-R		
No	u (m)	v (m)
1	0	0
2	5	0
3	5	10
4	15	10
5	15	0
6	20	0

Table 75 — Mean ground plane MGP and averaged ground factors (homogeneous)

Parameter	S -> O$_1$	O$_n$ -> R	S->R **right**	S->R **left**
a (MGP)	0,00	0,00	0,00	0,00
b (MGP) in m	0,00	0,00	0,00	0,00
z_1 in m	1,00	10,00	1,00	1,00
z_2 in m	10,00	4,00	4,00	4,00
d_p in m	5,00	5,00	24,15	24,15
G_{path}	0,50	0,50	0,50	0,50
G'_{path}	0,50		0,50	0,50

Table 76 — Coordinates of mirror points (homogeneous)

Mirror points	u (m)	v (m)
S' (S -> O)	0,00	-1,00
R' (O -> R)	20,00	-4,00

Table 77 — Calculation of the path length differences δ

Parameter	S->R		S'->R		S->R'		Lateral right		Lateral left	
	(H)	(F)	(H)	(F)	(H)	(F)	(H)	(F)	(H)	(F)
No(O$_1$)	3	3	3	3	3	3	-	-	-	-
No(O$_n$)	4	4	4	4	4	4	-	-	-	-
d	20,22	20,22	20,62	20,62	20,62	20,62	20,22	20,22	20,22	20,22
d_{ss}	10,30	10,30	12,08	12,08	10,30	10,30	7,11	7,11	7,11	7,11
d_{sr}	7,81	7,81	7,81	7,81	14,87	14,87	7,11	7,11	7,11	7,11
e	10,00	10,00	10,00	10,00	10,00	10,00	10,11	10,11	10,11	10,11
δ	7,88	7,88	9,28	9,28	14,55	14,55	4,12	4,12	4,12	4,12

Table 78 — Determination of $A_{boundary,H}$

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000
$\Delta_{dif(S,R)}$	18,23	21,88	26,33	30,63	34,21	37,39	40,45	43,47
$A_{ground,(S,O)}$	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50
$A_{ground,(O,R)}$	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50
$\Delta_{dif(S',R)}$	18,91	22,58	27,03	31,33	34,92	38,10	41,16	44,18
$\Delta_{dif(S,R')}$	20,80	24,51	28,97	33,28	36,87	40,05	43,11	46,13
$\Delta_{ground(S,O)}$	-1,40	-1,39	-1,39	-1,39	-1,39	-1,39	-1,39	-1,39
$\Delta_{ground(O,R)}$	-1,14	-1,13	-1,13	-1,13	-1,13	-1,13	-1,13	-1,13
A_{dif}	15,69	19,36	22,48	22,48	22,48	22,48	22,48	22,48
$A_{ground(S,R)}$	-	-	-	-	-	-	-	-
$A_{boundary,H}$	15,69	19,36	22,48	22,48	22,48	22,48	22,48	22,48

Table 79 — Determination of $A_{boundary,F}$

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000
$\Delta_{dif(S,R)}$	18,23	21,88	26,32	30,63	34,21	37,39	40,45	43,47
$A_{ground,(S,O)}$	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50
$A_{ground,(O,R)}$	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50
$\Delta_{dif(S',R)}$	18,91	22,58	27,03	31,33	34,92	38,10	41,16	44,18
$\Delta_{dif(S,R')}$	20,80	24,51	28,97	33,28	36,87	40,05	43,11	46,13
$\Delta_{ground(S,O)}$	-1,40	-1,39	-1,39	-1,39	-1,39	-1,39	-1,39	-1,39
$\Delta_{ground(O,R)}$	-1,14	-1,13	-1,13	-1,13	-1,13	-1,13	-1,13	-1,13
A_{dif}	15,69	19,36	22,48	22,48	22,48	22,48	22,48	22,48
$A_{ground(S,R)}$	-	-	-	-	-	-	-	-
$A_{boundary,F}$	15,69	19,36	22,48	22,48	22,48	22,48	22,48	22,48

Table 80 — Step by step and final results related to the propagation in the vertical plane

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000	
L_W in dB	93	93	93	93	93	93	93	93	
α_{atm}	0,12	0,41	1,04	1,93	3,66	9,66	32,77	116,88	
A_{atm} in dB	0,00	0,01	0,02	0,04	0,07	0,20	0,66	2,36	
A_{div} in dB	37,12	37,12	37,12	37,12	37,12	37,12	37,12	37,12	
$A_{boundary,H}$ in dB	15,69	19,36	22,48	22,48	22,48	22,48	22,48	22,48	
$A_{boundary,F}$ in dB	15,69	19,36	22,48	22,48	22,48	22,48	22,48	22,48	**Total**
L_H in dB	40,19	36,52	33,38	33,36	33,33	33,21	32,74	31,04	44,26
L_F in dB	40,19	36,52	33,38	33,36	33,33	33,21	32,74	31,04	44,26
L in dB	40,19	36,52	33,38	33,36	33,33	33,21	32,74	31,04	44,26
A-weighting in dB	-26,2	-16,1	-8,6	-3,2	0,0	1,2	1,0	-1,1	
L_A in dB	13,99	20,42	24,78	30,16	33,33	34,41	33,74	29,94	39,88

Table 81 — Ground attenuation related to lateral propagation paths

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000
Lateral right								
w (H)	0,00	0,00	0,00	0,01	0,08	0,41	2,10	10,13
C_f (H)	24,24	24,59	26,01	28,28	20,54	5,05	0,52	0,10

Table 81 *(continued)*

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000
$A_{ground,H}$ in dB	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50
w (F)	0,00	0,00	0,00	0,01	0,08	0,41	2,10	10,13
C_f (F)	24,24	24,59	26,01	28,28	20,54	5,05	0,52	0,10
$A_{ground,F}$ in dB	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50
lateral left								
w (H)	0,00	0,00	0,00	0,01	0,08	0,41	2,10	10,13
C_f (H)	24,24	24,59	26,01	28,28	20,54	5,05	0,52	0,10
$A_{ground,H}$ in dB	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50
w (F)	0,00	0,00	0,00	0,01	0,08	0,41	2,10	10,13
C_f (F)	24,24	24,59	26,01	28,28	20,54	5,05	0,52	0,10
*A*ground,F in dB	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50

Table 82 — Calculation of the linear partial levels related to the right lateral path (homogeneous)

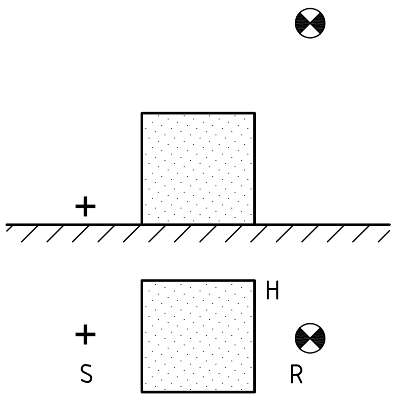
Lateral right (H)									
f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**	
L_W in dB	93	93	93	93	93	93	93	93	
α_{atm} (10°,70%)	0,12	0,41	1,04	1,93	3,66	9,66	32,77	116,88	
A_{atm} in dB	0,00	0,01	0,03	0,05	0,09	0,24	0,80	2,84	
A_{div} in dB	37,12	37,12	37,12	37,12	37,12	37,12	37,12	37,12	
$A_{ground,H}$ in dB	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50	
$\Delta_{dif,H}$ in dB	15,59	19,16	23,56	27,83	31,40	34,58	37,63	40,65	
A_H in dB	51,21	54,78	59,20	63,49	67,10	70,43	74,04	79,11	**Total**
L_H in dB	41,79	38,22	33,80	29,51	25,90	22,57	18,96	13,89	44,10

Table 83 — Calculation of the A-weighted sound pressure level

f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**	
L_H(vert) in dB	40,19	36,52	33,38	33,36	33,33	33,21	32,74	31,04	
L_H(right) in dB	41,79	38,22	33,80	29,51	25,90	22,57	18,96	13,89	
L_H(left) in dB	41,79	38,22	33,80	29,51	25,90	22,57	18,96	13,89	
L_H(tot) in dB	46,09	42,49	38,44	35,97	34,67	33,90	33,09	31,20	
L_F(vert) in dB	40,19	36,52	33,38	33,36	33,33	33,21	32,74	31,04	
L_F(right) in dB	41,79	38,22	33,80	29,51	25,90	22,57	18,96	13,89	
L_F(left) in dB	41,79	38,22	33,80	29,51	25,90	22,57	18,96	13,89	
L_F(tot) in dB	46,09	42,49	38,44	35,97	34,67	33,90	33,09	31,20	**Total**
L in dB	46,09	42,49	38,44	35,97	34,67	33,90	33,09	31,20	48,92
A-weighting in dB	-26,2	-16,1	-8,6	-3,2	0	1,2	1	-1,1	
L_A in dB	19,89	26,39	29,84	32,77	34,67	35,10	34,09	30,10	41,19

6.2.12 TC11 — Flat ground with homogeneous acoustic properties and cubic object – receiver at large height

The aim of this test case is to check the inclusion of the upper roof-surface in the calculation of the mean ground plane MGP and the averaged ground factors G_{path}. The ground factor of the terrain is spatially constant with G = 0,5. The test case is shown in Figures 19 and 20.



Key

S source

R receiver

H object

Figure 19 — Screening cubic object - receiver at large height

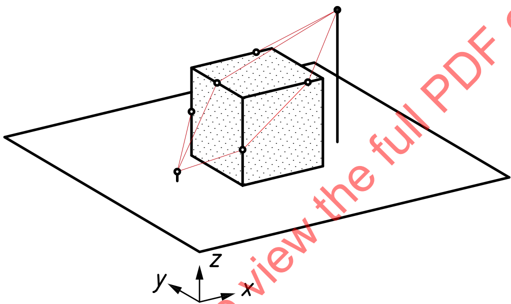


Figure 20 — 3D-presentation of scenario TC11

Table 84 contains the new receiver height, and Tables 85 to 97 show the intermediate and the final results. The calculation of partial sound pressure levels due to lateral diffraction is only shown for the right lateral path in Table 96 – due to symmetry, the results for the left path are identical.

Table 84 — Coordinates of source S and receiver R

Point	*x* (m)	*y* (m)	*z* (m)
S	50	10	1
R	70	10	15

Table 85 — *z*-profile (ground height) along the propagation path

z-profile S-R		
No	*u* (m)	*v* (m)
1	0	0
2	5	0
3	5	10
4	15	10
5	15	0
6	20	0

Table 86 — Mean ground plane MGP and averaged ground factors (homogeneous)

Parameter	S -> O_1	O_n -> R	S->R right	S->R left
a (MGP)	0,00	-0,89	0,10	0,10
b (MGP) in m	0,00	17,78	-0,13	-0,13
z_1 in m	1,00	0,00	1,13	1,13
z_2 in m	10,00	11,21	12,59	12,59
d_p in m	5,00	7,89	24,98	24,98
G_{path}	0,50	0,17	0,44	0,44
G'_{path}	0,50		0,50	0,50

Table 87 — Coordinates of mirror points (homogeneous)

Mirror points	*u* (m)	*v* (m)
S' (S -> O)	0,00	-1,00
R' (O -> R)	5,10	-1,76

Table 88 — Calculation of the path length differences *δ*

Parameter	S->R		S'->R		S->R'		Lateral right		Lateral left	
	(H)	(F)	(H)	(F)	(H)	(F)	(H)	(F)	(H)	(F)
No(O_1)	3	3	3	3	3	3	-	-	-	-
No(O_n)	3	3	3	3	3	3	-	-	-	-
d	24,41	24,41	25,61	25,61	5,80	5,80	24,41	24,41	24,41	24,41
d_{ss}	10,30	10,30	12,08	12,08	10,30	10,30	7,89	7,89	7,89	7,89
d_{sr}	15,81	15,81	15,81	15,81	11,76	11,76	10,05	10,05	10,05	10,05
e	0,00	0,00	0,00	0,00	0,00	0,00	9,59	9,59	9,59	9,59
δ	1,69	1,69	2,28	2,28	16,25	16,25	3,12	3,12	3,12	3,12

Table 89 — Determination of $A_{boundary,H}$

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000
$\Delta_{dif(S,R)}$	11,92	14,46	17,23	20,11	23,06	26,04	29,03	32,03
$A_{ground,(S,O)}$	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50
$A_{ground,(O,R)}$	-2,50	-2,50	-2,50	-2,50	-2,50	-2,50	-2,50	-2,50
$\Delta_{dif(S',R)}$	12,99	15,63	18,46	21,37	24,34	27,32	30,32	33,33

Table 89 *(continued)*

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000
$\Delta_{dif(S,R')}$	20,92	23,84	26,82	29,82	32,82	35,83	38,84	41,85
$A_{ground(S,O)}$	-1,34	-1,32	-1,32	-1,31	-1,31	-1,31	-1,31	-1,31
$A_{ground(O,R)}$	-0,97	-0,93	-0,91	-0,90	-0,89	-0,89	-0,89	-0,89
A_{dif}	9,61	12,20	15,00	17,90	20,86	22,80	22,80	22,80
$A_{ground(S,R)}$	-	-	-	-	-	-	-	-
$A_{boundary,H}$	9,61	12,20	15,00	17,90	20,86	22,80	22,80	22,80

Table 90 — Determination of $A_{boundary,F}$

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000
$\Delta_{dif(S,R)}$	11,92	14,46	17,23	20,11	23,06	26,04	29,03	32,03
$A_{ground,(S,O)}$	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50
$A_{ground,(O,R)}$	-2,50	-2,50	-2,50	-2,50	-2,50	-2,50	-2,50	-2,50
$\Delta_{dif(S',R)}$	12,99	15,63	18,46	21,37	24,34	27,32	30,32	33,32
$\Delta_{dif(S,R')}$	20,92	23,84	26,82	29,82	32,82	35,83	38,84	41,85
$A_{ground(S,O)}$	-1,34	-1,32	-1,32	-1,31	-1,31	-1,31	-1,31	-1,31
$A_{ground(O,R)}$	-0,97	-0,93	-0,91	-0,90	-0,89	-0,89	-0,89	-0,89
A_{dif}	9,61	12,20	15,00	17,90	20,86	22,80	22,80	22,80
$A_{ground(S,R)}$	-	-	-	-	-	-	-	-
$A_{boundary,F}$	9,61	12,20	15,00	17,90	20,86	22,80	22,80	22,80

Table 91 — Step by step and final results related to the propagation in the vertical plane

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000	
L_W in dB	93	93	93	93	93	93	93	93	
α_{atm}	0,12	0,41	1,04	1,93	3,66	9,66	32,77	116,88	
A_{atm} in dB	0,00	0,01	0,03	0,05	0,09	0,24	0,80	2,85	
A_{div} in dB	38,75	38,75	38,75	38,75	38,75	38,75	38,75	38,75	
$A_{boundary,H}$ in dB	9,61	12,20	15,00	17,90	20,86	22,80	22,80	22,80	
$A_{boundary,F}$ in dB	9,61	12,20	15,00	17,90	20,86	22,80	22,80	22,80	**Total**
L_H in dB	44,64	42,04	39,22	36,30	33,30	31,21	30,64	28,59	48,00
L_F in dB	44,64	42,04	39,22	36,30	33,30	31,21	30,64	28,59	48,00
L in dB	44,64	42,04	39,22	36,30	33,30	31,21	30,64	28,59	48,00
A-weighting in dB	-26,2	-16,1	-8,6	-3,2	0,0	1,2	1,0	-1,1	
L_A in dB	18,44	25,94	30,62	33,10	33,30	32,41	31,64	27,49	39,80

Table 92 — Height profiles along the direct and the two lateral paths (homogeneous)

z-profile S-O		z-profile O-R		z-profile right		z-profile left	
u (m)	z (m)	u (m)	z (m)	u (m)	z (m)	u (m)	z (m)
0,00	0,00	5,00	10,00	0,00	0,00	0,00	0,00
5,00	0,00	15,00	10,00	7,07	0,00	7,07	0,00
		15,00	0,00	14,93	0,00	14,93	0,00
		20,00	0,00	14,94	0,00	14,94	0,00
				14,94	10,00	14,94	10,00

Table 92 *(continued)*

z-profile S-O		*z*-profile O-R		*z*-profile right		*z*-profile left	
u (m)	*z* (m)	*u* (m)	*z* (m)	*u* (m)	*z* (m)	*u* (m)	*z* (m)
				17,55	10,00	17,55	10,00
				17,55	0,00	17,55	0,00
				23,65	0,00	23,65	0,00

Table 93 — Determination of G_{path} (homogeneous)

G-profile S -> O				*G*-profile O -> R			
from (m)	to (m)	length (m)	*G*	from (m)	to (m)	length (m)	*G*
0,00	5,00	5,00	0,5	0,00	10,00	10,00	0
		G_{path}	0,5	10,00	15,00	5,00	0,50
						G_{path}	0,17

Table 94 — *G*-profile along the two lateral paths (homogeneous)

G-profile lateral right				*G*-profile lateral left			
from (m)	to (m)	length (m)	G	from (m)	to (m)	length (m)	*G*
0,00	7,07	7,07	0,5	0,00	7,07	7,07	0,5
7,07	14,93	7,86	0,5	7,07	14,93	7,86	0,5
14,93	17,55	2,62	0,0	14,93	17,55	2,62	0,0
17,55	23,65	6,10	0,5	17,55	23,65	6,10	0,5

Table 95 — Ground attenuation related to lateral propagation paths

f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**
Lateral right								
w (H)	0,00	0,00	0,00	0,01	0,08	0,40	2,07	9,99
C_f (H)	25,07	25,45	26,93	29,26	21,08	5,11	0,53	0,10
$A_{ground,H}$ in dB	-1,51	-1,51	-1,51	-1,51	-1,51	-1,51	-1,51	-1,51
w (F)	0,00	0,00	0,00	0,01	0,06	0,31	1,60	7,90
C_f (F)	25,05	25,34	26,56	29,11	23,63	7,01	0,74	0,13
$A_{ground,F}$ in dB	-1,51	-1,51	-1,51	-1,51	-1,51	-1,51	-1,51	-1,51
lateral left								
w (H)	0,00	0,00	0,00	0,01	0,08	0,40	2,07	9,99
C_f (H)	25,07	25,45	26,93	29,26	21,08	5,11	0,53	0,10
$A_{ground,H}$ in dB	-1,51	-1,51	-1,51	-1,51	-1,51	-1,51	-1,51	-1,51
w (F)	0,00	0,00	0,00	0,01	0,06	0,31	1,60	7,90
C_f (F)	25,05	25,34	26,56	29,11	23,63	7,01	0,74	0,13
$A_{ground,F}$ in dB	-1,51	-1,51	-1,51	-1,51	-1,51	-1,51	-1,51	-1,51

Table 96 — Calculation of the linear partial levels related to the right lateral path (homogeneous)

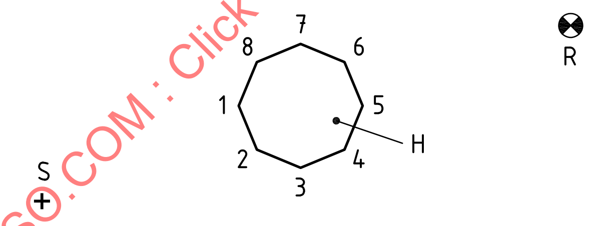
Lateral right (H)									
f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**	
L_W in dB	93	93	93	93	93	93	93	93	
α_{atm} (10°,70%)	0,12	0,41	1,04	1,93	3,66	9,66	32,77	116,88	
A_{atm} in dB	0,00	0,01	0,03	0,05	0,10	0,27	0,90	3,22	
A_{div} in dB	38,75	38,75	38,75	38,75	38,75	38,75	38,75	38,75	
$A_{ground,H}$ in dB	-1,51	-1,51	-1,51	-1,51	-1,51	-1,51	-1,51	-1,51	
$A_{dif,H}$ in dB	14,47	17,92	22,26	26,57	30,18	33,37	36,43	39,45	
A_H in dB	51,72	55,18	59,53	63,86	67,52	70,88	74,57	79,91	**Total**
L_H in dB	41,28	37,82	33,47	29,14	25,48	22,12	18,43	13,09	43,64

Table 97 — Partial and total sound pressure levels for all three propagation paths

f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**	**Total**
L_A in dB over top	18,44	25,94	30,62	33,10	33,30	32,41	31,64	27,49	39,80
L_A in dB right	15,08	21,72	24,87	25,94	25,48	23,32	19,43	11,99	31,91
L_A in dB left	15,08	21,72	24,87	25,94	25,48	23,32	19,43	11,99	31,91
L_A in dB	21,28	28,39	32,47	34,51	34,54	33,37	32,14	27,73	41,03

6.2.13 TC12 — Flat ground with homogeneous acoustic properties and polygonal object — Receiver at low height

The aim of this test case, shown in Figures 21 and 22, is to check the calculation of diffraction with a more complex shape of the screening object. The ground factor of the terrain is spatially constant with G = 0,5.



Key

S source

R receiver

H object

1 to 8 edge numbers

Figure 21 — Screening polygonal object — Receiver at low height

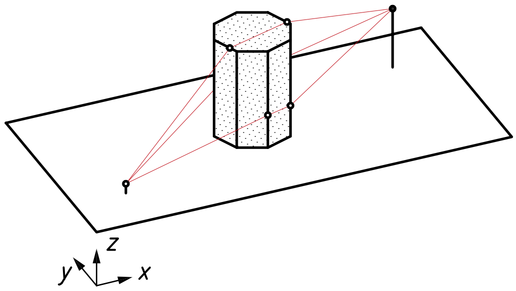


Figure 22 — 3D-presentation of scenario TC12

Tables 98 and 99 contain the input parameters, and Tables 100 to 110 show the intermediate and the final results.

Table 98 — Coordinates of source S and receiver R

Point	*x* (m)	*y* (m)	*z* (m)
S	0	10	1
R	30	20	6

Table 99 — Coordinates of acoustically opaque objects (buildings)

Object No	**Edge** No	*x* (m)	*y* (m)	*z* (m)
1	1	11,0	15,5	10,0
1	2	12,0	13,0	10,0
1	3	14,5	12,0	10,0
1	4	17,0	13,0	10,0
1	5	18,0	15,5	10,0
1	6	17,0	18,0	10,0
1	7	14,5	19,0	10,0
1	8	12,0	18,0	10,0

Table 100 — *z*-profile (ground height) along the propagation path

***z*-profile** S-R		
No	*u* (m)	*v* (m)
1	0,00	0,00
2	12,26	0,00
3	12,26	10,00
4	18,82	10,00
5	18,82	0,00
6	31,62	0,00

Table 101 — Mean ground plane MGP and averaged ground factors (homogeneous)

Parameter	S -> O1	O$_n$ -> R	S->R **right**	S->R **left**
a (MGP)	0,00	0,00	0,00	0,00
b (MGP) in m	0,00	0,00	0,00	0,00
z_1 in m	1,00	10,00	1,00	1,00
z_2 in m	10,00	6,00	6,00	6,00
d_p in m	12,26	12,80	32,11	32,66
G_{path}	0,50	0,50	0,50	0,50
G'_{path}	0,50		0,50	0,50

Table 102 — Coordinates of mirror points (homogeneous)

Mirror points	u (m)	v (m)
S' (S -> O)	0,00	-1,00
R' (O -> R)	31,62	-6,00

Table 103 — Calculation of the path length differences δ

Parameter	S->R		S'->R		S->R'		Lateral right		Lateral left	
	(H)	(F)	(H)	(F)	(H)	(F)	(H)	(F)	(H)	(F)
No(O$_1$)	3	3	3	3	3	3	-	-	-	-
No(O$_n$)	4	4	4	4	4	4	-	-	-	-
d	32,02	32,02	32,39	32,39	32,39	32,39	32,02	32,02	32,02	32,02
d_{ss}	15,21	15,21	16,47	16,47	15,21	15,21	14,81	14,81	14,59	14,59
d_{sr}	13,41	13,41	13,41	13,41	20,49	20,49	14,94	14,94	15,71	15,71
e	6,55	6,55	6,55	6,55	6,55	6,55	2,74	2,74	2,74	2,74
δ	3,17	3,16	4,06	4,05	9,87	9,87	0,48	0,48	1,03	1,03

Table 104 — Determination of $A_{boundary,H}$

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000
$\Delta_{dif(S,R)}$	14,37	17,50	21,47	25,97	29,98	33,36	36,47	39,50
$A_{ground,(S,O)}$	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50
$A_{ground,(O,R)}$	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50
$\Delta_{dif(S',R)}$	15,34	18,53	22,52	27,04	31,05	34,43	37,54	40,58
$\Delta_{dif(S,R')}$	18,98	22,28	26,34	30,89	34,91	38,29	41,41	44,44
$\Delta_{ground(S,O)}$	-1,35	-1,35	-1,34	-1,34	-1,34	-1,34	-1,34	-1,34
$\Delta_{ground(O,R)}$	-0,91	-0,90	-0,89	-0,88	-0,88	-0,88	-0,88	-0,88
A_{dif}	12,10	15,26	19,24	22,78	22,78	22,78	22,78	22,78
$A_{ground(S,R)}$	-	-	-	-	-	-	-	-
$A_{boundary,H}$	12,10	15,26	19,24	22,78	22,78	22,78	22,78	22,78

Table 105 — Determination of $A_{boundary,F}$

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000
$\Delta_{dif(S,R)}$	14,37	17,50	21,46	25,97	29,98	33,35	36,47	39,50
$A_{ground,(S,O)}$	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50

Table 105 *(continued)*

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000
$A_{ground,(O,R)}$	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50
$\Delta_{dif(S',R)}$	15,34	18,52	22,52	27,04	31,05	34,43	37,54	40,58
$\Delta_{dif(S,R')}$	18,97	22,28	26,34	30,89	34,91	38,29	41,41	44,44
$\Delta_{ground(S,O)}$	-1,35	-1,35	-1,34	-1,34	-1,34	-1,34	-1,34	-1,34
$\Delta_{ground(O,R)}$	-0,91	-0,90	-0,89	-0,88	-0,88	-0,88	-0,88	-0,88
A_{dif}	12,10	15,26	19,24	22,78	22,78	22,78	22,78	22,78
$A_{ground(S,R)}$	-	-	-	-	-	-	-	-
$A_{boundary,F}$	12,10	15,26	19,24	22,78	22,78	22,78	22,78	22,78

Table 106 — Step by step and final results related to the propagation in the vertical plane

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000	
L_W in dB	93	93	93	93	93	93	93	93	
α_{atm}	0,12	0,41	1,04	1,93	3,66	9,66	32,77	116,88	
A_{atm} in dB	0,00	0,01	0,03	0,06	0,12	0,31	1,05	3,74	
A_{div} in dB	41,11	41,11	41,11	41,11	41,11	41,11	41,11	41,11	
$A_{boundary,H}$ in dB	12,10	15,26	19,24	22,78	22,78	22,78	22,78	22,78	
$A_{boundary,F}$ in dB	12,10	15,26	19,24	22,78	22,78	22,78	22,78	22,78	**Total**
L_H in dB	39,78	36,62	32,62	29,05	29,00	28,80	28,06	25,37	42,85
L_F in dB	39,79	36,62	32,62	29,05	29,00	28,80	28,06	25,37	42,85
L in dB	39,78	36,62	32,62	29,05	29,00	28,80	28,06	25,37	42,85
A-weighting in dB	-26,2	-16,1	-8,6	-3,2	0,0	1,2	1,0	-1,1	
L_A in dB	13,58	20,52	24,02	25,85	29,00	30,00	29,06	24,27	35,61

Table 107 — Ground attenuation related to lateral propagation paths

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000
Lateral right								
w (H)	0,00	0,00	0,00	0,01	0,08	0,41	2,10	10,13
C_f (H)	32,26	32,87	35,13	37,43	23,55	4,65	0,49	0,10
$A_{ground,H}$ in dB	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50
w (F)	0,00	0,00	0,00	0,01	0,08	0,41	2,10	10,13
C_f (F)	32,26	32,87	35,13	37,43	23,55	4,65	0,49	0,10
$A_{ground,F}$ in dB	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50
lateral left								
w (H)	0,00	0,00	0,00	0,01	0,08	0,41	2,10	10,13
C_f (H)	32,82	33,45	35,78	38,05	23,71	4,62	0,49	0,10
$A_{ground,H}$ in dB	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50
w (F)	0,00	0,00	0,00	0,01	0,08	0,41	2,10	10,13
C_f (F)	32,82	33,45	35,78	38,05	23,71	4,62	0,49	0,10
$A_{ground,F}$ in dB	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50

Table 108 — Calculation of the linear partial levels related to the right lateral path (homogeneous)

Lateral right (H)									
f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**	
L_W in dB	93	93	93	93	93	93	93	93	
α_{atm} (10°,70%)	0,12	0,41	1,04	1,93	3,66	9,66	32,77	116,88	
A_{atm} in dB	0,00	0,01	0,03	0,06	0,12	0,31	1,06	3,80	
A_{div} in dB	41,11	41,11	41,11	41,11	41,11	41,11	41,11	41,11	
$A_{ground,H}$ in dB	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50	
$A_{dif,H}$ in dB	8,17	10,09	12,67	16,13	20,46	24,62	28,11	31,25	
A_H in dB	47,78	49,71	52,31	55,80	60,19	64,54	68,78	74,66	**Total**
L_H in dB	45,22	43,29	40,69	37,20	32,81	28,46	24,22	18,34	48,72

Table 109 — Calculation of the linear partial levels related to the right lateral path (favourable)

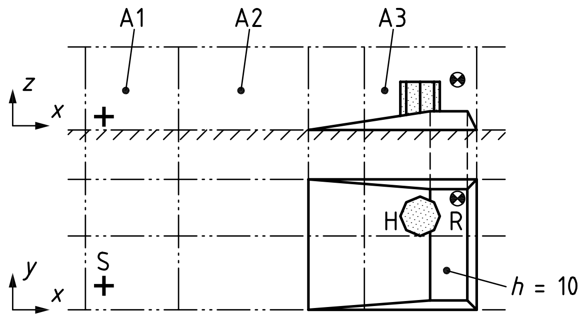
Lateral right (F)									
f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**	
L_W in dB	93	93	93	93	93	93	93	93	
α_{atm} (10°,70%)	0,12	0,41	1,04	1,93	3,66	9,66	32,77	116,88	
A_{atm} in dB	0,00	0,01	0,03	0,06	0,12	0,31	1,06	3,80	
A_{div} in dB	41,11	41,11	41,11	41,11	41,11	41,11	41,11	41,11	
$A_{ground,F}$ in dB	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50	
$A_{dif,F}$ in dB	8,17	10,09	12,67	16,13	20,46	24,62	28,11	31,25	
A_F in dB	47,78	49,71	52,31	55,80	60,19	64,54	68,78	74,66	**Total**
L_F in dB	45,22	43,29	40,69	37,20	32,81	28,46	24,22	18,34	48,72

Table 110 — Partial and total sound pressure levels for all three propagation paths

f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**	**Total**
L_A in dB over top	13,58	20,52	24,02	25,85	29,00	30,00	29,06	24,27	35,61
L_A in dB right	19,02	27,19	32,09	34,00	32,81	29,66	25,22	17,24	39,01
L_A in dB left	16,91	24,61	29,16	30,84	29,54	26,35	21,89	13,86	35,90
L_A in dB	21,81	29,66	34,31	36,14	35,57	33,72	31,12	25,37	41,90

6.2.14 TC13 — Ground with spatially varying heights and acoustic properties and polygonal object

The aim of this test case is to check the combination of different ground heights and ground factors below screened direct paths and lateral propagation paths. Contour lines and geometry of areas of constant ground factor G are the same as in TC05 (Tables 16 and 17), but the sequential arrangement of G-values is modified (see Figures 23 and 24 and Table 112).



Key

S source

R receiver

H object

h height, expressed in meters

A1 area with G = 0,5

A2 area with G = 0,9

A3 area with G = 0,2

Figure 23 — Ground with spatially varying heights and acoustic properties and polygonal object

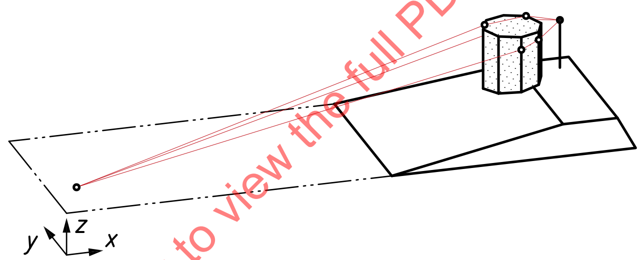


Figure 24 — 3D-presentation of scenario TC13

Tables 111 to 113 contain the modified and new input parameters, and Tables 114 to 127 show the intermediate and the final results.

Table 111 — Coordinates of source S and receiver R

Point	x (m)	y (m)	z (m)
S	10	10	1
R	200	50	28,5

Table 112 — Rectangular areas with constant ground factor G

G	x (m)		y (m)	
	min	max	min	max
0,5	0	50	-20	80
0,9	50	150	-20	80
0,2	150	225	-20	80

Table 113 — Coordinates of acoustically opaque objects (buildings)

Object No	Edge No	*x* (m)	*y* (m)	*z* (m)
1	1	169,4	41,0	30,0
1	2	172,5	33,5	30,0
1	3	180,0	30,4	30,0
1	4	187,5	33,5	30,0
1	5	190,6	41,0	30,0
1	6	187,5	48,5	30,0
1	7	180,0	51,6	30,0
1	8	172,5	48,5	30,0

Table 114 — Determination of G_{path} (homogeneous)

G-profile S -> O				*G*-profile O -> R			
from (m)	to (m)	length (m)	*G*	from (m)	to (m)	length (m)	*G*
0,00	40,88	40,88	0,5	0,00	12,33	12,33	0,2
40,88	143,07	102,19	0,9			G_{path}	0,20
143,07	164,07	21,00	0,20				
		G_{path}	0,71				

Table 115 — *G*-profile along the two lateral paths (homogeneous)

G-profile lateral right				*G*-profile lateral left			
from (m)	to (m)	length (m)	*G*	from (m)	to (m)	length (m)	*G*
0,00	40,29	40,29	0,5	0,00	41,18	41,18	0,5
40,29	141,00	100,72	0,9	41,18	144,13	102,95	0,9
141,00	171,22	30,21	0,2	144,13	175,02	30,88	0,2
171,22	179,34	8,12	0,2	175,02	195,08	20,07	0,2
179,34	200,04	20,70	0,2			G_{path}	0,63
		G_{path}	0,61				

Table 116 — Height profiles along the direct and the two lateral paths (homogeneous)

z-profile S-O		*z*-profile O-R		*z*-profile right		*z*-profile left	
u (m)	*z* (m)	*u* (m)	*z* (m)	*u* (m)	*z* (m)	*u* (m)	*z* (m)
0,00	0,00	181,83	10,00	0,00	0,00	0,00	0,00
112,41	0,00	194,16	10,00	110,79	0,00	113,25	0,00
164,07	7,78			171,22	9,23	175,02	9,23
				176,63	10,00	180,04	10,00
				179,34	10,00	195,08	10,00
				200,04	10,00		

Table 117 — z-profile (ground height) along the propagation path

z-profile S-R		
No	u (m)	v (m)
1	0,00	0,00
2	112,41	0,00
3	164,07	7,78
4	164,07	30,00
5	181,83	30,00
6	181,83	10,00
7	194,16	10,00

Table 118 — Mean ground plane MGP and averaged ground factors (homogeneous)

Parameter	S -> O_1	O_n -> R	S->R **right**	S->R **left**
a (MGP)	0,04	0,00	0,06	0,05
b (MGP) in m	-1,68	10,00	-2,99	-2,82
z_1 in m	2,68	20,00	3,98	3,82
z_2 in m	25,86	18,50	19,83	20,69
d_p in m	164,99	12,33	201,30	196,29
G_{path}	0,71	0,20	0,61	0,63
G'_{path}	0,54		0,53	0,54

Table 119 — Coordinates of mirror points (homogeneous)

Mirror points	u (m)	v (m)
S' (S -> O)	0,19	-4,35
R' (O -> R)	194,16	-8,50

Table 120 — Calculation of the path length differences δ

Parameter	S->R		S'->R		S->R'		**Lateral right**		**Lateral left**	
	(H)	(F)	(H)	(F)	(H)	(F)	(H)	(F)	(H)	(F)
No(O_1)	4	4	4	4	4	4	-	-	-	-
No(O_n)	5	5	5	5	5	5	-	-	-	-
d	196,10	196,23	196,74	196,87	194,40	194,52	196,10	196,10	196,10	196,10
d_{ss}	166,61	166,69	167,44	167,52	166,61	166,69	172,91	172,91	176,76	176,76
d_{sr}	12,42	12,42	12,42	12,42	40,43	40,43	20,82	20,82	20,25	20,25
e	17,76	17,76	17,76	17,76	17,76	17,76	8,20	8,20	0,00	0,00
δ	0,70	0,65	0,89	0,84	30,41	30,36	5,83	5,83	0,91	0,91

Table 121 — Determination of $A_{boundary,H}$

f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**
$A_{dif(S,R)}$	9,76	13,15	17,15	20,71	23,88	26,92	29,93	32,94
$A_{ground,(S,O)}$	-1,38	-1,38	-1,38	-1,38	-1,38	-1,38	-1,38	-1,38
$A_{ground,(O,R)}$	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40
$A_{dif(S',R)}$	10,52	14,08	18,17	21,75	24,94	27,98	31,00	34,01
$A_{dif(S,R')}$	24,55	28,89	33,30	37,00	40,23	43,30	46,32	49,34

Table 121 *(continued)*

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000
$\Delta_{ground(S,O)}$	-1,27	-1,25	-1,24	-1,23	-1,23	-1,23	-1,23	-1,23
$\Delta_{ground(O,R)}$	-0,49	-0,44	-0,42	-0,41	-0,41	-0,41	-0,41	-0,41
A_{dif}	8,00	11,46	15,50	19,06	22,24	23,36	23,36	23,36
$A_{ground(S,R)}$	-	-	-	-	-	-	-	-
$A_{boundary,H}$	8,00	11,46	15,50	19,06	22,24	23,36	23,36	23,36

Table 122 — Determination of $A_{boundary,F}$

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000
$\Delta_{dif(S,R)}$	9,54	12,88	16,85	20,40	23,57	26,60	29,62	32,62
$A_{ground,(S,O)}$	-1,38	-1,38	-1,38	-1,38	-1,38	-1,38	-1,38	-1,38
$A_{ground,(O,R)}$	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40
$\Delta_{dif(S',R)}$	10,34	13,86	17,93	21,51	24,69	27,74	30,75	33,76
$\Delta_{dif(S,R')}$	24,55	28,88	33,30	37,00	40,22	43,29	46,32	49,33
$\Delta_{ground(S,O)}$	-1,27	-1,24	-1,23	-1,22	-1,22	-1,22	-1,22	-1,22
$\Delta_{ground(O,R)}$	-0,48	-0,43	-0,41	-0,40	-0,40	-0,40	-0,40	-0,39
A_{dif}	7,80	11,21	15,22	18,78	21,95	23,38	23,38	23,38
$A_{ground(S,R)}$	-	-	-	-	-	-	-	-
$A_{boundary,F}$	7,80	11,21	15,22	18,78	21,95	23,38	23,38	23,38

Table 123 — Step by step and final results related to the propagation in the vertical plane

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000	
L_W in dB	93	93	93	93	93	93	93	93	
α_{atm}	0,12	0,41	1,04	1,93	3,66	9,66	32,77	116,88	
A_{atm} in dB	0,02	0,08	0,20	0,38	0,72	1,90	6,43	22,92	
A_{div} in dB	56,85	56,85	56,85	56,85	56,85	56,85	56,85	56,85	
$A_{boundary,H}$ in dB	8,00	11,46	15,50	19,06	22,24	23,36	23,36	23,36	
$A_{boundary,F}$ in dB	7,80	11,21	15,22	18,78	21,95	23,38	23,38	23,38	**Total**
L_H in dB	28,13	24,61	20,45	16,71	13,19	10,90	6,36	-10,13	30,55
L_F in dB	28,33	24,86	20,73	17,00	13,49	10,87	6,34	-10,16	30,77
L in dB	28,23	24,73	20,59	16,85	13,34	10,88	6,35	-10,14	30,66
A-weighting in dB	-26,2	-16,1	-8,6	-3,2	0,0	1,2	1,0	-1,1	
L_A in dB	2,03	8,63	11,99	13,65	13,34	12,08	7,35	-11,24	19,60

Table 124 — Ground attenuation related to lateral propagation paths

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000
Lateral right								
w (H)	0,00	0,00	0,00	0,02	0,09	0,48	2,42	11,50
C_f (H)	207,46	223,88	230,36	122,25	18,84	2,12	0,41	0,09
$A_{ground,H}$ in dB	-1,40	-1,40	-1,40	-1,40	-1,40	-1,40	-1,40	-1,40
w (F)	0,00	0,00	0,00	0,02	0,13	0,67	3,32	15,27
C_f (F)	209,72	228,83	218,90	92,01	11,30	1,50	0,30	0,07
$A_{ground,F}$ in dB	-1,40	-1,40	-1,40	-1,40	-1,40	-1,40	-1,40	-1,40
lateral left								

Table 124 *(continued)*

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000
w (H)	0,00	0,00	0,00	0,02	0,09	0,48	2,46	11,67
C_f (H)	202,25	218,20	224,79	119,88	18,59	2,08	0,41	0,09
$A_{ground,H}$ in dB	-1,39	-1,39	-1,39	-1,39	-1,39	-1,39	-1,39	-1,39
w (F)	0,00	0,00	0,00	0,03	0,14	0,72	3,56	16,24
C_f (F)	204,90	223,86	211,09	85,42	10,19	1,39	0,28	0,06
$A_{ground,F}$ in dB	-1,39	-1,39	-1,39	-1,39	-1,39	-1,39	-1,39	-1,39

Table 125 — Calculation of the linear partial levels related to the right lateral path (homogeneous)

Lateral right (H)									
f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**	
L_W in dB	93	93	93	93	93	93	93	93	
α_{atm} (10°,70%)	0,12	0,41	1,04	1,93	3,66	9,66	32,77	116,88	
A_{atm} in dB	0,02	0,08	0,21	0,39	0,74	1,95	6,62	23,60	
A_{div} in dB	56,85	56,85	56,85	56,85	56,85	56,85	56,85	56,85	
$A_{ground,H}$ in dB	-1,40	-1,40	-1,40	-1,40	-1,40	-1,40	-1,40	-1,40	
$\Delta_{dif,H}$ in dB	16,88	20,30	24,57	29,02	32,80	36,06	39,13	42,16	
A_H in dB	72,35	75,83	80,23	84,86	88,98	93,45	101,20	121,21	**Total**
L_H in dB	20,65	17,17	12,77	8,14	4,02	-0,45	-8,20	-28,21	22,95

Table 126 — Calculation of the linear partial levels related to the left lateral path (homogeneous)

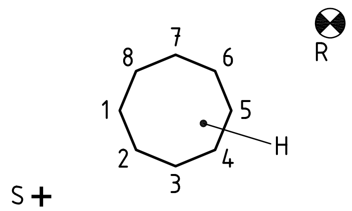
Lateral left (H)									
f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**	
L_W in dB	93	93	93	93	93	93	93	93	
α_{atm} (10°,70%)	0,12	0,41	1,04	1,93	3,66	9,66	32,77	116,88	
A_{atm} in dB	0,02	0,08	0,21	0,38	0,72	1,90	6,46	23,03	
A_{div} in dB	56,85	56,85	56,85	56,85	56,85	56,85	56,85	56,85	
$A_{ground,H}$ in dB	-1,39	-1,39	-1,39	-1,39	-1,39	-1,39	-1,39	-1,39	
$\Delta_{dif,H}$ in dB	9,89	12,15	14,74	17,53	20,42	23,37	26,35	29,35	
A_H in dB	65,37	67,68	70,40	73,36	76,60	80,73	88,26	107,83	**Total**
L_H in dB	27,63	25,32	22,60	19,64	16,40	12,27	4,74	-14,83	30,99

Table 127 — Partial and total sound pressure levels for all three propagation paths

f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**	**Total**
L_A in dB over top	2,03	8,63	11,99	13,65	13,34	12,08	7,35	-11,24	19,60
L_A in dB right	-5,55	1,07	4,17	4,94	4,02	0,75	-7,20	-29,31	10,49
L_A in dB left	1,43	9,22	14,00	16,44	16,40	13,47	5,74	-15,93	21,72
L_A in dB	5,14	12,29	16,39	18,47	18,31	15,97	9,72	-9,92	24,00

6.2.15 TC14 — Flat ground with homogeneous acoustic properties and polygonal object — Receiver at large height

The aim of this test case, shown in Figures 25 and 26, is to check the correct ray geometry for the direct and laterally diffracted sound. The ground factor of the terrain is spatially constant with G = 0,2.



Key

S source

R receiver

H object

1 to 8 edge numbers

Figure 25 — Screening polygonal object — Receiver at large height

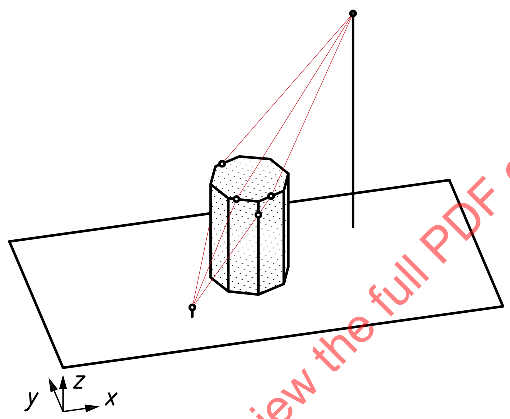


Figure 26 — 3D-presentation of scenario TC14

Table 128 contains the new receiver height as input parameter, and Tables 129 to 145 show the intermediate and the final results.

Table 128 — Coordinates of source S and receiver R

Point	x (m)	y (m)	z (m)
S	8	10	1
R	25	20	23

Table 129 — Determination of G_{path} (homogeneous)

G-profile S -> O				*G*-profile O -> R			
from (m)	to (m)	length (m)	G	from (m)	to (m)	length (m)	G
0,00	5,39	5,39	0,2	0,00	6,10	6,10	0
		G_{path}	0,2	6,10	14,33	8,23	0,20
						G_{path}	0,11

Table 130 — *G*-profile along the two lateral paths (homogeneous)

G-profile lateral right				*G*-profile lateral left			
from (m)	to (m)	length (m)	*G*	from (m)	to (m)	length (m)	*G*
0,00	6,79	6,79	0,2	0,00	8,95	8,95	0,2
6,79	8,27	1,49	0,2	8,95	9,52	0,57	0,2
8,27	8,29	0,02	0,2	9,52	9,53	0,01	0,2
8,29	10,10	1,81	0,0	9,53	12,48	2,95	0,0
10,10	20,07	9,97	0,2	12,48	22,12	9,64	0,2
		G_{path}	0,18			G_{path}	0,17

Table 131 — Height profiles along the direct and the two lateral paths (homogeneous)

z-profile S-O		*z*-profile O-R		*z*-profile right		*z*-profile left	
u (m)	*z* (m)	*u* (m)	*z* (m)	*u* (m)	*z* (m)	*u* (m)	*z* (m)
0,00	0,00	5,39	10,00	0,00	0,00	0,00	0,00
5,39	0,00	11,49	10,00	6,79	0,00	8,95	0,00
		11,49	0,00	8,27	0,00	9,52	0,00
		19,72	0,00	8,29	0,00	9,53	0,00
				8,29	10,00	9,53	10,00
				10,10	10,00	12,48	10,00
				10,10	0,00	12,48	0,00
				20,07	0,00	22,12	0,00

Table 132 — *z*-profile (ground height) along the propagation path

z-profile S-R		
No	*u* (m)	*v* (m)
1	0,00	0,00
2	5,39	0,00
3	5,39	10,00
4	11,49	10,00
5	11,49	0,00
6	19,72	0,00

Table 133 — Mean ground plane MGP and averaged ground factors (homogeneous)

Parameter	S -> O_1	O_n -> R	S->R **right**	S->R **left**
a (MGP)	0,00	-1,02	-0,02	0,00
b (MGP) in m	0,00	17,11	1,13	1,35
z_1 in m	1,00	0,00	0,00	0,00
z_2 in m	10,00	18,23	22,32	21,69
d_p in m	5,39	0,72	19,57	22,08
G_{path}	0,20	0,11	0,18	0,17
G'_{path}	0,20		0,20	0,20

Table 134 — Coordinates of mirror points (homogeneous)

Mirror points	u (m)	v (m)
S' (S -> O)	0,00	-1,00
R' (O -> R)	-6,35	-2,48

Table 135 — Calculation of the path length differences δ

Parameter	S->R		S'->R		S->R'		Lateral right		Lateral left	
	(H)	(F)	(H)	(F)	(H)	(F)	(H)	(F)	(H)	(F)
No(O_1)	3	3	3	3	3	3	-	-	-	-
No(O_n)	3	3	3	3	3	3	-	-	-	-
d	29,55	29,55	31,06	31,07	7,24	7,24	29,55	29,55	29,55	29,55
d_{ss}	10,49	10,49	12,25	12,25	10,49	10,49	10,01	10,01	12,25	12,25
d_{sr}	19,35	19,35	19,35	19,35	17,13	17,13	17,55	17,55	18,10	18,10
e	0,00	0,00	0,00	0,00	0,00	0,00	2,21	2,21	0,85	0,85
δ	0,29	0,29	0,54	0,54	20,38	20,38	0,23	0,23	1,66	1,66

Table 136 — Determination of $A_{boundary,H}$

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000
$A_{dif(S,R)}$	7,15	8,65	10,67	13,08	15,76	18,59	21,51	24,48
$A_{ground,(S,O)}$	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40
$A_{ground,(O,R)}$	-2,66	-2,66	-2,66	-2,66	-2,66	-2,66	-2,66	-2,66
$A_{dif(S',R)}$	8,43	10,37	12,73	15,38	18,20	21,11	24,07	27,05
$A_{dif(S,R')}$	21,88	24,81	27,80	30,80	33,80	36,81	39,82	42,83
$A_{ground(S,O)}$	-2,11	-2,02	-1,94	-1,90	-1,87	-1,86	-1,85	-1,84
$A_{ground(O,R)}$	-0,55	-0,47	-0,42	-0,39	-0,38	-0,37	-0,37	-0,37
A_{dif}	4,49	6,17	8,30	10,79	13,51	16,37	19,30	22,27
$A_{ground(S,R)}$	-	-	-	-	-	-	-	-
$A_{boundary,H}$	4,49	6,17	8,30	10,79	13,51	16,37	19,30	22,27

Table 137 — Determination of $A_{boundary,F}$

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000
$A_{dif(S,R)}$	7,14	8,65	10,66	13,07	15,75	18,58	21,50	24,47
$A_{ground,(S,O)}$	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40
$A_{ground,(O,R)}$	-2,66	-2,66	-2,66	-2,66	-2,66	-2,66	-2,66	-2,66
$A_{dif(S',R)}$	8,43	10,36	12,73	15,38	18,19	21,10	24,06	27,05
$A_{dif(S,R')}$	21,88	24,81	27,80	30,80	33,80	36,81	39,82	42,83
$A_{ground(S,O)}$	-2,11	-2,02	-1,94	-1,90	-1,87	-1,86	-1,85	-1,84
$A_{ground(O,R)}$	-0,55	-0,47	-0,42	-0,39	-0,38	-0,37	-0,37	-0,37
A_{dif}	4,48	6,16	8,30	10,78	13,50	16,36	19,29	22,26
$A_{ground(S,R)}$	-	-	-	-	-	-	-	-
$A_{boundary,F}$	4,48	6,16	8,30	10,78	13,50	16,36	19,29	22,26

Table 138 — Linear octave-band sound pressure levels related to the vertical propagation plane (homogeneous)

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000	
L_W in dB	93	93	93	93	93	93	93	93	
α_{atm}	0,1	0,4	1,0	1,9	3,7	9,7	32,8	116,9	
A_{atm} in dB	0,00	0,01	0,03	0,06	0,11	0,29	0,97	3,45	
A_{div} in dB	40,41	40,41	40,41	40,41	40,41	40,41	40,41	40,41	
$A_{boundary,H}$ in dB	4,49	6,17	8,30	10,79	13,51	16,37	19,30	22,27	
L_H in dB	48,10	46,41	44,26	41,74	38,97	35,94	32,33	26,87	52,15

Table 139 — Linear octave-band sound pressure levels related to the vertical propagation plane (favourable)

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000
L_W in dB	93	93	93	93	93	93	93	93
α_{atm}	0,1	0,4	1,0	1,9	3,7	9,7	32,8	116,9
A_{atm} in dB	0,00	0,01	0,03	0,06	0,11	0,29	0,97	3,45
A_{div} in dB	40,41	40,41	40,41	40,41	40,41	40,41	40,41	40,41
$A_{boundary,F}$ in dB	4,48	6,16	8,30	10,78	13,50	16,36	19,29	22,26
L_F in dB	48,10	46,42	44,26	41,75	38,98	35,95	32,33	26,88

Table 140 — Ground attenuation related to lateral propagation paths

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000
Lateral right								
w (H)	0,00	0,00	0,00	0,00	0,01	0,04	0,23	1,23
C_f (H)	19,57	19,60	19,73	20,34	22,18	21,49	9,40	1,20
$A_{ground,H}$ in dB	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40
w (F)	0,00	0,00	0,00	0,00	0,01	0,03	0,18	0,98
C_f (F)	19,57	19,59	19,70	20,20	21,86	22,22	11,29	1,67
$A_{ground,F}$ in dB	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40
lateral left								
w (H)	0,00	0,00	0,00	0,00	0,01	0,04	0,23	1,22
C_f (H)	22,09	22,12	22,28	23,04	25,19	23,72	9,58	1,15
$A_{ground,H}$ in dB	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40
w (F)	0,00	0,00	0,00	0,00	0,01	0,03	0,16	0,87
C_f (F)	22,09	22,11	22,23	22,79	24,66	25,08	12,76	1,88
$A_{ground,F}$ in dB	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40

Table 141 — Calculation of the linear partial levels related to the right lateral path (homogeneous)

Lateral right (H)								
f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**
L_W in dB	93	93	93	93	93	93	93	93
α_{atm} (10°,70%)	0,12	0,41	1,04	1,93	3,66	9,66	32,77	116,88
A_{atm} in dB	0,00	0,01	0,03	0,06	0,11	0,29	0,98	3,48
A_{div} in dB	40,41	40,41	40,41	40,41	40,41	40,41	40,41	40,41
$A_{ground,H}$ in dB	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40

Table 141 *(continued)*

Lateral right (H)									
f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**	
$\Delta_{dif,H}$ in dB	6,76	8,13	10,15	13,04	17,02	21,28	24,93	28,14	
A_H in dB	44,77	46,15	48,19	51,11	55,14	59,58	63,91	69,63	**Total**
L_H in dB	48,23	46,85	44,81	41,89	37,86	33,42	29,09	23,37	52,31

Table 142 — Calculation of the linear partial levels related to the right lateral path (favourable)

Lateral right (F)									
f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**	
L_W in dB	93	93	93	93	93	93	93	93	
α_{atm}(10°,70%)	0,12	0,41	1,04	1,93	3,66	9,66	32,77	116,88	
A_{atm} in dB	0,00	0,01	0,03	0,06	0,11	0,29	0,98	3,48	
A_{div} in dB	40,41	40,41	40,41	40,41	40,41	40,41	40,41	40,41	
$A_{ground,F}$ in dB	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40	
$\Delta_{dif,F}$ in dB	6,76	8,13	10,15	13,04	17,02	21,28	24,93	28,14	
A_F in dB	44,77	46,15	48,19	51,11	55,14	59,58	63,91	69,63	**Total**
L_F in dB	48,23	46,85	44,81	41,89	37,86	33,42	29,09	23,37	52,31

Table 143 — Calculation of the linear partial levels related to the left lateral path (homogeneous)

Lateral left (H)									
f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**	
L_W in dB	93	93	93	93	93	93	93	93	
α_{atm} (10°,70%)	0,12	0,41	1,04	1,93	3,66	9,66	32,77	116,88	
A_{atm} in dB	0,00	0,01	0,03	0,06	0,11	0,30	1,02	3,65	
A_{div} in dB	40,41	40,41	40,41	40,41	40,41	40,41	40,41	40,41	
$A_{ground,H}$ in dB	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40	
$\Delta_{dif,H}$ in dB	11,85	14,39	17,19	20,19	23,58	27,70	32,24	36,23	
A_H in dB	49,86	52,41	55,23	58,26	61,70	66,01	71,27	77,88	**Total**
L_H in dB	43,14	40,59	37,77	34,74	31,30	26,99	21,73	15,12	46,34

Table 144 — Calculation of the linear partial levels related to the left lateral path (favourable)

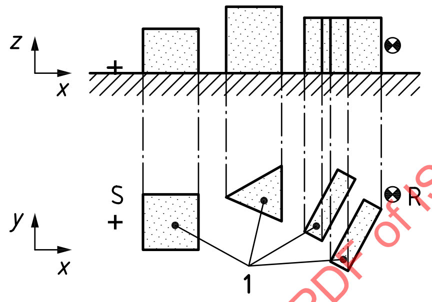
Lateral left (F)									
f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**	
L_W in dB	93	93	93	93	93	93	93	93	
α_{atm}(10°,70%)	0,12	0,41	1,04	1,93	3,66	9,66	32,77	116,88	
A_{atm} in dB	0,00	0,01	0,03	0,06	0,11	0,30	1,02	3,65	
A_{div} in dB	40,41	40,41	40,41	40,41	40,41	40,41	40,41	40,41	
$A_{ground,F}$ in dB	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40	
$\Delta_{dif,F}$ in dB	11,85	14,39	17,19	20,19	23,58	27,70	32,24	36,23	
A_F in dB	49,86	52,41	55,23	58,26	61,70	66,01	71,27	77,88	**Total**
L_F in dB	43,14	40,59	37,77	34,74	31,30	26,99	21,73	15,12	46,34

Table 145 — Partial and total sound pressure levels for all three propagation paths

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000	Total
L_A in dB over top	21,90	30,31	35,66	38,55	38,98	37,14	33,33	25,77	44,42
L_A in dB right	22,03	30,75	36,21	38,69	37,86	34,62	30,09	22,27	43,64
L_A in dB left	16,94	24,49	29,17	31,54	31,30	28,19	22,73	14,02	36,81
L_A in dB	25,61	34,06	39,39	42,04	41,86	39,42	35,26	27,57	47,45

6.2.16 TC15 — Flat ground with homogeneous acoustic properties and four buildings

The aim of this test case is to check the calculation with more buildings blocking the direct path. The ground factor of the terrain is spatially constant with G = 0,5. The scenario is shown in Figures 27 and 28. Building H4 is neglected when the laterally diffracted ray is constructed.



Key

1 buildings H1, H2, H3 and H4

S source

R receiver

Figure 27 — Four buildings (H1, H2, H3 and H4) between source and receiver

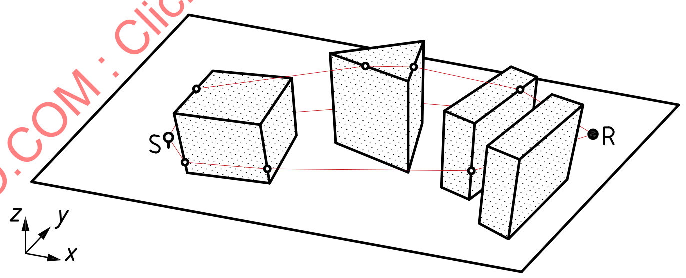


Figure 28 — 3D-presentation of scenario TC15

Tables 146 and 147 contain the modified and new input parameters, and Tables 148 to 159 show the intermediate and the final results.

Table 146 — Coordinates of source S and receiver R

Point	x (m)	y (m)	z (m)
S	50	10	1
R	100	15	5

Table 147 — Coordinates of acoustically opaque objects (buildings)

Object No	**Edge** No	*x* (m)	*y* (m)	*z* (m)
1	1	55,0	5,0	8,0
1	2	65,0	5,0	8,0
1	3	65,0	15,0	8,0
1	4	55,0	15,0	8,0
2	5	70,0	14,5	12,0
2	6	80,0	10,2	12,0
2	7	80,0	20,2	12,0
3	8	90,1	19,5	10,0
3	9	93,3	17,8	10,0
3	10	87,3	6,6	10,0
3	11	84,1	8,3	10,0
4	12	94,9	14,1	10,0
4	13	98,02	12,37	10
4	14	92,03	1,2	10
4	15	88,86	2,9	10

Table 148 — *z*-profile (ground height) along the propagation path

***z*-profile** S-R		
No	*u* (m)	*v* (m)
1	0,00	0,00
2	5,02	0,00
3	5,02	8,00
4	15,07	8,00
5	15,08	0,00
6	24,81	0,00
7	24,81	12,00
8	30,15	12,00
9	30,15	0,00
10	37,19	0,00
11	37,19	10,00
12	41,52	10,00
13	41,52	0,00
14	50,25	0,00

Table 149 — Mean ground plane MGP and averaged ground factors (homogeneous)

Parameter	S -> O1	O_n -> R	S->R **right**	S->R **left**
a (MGP)	0,00	0,00	0,08	0,00
b (MGP) in m	0,00	0,00	-1,19	0,00
z_1 in m	1,00	10,00	2,18	1,00
z_2 in m	8,00	5,00	2,01	5,00
d_p in m	5,02	8,73	54,80	53,60

Table 149 *(continued)*

Parameter	S -> O1	O_n -> R	S->R **right**	S->R **left**
G_{path}	0,50	0,50	0,46	0,50
G'_{path}	0,50		0,48	0,50

Table 150 — Coordinates of mirror points (homogeneous)

Mirror points	*u* (m)	*v* (m)
S' (S -> O)	0,00	-1,00
R' (O -> R)	50,25	-5,00

Table 151 — Calculation of the path length differences δ

Parameter	S->R		S'->R		S->R'		Lateral right		Lateral left	
	(H)	(F)	(H)	(F)	(H)	(F)	(H)	(F)	(H)	(F)
No(O_1)	3	3	3	3	3	3	-	-	-	-
No(O_n)	12	12	12	12	12	12	-	-	-	-
d	50,41	50,41	50,61	50,61	50,61	50,61	50,41	50,41	50,41	50,41
d_{ss}	8,62	8,62	10,31	10,31	8,62	8,62	7,08	7,08	7,09	7,09
d_{sr}	10,06	10,06	10,06	10,06	17,36	17,36	15,29	15,29	10,88	10,88
e	37,07	37,07	37,07	37,07	37,07	37,07	32,43	32,43	35,77	35,77
δ	5,34	5,33	6,83	6,83	12,43	12,43	4,39	4,39	3,34	3,34

Table 152 — Determination of $A_{boundary,H}$

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000
$\Delta_{dif(S,R)}$	18,64	22,86	26,49	29,68	32,74	35,76	38,77	41,78
$A_{ground,(S,O)}$	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50
$A_{ground,(O,R)}$	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50
$\Delta_{dif(S',R)}$	19,67	23,92	27,55	30,75	33,81	36,83	39,84	42,85
$\Delta_{dif(S,R')}$	22,21	26,50	30,14	33,35	36,41	39,43	42,44	45,45
$\Delta_{ground(S,O)}$	-1,34	-1,34	-1,34	-1,34	-1,34	-1,34	-1,34	-1,34
$\Delta_{ground(O,R)}$	-1,02	-1,02	-1,01	-1,01	-1,01	-1,01	-1,01	-1,01
A_{dif}	16,27	20,51	22,65	22,65	22,65	22,65	22,65	22,65
$A_{ground(S,R)}$	-	-	-	-	-	-	-	-
$A_{boundary,H}$	16,27	20,51	22,65	22,65	22,65	22,65	22,65	22,65

Table 153 — Step by step and final results related to the propagation in the vertical plane

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000
L_W in dB	93	93	93	93	93	93	93	93
αatm	0,12	0,41	1,04	1,93	3,66	9,66	32,77	116,88
A_{atm} in dB	0,01	0,02	0,05	0,10	0,18	0,49	1,65	5,89
A_{div} in dB	45,05	45,05	45,05	45,05	45,05	45,05	45,05	45,05
$A_{boundary,H}$ in dB	16,27	20,51	22,65	22,65	22,65	22,65	22,65	22,65

Table 153 *(continued)*

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000	
$A_{boundary,F}$ in dB	16,27	20,50	22,65	22,65	22,65	22,65	22,65	22,65	**Total**
L_H in dB	31,67	27,42	25,25	25,20	25,12	24,81	23,65	19,41	35,60
L_F in dB	31,67	27,43	25,25	25,20	25,12	24,81	23,65	19,41	35,61
L in dB	31,67	27,42	25,25	25,20	25,12	24,81	23,65	19,41	35,61
A-weighting dB	-26,2	-16,1	-8,6	-3,2	0,0	1,2	1,0	-1,1	
L_A in dB	5,47	11,32	16,65	22,00	25,12	26,01	24,65	18,31	31,16

Table 154 — Ground attenuation related to lateral propagation paths

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000
Lateral right								
w (H)	0,00	0,00	0,00	0,01	0,07	0,37	1,92	9,32
C_f (H)	55,20	56,69	61,53	61,63	29,93	4,28	0,52	0,11
$A_{ground,H}$ in dB	-1,56	-1,56	-1,32	-1,23	-1,56	-1,56	-1,56	-1,56
w (F)	0,00	0,00	0,00	0,01	0,06	0,33	1,69	8,30
C_f (F)	55,15	56,48	61,02	62,61	33,11	5,18	0,59	0,12
$A_{ground,F}$ in dB	-1,56	-1,30	-1,08	-1,56	-1,56	-1,56	-1,56	-1,56
lateral left								
w (H)	0,00	0,00	0,00	0,01	0,08	0,41	2,10	10,13
C_f (H)	54,02	55,58	60,47	59,60	27,53	3,75	0,47	0,10
$A_{ground,H}$ in dB	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50
w (F)	0,00	0,00	0,00	0,01	0,08	0,41	2,10	10,13
C_f (F)	54,02	55,58	60,47	59,60	27,53	3,75	0,47	0,10
$A_{ground,F}$ in dB	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50

Table 155 — Calculation of the linear partial levels related to the right lateral path (homogeneous)

Lateral right (H)									
f in Hz	63	125	250	500	1 000	2 000	4 000	8 000	
L_W in dB	93	93	93	93	93	93	93	93	
α_{atm} (10°,70%)	0,12	0,41	1,04	1,93	3,66	9,66	32,77	116,88	
A_{atm} in dB	0,01	0,02	0,06	0,11	0,20	0,53	1,80	6,41	
A_{div} in dB	45,05	45,05	45,05	45,05	45,05	45,05	45,05	45,05	
$A_{ground,H}$ in dB	-1,56	-1,56	-1,32	-1,23	-1,56	-1,56	-1,56	-1,56	
$\Delta_{dif,H}$ in dB	17,54	21,82	25,57	28,82	31,89	34,91	37,92	40,93	
A_H in dB	61,03	65,34	69,36	72,74	75,58	78,93	83,21	90,83	**Total**
L_H in dB	31,97	27,66	23,64	20,26	17,42	14,07	9,79	2,17	34,13

Table 156 — Calculation of the linear partial levels related to the right lateral path (favourable)

Lateral right (F)								
f in Hz	63	125	250	500	1 000	2 000	4 000	8 000
L_W in dB	93	93	93	93	93	93	93	93
α_{atm} (10°,70%)	0,12	0,41	1,04	1,93	3,66	9,66	32,77	116,88
A_{atm} in dB	0,01	0,02	0,06	0,11	0,20	0,53	1,80	6,41

Table 156 *(continued)*

Lateral right (F)									
f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**	
A_{div} in dB	45,05	45,05	45,05	45,05	45,05	45,05	45,05	45,05	
$A_{ground,F}$ in dB	-1,56	-1,30	-1,08	-1,56	-1,56	-1,56	-1,56	-1,56	
$\Delta_{dif,F}$ in dB	17,54	21,82	25,57	28,82	31,89	34,91	37,92	40,93	
A_F in dB	61,03	65,59	69,60	72,41	75,58	78,93	83,21	90,83	**Total**
L_F in dB	31,97	27,41	23,40	20,59	17,42	14,07	9,79	2,17	34,06

Table 157 — Calculation of the linear partial levels related to the left lateral path (homogeneous)

Lateral left (H)									
f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**	
L_W in dB	93	93	93	93	93	93	93	93	
α_{atm} (10°,70%)	0,12	0,41	1,04	1,93	3,66	9,66	32,77	116,88	
A_{atm} in dB	0,01	0,02	0,06	0,10	0,20	0,52	1,76	6,28	
A_{div} in dB	45,05	45,05	45,05	45,05	45,05	45,05	45,05	45,05	
$A_{ground,H}$ in dB	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50	
$\Delta_{dif,H}$ in dB	16,63	20,81	24,44	27,65	30,70	33,72	36,73	39,74	
A_H in dB	60,19	64,38	68,05	71,30	74,45	77,79	82,04	89,57	**Total**
L_H in dB	32,81	28,62	24,95	21,70	18,55	15,21	10,96	3,43	35,08

Table 158 — Calculation of the linear partial levels related to the left lateral path (favourable)

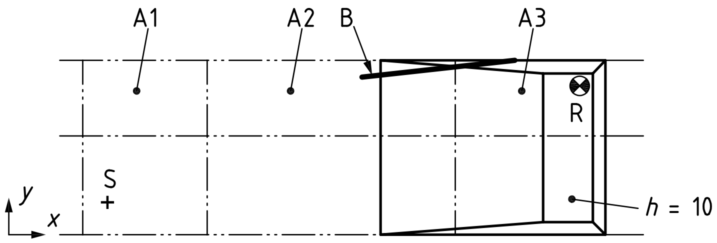
Lateral left (F)									
f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**	
L_W in dB	93	93	93	93	93	93	93	93	
α_{atm} (10°,70%)	0,12	0,41	1,04	1,93	3,66	9,66	32,77	116,88	
A_{atm} in dB	0,01	0,02	0,06	0,10	0,20	0,52	1,76	6,28	
A_{div} in dB	45,05	45,05	45,05	45,05	45,05	45,05	45,05	45,05	
$A_{ground,F}$ in dB	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50	-1,50	
$\Delta_{dif,F}$ in dB	16,63	20,81	24,44	27,65	30,70	33,72	36,73	39,74	
A_F in dB	60,19	64,38	68,05	71,30	74,45	77,79	82,04	89,57	**Total**
L_F in dB	32,81	28,62	24,95	21,70	18,55	15,21	10,96	3,43	35,08

Table 159 — Partial and total sound pressure levels for all three propagation paths

f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**	**Total**
L_A in dB over top	5,47	11,32	16,65	22,00	25,12	26,01	24,65	18,31	31,16
L_A in dB right	5,77	11,44	14,92	17,22	17,42	15,27	10,79	1,07	23,09
L_A in dB left	6,61	12,52	16,35	18,50	18,55	16,41	11,96	2,33	24,30
L_A in dB	10,75	16,57	20,81	24,51	26,55	26,78	25,04	18,50	32,50

6.2.17 TC16 — Reflecting barrier on ground with spatially varying heights and acoustic properties

The aim of this test case is to check the calculation of reflected sound. Contour lines and geometry of areas of constant ground factor G are the same as in TC05 (Tables 16 and 17). The scenario is shown in Figure 29 and 30.



Key

S source

R receiver

B1 barrier

A1 area with G = 0,9

A2 area with G = 0,5

A3 area with G = 0,2

Figure 29 — Ground with spatially varying heights and acoustic properties and reflecting barrier

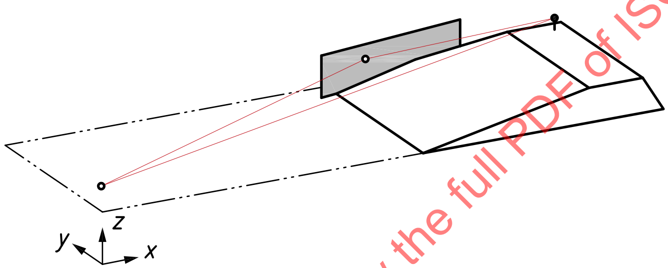


Figure 30 — 3D-presentation of scenario TC16

Tables 160 to 162 contain the modified and new input parameters, and Tables 163 to 177 show the intermediate and the final results.

Table 160 — Coordinates of source S and receiver R

Point	x (m)	y (m)	z (m)
S	10	10	1
R	200	50	14

Table 161 — Coordinates of screens (upper edges)

Screen No	x (m)	y (m)	z (m)
1	114	52	15
1	170	60	15

Table 162 — Absorption coefficient of reflecting surfaces

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000
α	0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,5

Table 163 — *z*-profile (ground height) along the propagation path

***z*-profile** S-R		
No	*u* (m)	*v* (m)
1	0,00	0,00
2	112,41	0,00
3	178,84	10,00
4	194,16	10,00

Table 164 — *G*-profile (ground factor) along the propagation path

***G*-profile** S -> R			
from (m)	to (m)	length (m)	*G*
0,00	40,88	40,88	0,9
40,88	143,07	102,19	0,5
143,07	194,16	51,09	0,2

Table 165 — Mean ground plane MGP and averaged ground factors

Parameter	S -> R
a (MGP)	0,05
b (MGP) in m	-2,83
z_1 in m	3,83
z_2 in m	6,16
d_p in m	194,59
G_{path}	0,51
G'_{path}	0,64

Table 166 — Coordinates of mirror points (homogeneous)

Mirror points	*u* (m)	*v* (m)
S' (S -> R)	0,42	-6,64
R' (S -> R)	194,84	1,70

Table 167 — Ground attenuation (in frequency bands where no diffraction is relevant)

f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**
w (H)	1,6E-04	8,7E-04	4,8E-03	0,03	0,14	0,75	3,70	16,77
C_f (H)	203,37	222,35	207,73	82,09	9,63	1,33	0,27	0,06
$A_{ground,H}$ in dB	-1,07	-1,07	-1,07	-1,07	-1,07	-1,07	-1,07	-1,07
w (F)	0,00	0,00	0,00	0,01	0,08	0,42	2,16	10,35
C_f (F)	199,73	214,27	225,54	131,93	22,89	2,42	0,46	0,10
$A_{ground,F}$ in dB	-1,07	-1,07	-1,07	-1,07	-1,07	-1,07	-1,07	-1,07

Table 168 — Step by step and final results related to the propagation in the vertical plane

f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**
L_W in dB	93	93	93	93	93	93	93	93
*α*atm	0,12	0,41	1,04	1,93	3,66	9,66	32,77	116,88

Table 168 *(continued)*

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000	
A_{atm} in dB	0,02	0,08	0,20	0,38	0,71	1,88	6,38	22,75	
A_{div} in dB	56,78	56,78	56,78	56,78	56,78	56,78	56,78	56,78	
$A_{boundary,H}$ in dB	-1,07	-1,07	-1,07	-1,07	-1,07	-1,07	-1,07	-1,07	
$A_{boundary,F}$ in dB	-1,07	-1,07	-1,07	-1,07	-1,07	-1,07	-1,07	-1,07	**Total**
L_H in dB	37,26	37,21	37,08	36,91	36,57	35,41	30,91	14,54	44,75
L_F in dB	37,26	37,21	37,08	36,91	36,57	35,41	30,91	14,54	44,75
L in dB	37,26	37,21	37,08	36,91	36,57	35,41	30,91	14,54	44,75
A-weighting in dB	-26,2	-16,1	-8,6	-3,2	0,0	1,2	1,0	-1,1	
L_A in dB	11,06	21,11	28,48	33,71	36,57	36,61	31,91	13,44	41,43

Table 169 — *z*-profile (ground-height) along the path — Reflection

z-profile S-R		
Points	*u*	*z*
1	0,00	0,00
2	117,12	0,00
3	129,75	1,82
4	129,75	1,82
5	129,75	1,82
6	183,01	10,00
7	198,04	10,00

Table 170 — *G*-profile along the path — Reflection

G-profile			
from	to	length	*G*
0,00	42,59	42,59	0,9
42,59	42,59	0,00	0,9
42,59	129,75	87,16	0,5
129,75	147,93	18,18	0,5
147,93	147,93	0,00	0,5
147,93	198,04	50,11	0,2

Table 171 — Mean ground plane MGP and averaged ground factors — Reflection

Parameter	S -> R
a (MGP)	0,05
b (MGP) in m	-2,80
z_1 in m	3,80
z_2 in m	6,37
d_p in m	198,45
G_{path}	0,51
G'_{path}	0,65

Table 172 — Coordinates of mirror points (homogeneous) — Reflection

Mirror points	*u* (m)	*v* (m)
S' (S -> R)	0,40	-6,58
R' (S -> R)	198,71	1,27

Table 173 — Ground attenuation (in frequency bands where no diffraction is relevant) — Reflection

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000
w (H)	1,6E-04	8,7E-04	4,9E-03	0,03	0,14	0,76	3,73	16,91
C_f (H)	207,64	227,15	210,40	81,36	9,40	1,32	0,27	0,06
$A_{ground,H}$ in dB	-1,06	-1,06	-1,06	-1,06	-1,06	-1,06	-1,06	-1,06
w (F)	0,00	0,00	0,00	0,01	0,08	0,43	2,20	10,56
C_f (F)	203,91	219,10	229,36	130,79	21,96	2,36	0,45	0,09
$A_{ground,F}$ in dB	-1,06	-1,06	-1,06	-1,06	-1,06	-1,06	-1,06	-1,06

Table 174 — Calculation of the linear partial levels (homogeneous) — Reflection

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000	
L_W in dB	93	93	93	93	93	93	93	93	
dL_{abs}	-0,46	-0,97	-1,55	-2,22	-3,01	-3,98	-5,23	-3,01	
$dL_{retrodif}$	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	
L_W in dB	92,54	92,03	91,45	90,78	89,99	89,02	87,77	89,99	
α_{atm}	0,1	0,4	1,0	1,9	3,7	9,7	32,8	116,9	
A_{atm} in dB	0,02	0,08	0,21	0,38	0,73	1,92	6,50	23,20	
A_{div} in dB	56,95	56,95	56,95	56,95	56,95	56,95	56,95	56,95	
$A_{boundary,H}$ in dB	-1,06	-1,06	-1,06	-1,06	-1,06	-1,06	-1,06	-1,06	**Total**
L_H in dB	36,63	36,06	35,35	34,51	33,37	31,21	25,37	10,90	42,73

Table 175 — Calculation of the linear partial levels (favourable) — Reflection

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000	
L_W in dB	93	93	93	93	93	93	93	93	
dL_{abs} in dB	-0,46	-0,97	-1,55	-2,22	-3,01	-3,98	-5,23	-3,01	
$dL_{retrodif}$ in dB	0,68	0,00	0,00	0,00	0,00	0,00	0,00	0,00	
L_W in dB	91,86	92,03	91,45	90,78	89,99	89,02	87,77	89,99	
α_{atm}	0,1	0,4	1,0	1,9	3,7	9,7	32,8	116,9	
A_{atm} in dB	0,02	0,08	0,21	0,38	0,73	1,92	6,50	23,20	
A_{div} in dB	56,95	56,95	56,95	56,95	56,95	56,95	56,95	56,95	
$A_{boundary,F}$ in dB	-1,06	-1,06	-1,06	-1,06	-1,06	-1,06	-1,06	-1,06	**Total**
L_F in dB	35,94	36,06	35,35	34,51	33,37	31,21	25,37	10,90	42,57

Table 176 — Calculation of the A-weighted partial levels (homogeneous and favourable) — Reflection

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000
L_W in dB	93	93	93	93	93	93	93	93
$dL_{abs,H}$	-0,46	-0,97	-1,55	-2,22	-3,01	-3,98	-5,23	-3,01
$dL_{retrodif,H}$	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00

Table 176 *(continued)*

f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**	
$L_{W,H}$ in dB	92,54	92,03	91,45	90,78	89,99	89,02	87,77	89,99	
$\alpha_{atm,H}$	0,1	0,4	1,0	1,9	3,7	9,7	32,8	116,9	
$A_{atm,H}$ in dB	0,02	0,08	0,21	0,38	0,73	1,92	6,50	23,20	
A_{div} in dB	56,95	56,95	56,95	56,95	56,95	56,95	56,95	56,95	
$A_{boundary,H}$ in dB	-1,06	-1,06	-1,06	-1,06	-1,06	-1,06	-1,06	-1,06	
L_H in dB	36,63	36,06	35,35	34,51	33,37	31,21	25,37	10,90	
$dL_{abs,F}$	-0,46	-0,97	-1,55	-2,22	-3,01	-3,98	-5,23	-3,01	
$dL_{retrodif,F}$	0,68	0,00	0,00	0,00	0,00	0,00	0,00	0,00	
$L_{W,F}$ in dB	91,86	92,03	91,45	90,78	89,99	89,02	87,77	89,99	
$\alpha_{atm,F}$	0,12	0,41	1,04	1,93	3,66	9,66	32,77	116,88	
$A_{atm,F}$ in dB	0,02	0,08	0,21	0,38	0,73	1,92	6,50	23,20	
A_{div} in dB	56,95	56,95	56,95	56,95	56,95	56,95	56,95	56,95	
$A_{boundary,F}$ in dB	-1,06	-1,06	-1,06	-1,06	-1,06	-1,06	-1,06	-1,06	
L_F in dB	35,94	36,06	35,35	34,51	33,37	31,21	25,37	10,90	
L in dB	36,30	36,06	35,35	34,51	33,37	31,21	25,37	10,90	
A-weighting in dB	-26,2	-16,1	-8,6	-3,2	0,0	1,2	1,0	-1,1	**Total**
L_A in dB	10,10	19,96	26,75	31,31	33,37	32,41	26,37	9,80	37,99

Table 177 — Calculation of the A-weighted sound pressure level

f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**	**Total**
L_A in dB direct	11,06	21,11	28,48	33,71	36,57	36,61	31,91	13,44	41,43
L_A in dB reflection	10,10	19,96	26,75	31,31	33,37	32,41	26,37	9,80	37,99
L_A in dB	13,62	23,58	30,71	35,68	38,27	38,01	32,98	15,00	43,05

6.2.18 TC17 — Reflecting barrier on ground with spatially varying heights and acoustic properties — Reduced receiver height

This scenario differs from TC16 only by the lower height of 11,5 m of the receiver R – the terrain edge is diffracting for some octave bands.

Tables 178 to 190 show the intermediate and the final results. No diffraction occurs in the octave bands 63 Hz to 250 Hz due to the violated Rayleigh Criterion (see Tables 184 to 185).

Table 178 — *z*-profile (ground height) along the propagation path

z-profile S-R		
No	u (m)	v (m)
1	0,00	0,00
2	112,41	0,00
3	178,84	10,00
4	194,16	10,00

Table 179 — Check of the "Rayleigh-Criterion" (homogeneous)

Parameter	Homogeneous							
	63	125	250	500	1 000	2 000	4 000	8 000
O (No of edge in *z*-profile)	3,00	3,00	3,00	-	-	-	-	-
$-\lambda/20$	-0,27	-0,14	-0,07	-	-	-	-	-
S-R	194,45	194,45	194,45	-	-	-	-	-
d_{ss} (S-D-R)	179,06	179,06	179,06	-	-	-	-	-
d_{sr} (S-D-R)	15,40	15,40	15,40	-	-	-	-	-
δ_D	-0,02	-0,02	-0,02	-	-	-	-	-
$\delta_D > -\lambda/20$?	yes	yes	yes	-	-	-	-	-
S*-R*	194,37	194,37	194,37	-	-	-	-	-
d_{ss} (S*-D-R*)	179,21	179,21	179,21	-	-	-	-	-
d_{sr} (S*-D-R*)	15,40	15,40	15,40	-	-	-	-	-
δ_D*	0,24	0,24	0,24	-	-	-	-	-
$\lambda/4-\delta_D$*	1,11	0,44	0,10	-	-	-	-	-
$\delta_D > (\lambda/4 - \delta_D^*)$?	no	no	no	-	-	-	-	-
R-Criterion OK?	no	no	no	-	-	-	-	-

Table 180 — Check of the "Rayleigh-Criterion" (favourable)

Parameter	Favourable							
	63	125	250	500	1 000	2 000	4 000	8 000
O (No of edge in *z*-profile)	3,00	3,00	3,00	-	-	-	-	-
$-\lambda/20$	-0,27	-0,14	-0,07	-	-	-	-	-
S-R	194,58	194,58	194,58	-	-	-	-	-
d_{ss} (S-D-R)	179,16	179,16	179,16	-	-	-	-	-
d_{sr} (S-D-R)	15,40	15,40	15,40	-	-	-	-	-
δ_D	-0,04	-0,04	-0,04	-	-	-	-	-
$\delta_D > -\lambda/20$?	yes	yes	yes	-	-	-	-	-
S*-R*	194,50	194,50	194,50	-	-	-	-	-
d_{ss} (S*-D-R*)	179,31	179,31	179,31	-	-	-	-	-
d_{sr} (S*-D-R*)	15,40	15,40	15,40	-	-	-	-	-
δ_D*	0,21	0,21	0,21	-	-	-	-	-
$\lambda/4-\delta_D$*	1,13	0,47	0,13	-	-	-	-	-
$\delta_D > (\lambda/4 - \delta_D^*)$?	no	no	no	-	-	-	-	-
R-Criterion OK?	no	no	no	-	-	-	-	-

Table 181 — Ground attenuation (in frequency bands where no diffraction is relevant)

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000
w (H)	1,1E-04	6,0E-04	3,4E-03	-	-	0,53	2,70	12,70
C_f (H)	200,89	217,45	220,41	-	-	1,88	0,37	0,08
$A_{ground,H}$ in dB	-1,32	-1,32	-1,32	-	-	-1,32	-1,32	-1,32
w (F)	0,00	0,00	0,00	0,01	0,08	0,42	2,16	10,35
C_f (F)	199,59	214,11	225,39	131,90	22,89	2,42	0,46	0,10
$A_{ground,F}$ in dB	-1,32	-1,32	-1,29	-1,05	-1,32	-1,32	-1,32	-1,32

Table 182 — Determination of $A_{boundary,H}$

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000
$\Delta_{dif(S,R)}$	0,00	0,00	0,00	3,16	0,56	0,00	0,00	0,00
$A_{ground,(S,O)}$	-	-	-	2,74	-1,21	-	-	-
$A_{ground,(O,R)}$	-	-	-	-2,40	-2,40	-	-	-
$\Delta_{dif(S',R)}$	-	-	-	4,71	4,65	-	-	-
$\Delta_{dif(S,R')}$	-	-	-	10,83	13,26	-	-	-
$\Delta_{ground(S,O)}$	-	-	-	2,23	-0,77	-	-	-
$\Delta_{ground(O,R)}$	-	-	-	-1,07	-0,62	-	-	-
A_{dif}	-	-	-	4,31	-0,83	-	-	-
$A_{ground(S,R)}$	-1,32	-1,32	-1,32	-	-	-1,32	-1,32	-1,32
$A_{boundary,H}$	-1,32	-1,32	-1,32	4,31	-0,83	-1,32	-1,32	-1,32

Table 183 — Step by step and final results related to the propagation in the vertical plane

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000	
L_W in dB	93	93	93	93	93	93	93	93	
α_{atm}	0,12	0,41	1,04	1,93	3,66	9,66	32,77	116,88	
A_{atm} in dB	0,02	0,08	0,20	0,37	0,71	1,88	6,37	22,73	
A_{div} in dB	56,78	56,78	56,78	56,78	56,78	56,78	56,78	56,78	
$A_{boundary,H}$ in dB	-1,32	-1,32	-1,32	4,31	-0,83	-1,32	-1,32	-1,32	
$A_{boundary,F}$ in dB	-1,32	-1,32	-1,29	-1,05	-1,32	-1,32	-1,32	-1,32	**Total**
L_H in dB	37,53	37,47	37,35	31,54	36,34	35,67	31,18	14,82	44,38
L_F in dB	37,53	37,47	37,31	36,89	36,84	35,67	31,18	14,82	44,97
L in dB	37,53	37,47	37,33	34,99	36,60	35,67	31,18	14,82	44,68
A-weighting in dB	-26,2	-16,1	-8,6	-3,2	0,0	1,2	1,0	-1,1	
L_A in dB	11,33	21,37	28,73	31,79	36,60	36,87	32,18	13,72	41,31

Table 184 — Check of the "Rayleigh-Criterion" (homogeneous) — Reflection

Parameter	Homogeneous							
	63	125	250	500	1 000	2 000	4 000	8 000
O (No of edge in z-profile)	6,00	6,00	6,00	-	-	-	-	-
$-\lambda/20$	-0,27	-0,14	-0,07	-	-	-	-	-
S-R	198,32	198,32	198,32	-	-	-	-	-
d_{ss} (S-D-R)	183,23	183,23	183,23	-	-	-	-	-
d_{sr} (S-D-R)	15,11	15,11	15,11	-	-	-	-	-
δ_D	-0,02	-0,02	-0,02	-	-	-	-	-
$\delta_D > -\lambda/20$?	yes	yes	yes	-	-	-	-	-
S*-R*	198,25	198,25	198,25	-	-	-	-	-
d_{ss} (S*-D-R*)	183,38	183,38	183,38	-	-	-	-	-
d_{sr} (S*-D-R*)	15,11	15,11	15,11	-	-	-	-	-
δ_D*	0,24	0,24	0,24	-	-	-	-	-
$\lambda/4-\delta_D$*	1,11	0,44	0,10	-	-	-	-	-
$\delta_D > (\lambda/4 - \delta_D^*)$?	no	no	no	-	-	-	-	-
R-Criterion OK?	no	no	no	-	-	-	-	-

Table 185 — Check of the "Rayleigh-Criterion" (favourable) — Reflection

Parameter	Favourable							
	63	125	250	500	1 000	2 000	4 000	8 000
O (No of edge in z-profile)	6,00	6,00	6,00	-	-	-	-	-
$-\lambda/20$	-0,27	-0,14	-0,07	-	-	-	-	-
S-R	198,45	198,45	198,45	-	-	-	-	-
d_{ss} (S-D-R)	183,33	183,33	183,33	-	-	-	-	-
d_{sr} (S-D-R)	15,11	15,11	15,11	-	-	-	-	-
δ_D	-0,04	-0,04	-0,04	-	-	-	-	-
$\delta_D > -\lambda/20$?	yes	yes	yes	-	-	-	-	-
S*-R*	198,38	198,38	198,38	-	-	-	-	-
d_{ss} (S*-D-R*)	183,48	183,48	183,48	-	-	-	-	-
d_{sr} (S*-D-R*)	15,11	15,11	15,11	-	-	-	-	-
δ_D*	0,21	0,21	0,21	-	-	-	-	-
$\lambda/4-\delta_D$*	1,14	0,47	0,13	-	-	-	-	-
$\delta_D > (\lambda/4 - \delta_D*)$?	no	no	no	-	-	-	-	-
R-Criterion OK?	no	no	no	-	-	-	-	-

Table 186 — Ground attenuation (in frequency bands where no diffraction is relevant) — Reflection

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000
w (H)	1,1E-04	6,2E-04	3,4E-03	-	0,10	0,55	2,77	12,97
C_f (H)	205,15	222,41	223,52	-	15,34	1,83	0,36	0,08
$A_{ground,H}$ in dB	-1,31	-1,31	-1,31	-	-1,31	-1,31	-1,31	-1,31
w (F)	0,00	0,00	0,00	0,01	0,08	0,43	2,20	10,56
C_f (F)	203,77	218,95	229,22	130,76	21,97	2,36	0,45	0,09
$A_{ground,F}$ in dB	-1,31	-1,31	-1,26	-1,28	-1,31	-1,31	-1,31	-1,31

Table 187 — Determination of $A_{boundary,H}$ — Reflection

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000
$A_{dif(S,R)}$	0,00	0,00	0,00	2,92	0,00	0,00	0,00	0,00
$A_{ground,(S,O)}$	-	-	-	2,66	-	-	-	-
$A_{ground,(O,R)}$	-	-	-	-2,40	-	-	-	-
$A_{dif(S',R)}$	-	-	-	4,65	-	-	-	-
$A_{dif(S,R')}$	-	-	-	10,81	-	-	-	-
$A_{ground(S,O)}$	-	-	-	2,12	-	-	-	-
$A_{ground(O,R)}$	-	-	-	-1,05	-	-	-	-
A_{dif}	-	-	-	3,99	-	-	-	-
$A_{ground(S,R)}$	-1,31	-1,31	-1,31	-	-1,31	-1,31	-1,31	-1,31
$A_{boundary,H}$	-1,31	-1,31	-1,31	3,99	-1,31	-1,31	-1,31	-1,31

Table 188 — Calculation of the linear partial levels (homogeneous) — Reflection

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000
L_W in dB	93	93	93	93	93	93	93	93
dL_{abs}	-0,46	-0,97	-1,55	-2,22	-3,01	-3,98	-5,23	-3,01

Table 188 *(continued)*

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000	
$dL_{retrodif}$	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	
L_W in dB	92,54	92,03	91,45	90,78	89,99	89,02	87,77	89,99	
α_{atm}	0,1	0,4	1,0	1,9	3,7	9,7	32,8	116,9	
A_{atm} in dB	0,02	0,08	0,21	0,38	0,73	1,92	6,50	23,18	
A_{div} in dB	56,95	56,95	56,95	56,95	56,95	56,95	56,95	56,95	
$A_{boundary,H}$ in dB	-1,31	-1,31	-1,31	3,99	-1,31	-1,31	-1,31	-1,31	**Total**
L_H in dB	36,88	36,31	35,60	29,46	33,62	31,46	25,63	11,17	42,49

Table 189 — Calculation of the linear partial levels (favourable) — Reflection

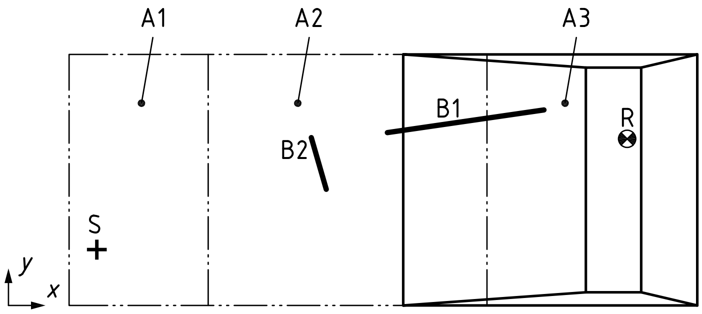
f in Hz	63	125	250	500	1 000	2 000	4 000	8 000	
L_W in dB	93	93	93	93	93	93	93	93	
dL_{abs} in dB	-0,46	-0,97	-1,55	-2,22	-3,01	-3,98	-5,23	-3,01	
$dL_{retrodif}$ in dB	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	
L_W in dB	92,54	92,03	91,45	90,78	89,99	89,02	87,77	89,99	
α_{atm}	0,1	0,4	1,0	1,9	3,7	9,7	32,8	116,9	
A_{atm} in dB	0,02	0,08	0,21	0,38	0,73	1,92	6,50	23,18	
A_{div} in dB	56,95	56,95	56,95	56,95	56,95	56,95	56,95	56,95	
$A_{boundary,F}$ in dB	-1,31	-1,31	-1,26	-1,28	-1,31	-1,31	-1,31	-1,31	**Total**
L_F in dB	36,88	36,31	35,56	34,73	33,62	31,46	25,63	11,17	42,97

Table 190 — Calculation of the A-weighted sound pressure level

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000	Total
L_A in dB direct	11,33	21,37	28,73	31,79	36,60	36,87	32,18	13,72	41,31
L_A in dB reflection	10,68	20,21	26,98	29,65	33,62	32,66	26,63	10,07	37,90
L_A in dB	14,02	23,84	30,95	33,86	38,37	38,27	33,25	15,28	42,94

6.2.19 TC18 — Screening and reflecting barrier on ground with spatially varying heights and acoustic properties

This scenario, shown in Figures 31 and 32, differs from TC16 only by the height of the receiver R and by the additional barrier B2. The ray reflected by barrier B1 is diffracted by barrier B2.



Key

S source

R receiver

B1 barrier

B2 barrier

A1 area with G = 0,9

A2 area with G = 0,5

A3 area with G = 0,2

Figure 31 — Ground with spatially varying heights and acoustic properties and two barriers

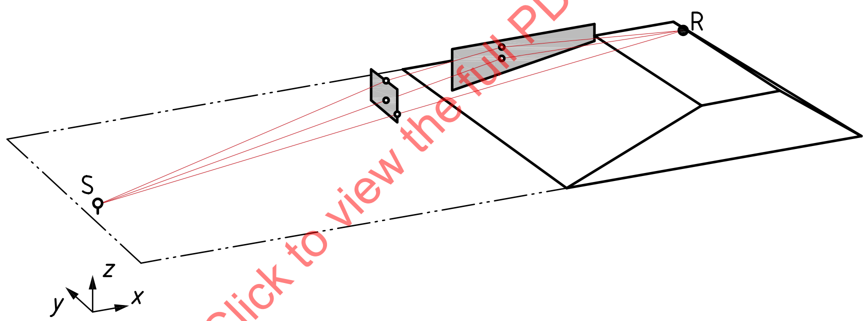


Figure 32 — 3D-presentation of scenario TC18

Tables 191 and 192 contain the modified or new input parameters, and Tables 193 to 201 show the intermediate and the final results.

Table 191 — Coordinates of source S and receiver R

Point	x (m)	y (m)	z (m)
S	10	10	1
R	200	50	12

Table 192 — Coordinates of screens (upper edges)

Screen No	x (m)	y (m)	z (m)
1	114	52	15
1	170	60	15
2	87	50	12
2	92	32	12

Table 193 — *z*-profile (ground height) along the propagation path

z-profile S-R		
No	*u* (m)	*v* (m)
1	0,00	0,00
2	112,41	0,00
3	178,84	10,00
4	194,16	10,00

Table 194 — Mean ground plane MGP and averaged ground factors

Parameter	S -> R
a (MGP)	0,05
b (MGP) in m	-2,83
z_1 in m	3,83
z_2 in m	4,16
d_p in m	194,48
G_{path}	0,51
G'_{path}	0,58

Table 195 — Ground attenuation (in frequency bands where no diffraction is relevant)

f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**
w (H)	1,2E-04	6,6E-04	3,7E-03	0,02	0,11	0,58	2,94	13,68
C_f (H)	201,47	218,76	217,74	102,89	14,04	1,71	0,34	0,07
$A_{ground,H}$ in dB	-1,26	-1,26	-1,26	2,12	-1,26	-1,26	-1,26	-1,26
w (F)	0,00	0,00	0,00	0,01	0,08	0,42	2,16	10,35
C_f (F)	199,62	214,14	225,42	131,91	22,89	2,42	0,46	0,10
$A_{ground,F}$ in dB	-1,26	-1,26	-1,26	-1,26	-1,26	-1,26	-1,26	-1,26

Table 196 — Step by step and final results related to the propagation in the vertical plane

f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**	
L_W in dB	93	93	93	93	93	93	93	93	
α_{atm}	0,12	0,41	1,04	1,93	3,66	9,66	32,77	116,88	
A_{atm} in dB	0,02	0,08	0,20	0,37	0,71	1,88	6,37	22,73	
A_{div} in dB	56,78	56,78	56,78	56,78	56,78	56,78	56,78	56,78	
$A_{boundary,H}$ in dB	-1,26	-1,26	-1,26	2,12	-1,26	-1,26	-1,26	-1,26	
$A_{boundary,F}$ in dB	-1,26	-1,26	-1,26	-1,26	-1,26	-1,26	-1,26	-1,26	**Total**
L_H in dB	37,46	37,40	37,28	33,73	36,77	35,60	31,11	14,75	44,55
L_F in dB	37,46	37,40	37,28	37,11	36,77	35,60	31,11	14,75	44,95
L in dB	37,46	37,40	37,28	35,74	36,77	35,60	31,11	14,75	44,75
A-weighting in dB	-26,2	-16,1	-8,6	-3,2	0,0	1,2	1,0	-1,1	
L_A in dB	11,26	21,30	28,68	32,54	36,77	36,80	32,11	13,65	41,42

Table 197 — Mean ground plane MGP and averaged ground factors (homogeneous) — Reflection

Parameter	S -> O$_1$	O$_n$ -> R
a (MGP)	0,00	0,11
b (MGP) in m	0,00	-12,03
z_1 in m	1,00	14,16
z_2 in m	12,00	1,29
d_p in m	85,16	112,14
G_{path}	0,70	0,37
G'_{path}	0,86	

Table 198 — Determination of $A_{boundary,H}$ — Reflection

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000
$\Delta_{dif(S,R)}$	7,77	9,50	11,71	14,26	17,02	19,90	22,84	25,82
$A_{ground,(S,O)}$	-0,43	-0,43	-0,43	-0,43	-0,43	-0,43	-0,43	-0,43
$A_{ground,(O,R)}$	-1,90	-1,90	-1,90	-1,90	-1,90	-1,90	-1,90	-1,90
$\Delta_{dif(S',R)}$	8,54	10,51	12,90	15,56	18,38	21,30	24,26	27,25
$\Delta_{dif(S,R')}$	8,53	10,49	12,88	15,54	18,36	21,27	24,24	27,22
$\Delta_{ground(S,O)}$	-0,39	-0,38	-0,38	-0,37	-0,37	-0,37	-0,37	-0,37
$\Delta_{ground(O,R)}$	-1,75	-1,71	-1,68	-1,66	-1,65	-1,65	-1,64	-1,64
A_{dif}	5,62	7,40	9,65	12,22	15,00	17,88	20,83	22,99
$A_{ground(S,R)}$	-	-	-	-	-	-	-	-
$A_{boundary,H}$	5,62	7,40	9,65	12,22	15,00	17,88	20,83	22,99

Table 199 — Determination of $A_{boundary,F}$ — Reflection

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000
$\Delta_{dif(S,R)}$	7,22	8,76	10,80	13,24	15,93	18,77	21,69	24,65
$A_{ground,(S,O)}$	-0,43	-0,43	-0,43	-0,43	-0,43	-0,43	-0,43	-0,43
$A_{ground,(O,R)}$	-1,90	-1,90	-1,90	-1,90	-1,90	-1,90	-1,90	-1,90
$\Delta_{dif(S',R)}$	8,09	9,93	12,22	14,82	17,61	20,51	23,46	26,44
$\Delta_{dif(S,R')}$	8,08	9,91	12,20	14,80	17,59	20,48	23,43	26,41
$\Delta_{ground(S,O)}$	-0,39	-0,38	-0,37	-0,36	-0,36	-0,35	-0,35	-0,35
$\Delta_{ground(O,R)}$	-1,74	-1,69	-1,64	-1,61	-1,60	-1,59	-1,58	-1,58
A_{dif}	5,09	6,70	8,79	11,26	13,97	16,82	19,75	22,72
$A_{ground(S,R)}$	-	-	-	-	-	-	-	-
$A_{boundary,F}$	5,09	6,70	8,79	11,26	13,97	16,82	19,75	22,72

Table 200 — Calculation of the A-weighted partial levels (homogeneous and favourable) — Reflection

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000
L_W in dB	93	93	93	93	93	93	93	93
$dL_{abs,H}$	-0,46	-0,97	-1,55	-2,22	-3,01	-3,98	-5,23	-3,01
$dL_{retrodif,H}$	2,47	0,00	0,00	0,00	0,00	0,00	0,00	0,00
$L_{W,H}$ in dB	90,08	92,03	91,45	90,78	89,99	89,02	87,77	89,99
$\alpha_{atm,H}$	0,1	0,4	1,0	1,9	3,7	9,7	32,8	116,9

Table 200 *(continued)*

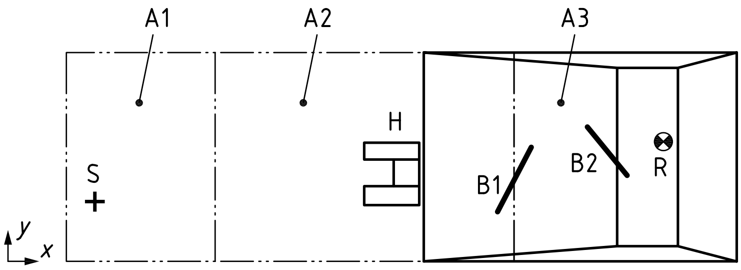
f in Hz	63	125	250	500	1 000	2 000	4 000	8 000	
$A_{atm,H}$ in dB	0,02	0,08	0,21	0,38	0,73	1,92	6,50	23,18	
A_{div} in dB	56,95	56,95	56,95	56,95	56,95	56,95	56,95	56,95	
$A_{boundary,H}$ in dB	5,62	7,40	9,65	12,22	15,00	17,88	20,83	22,99	
L_H in dB	27,49	27,60	24,64	21,23	17,32	12,27	3,49	-13,13	
$dL_{abs,F}$	-0,46	-0,97	-1,55	-2,22	-3,01	-3,98	-5,23	-3,01	
$dL_{retrodif,F}$	2,77	0,00	0,00	0,00	0,00	0,00	0,00	0,00	
$L_{W,F}$ in dB	89,78	92,03	91,45	90,78	89,99	89,02	87,77	89,99	
$\alpha_{atm,F}$	0,12	0,41	1,04	1,93	3,66	9,66	32,77	116,88	
$A_{atm,F}$ in dB	0,02	0,08	0,21	0,38	0,73	1,92	6,50	23,18	
A_{div} in dB	56,95	56,95	56,95	56,95	56,95	56,95	56,95	56,95	
$A_{boundary,F}$ in dB	5,09	6,70	8,79	11,26	13,97	16,82	19,75	22,72	
L_F in dB	27,71	28,30	25,50	22,19	18,34	13,33	4,57	-12,86	
L in dB	27,60	27,97	25,09	21,74	17,86	12,83	4,07	-13,00	
A-weighting in dB	-26,2	-16,1	-8,6	-3,2	0,0	1,2	1,0	-1,1	**Total**
L_A in dB	1,40	11,87	16,49	18,54	17,86	14,03	5,07	-14,10	23,47

Table 201 — Calculation of the A-weighted sound pressure level

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000	Total
L_A in dB direct	11,26	21,30	28,68	32,54	36,77	36,80	32,11	13,65	41,42
L_A in dB reflection	1,40	11,87	16,49	18,54	17,86	14,03	5,07	-14,10	23,47
L_A in dB	11,69	21,77	28,93	32,71	36,83	36,83	32,12	13,66	41,49

6.2.20 TC19 — Complex object and 2 barriers on ground with spatially varying heights and acoustic properties

This test case, shown in Figures 33 and 34, introduces a further degree of difficulty by combining a building and two barriers on ground with varying heights and ground factors. Contour lines and geometry of areas of constant ground factor G are the same as in TC05 (Tables 16 and 17).



Key

S source
R receiver
B1 barrier
B2 barrier
H building
A1 area with G = 0,9
A2 area with G = 0,5
A3 area with G = 0,2

Figure 33 — Ground with spatially varying heights and acoustic properties, a building and two barriers

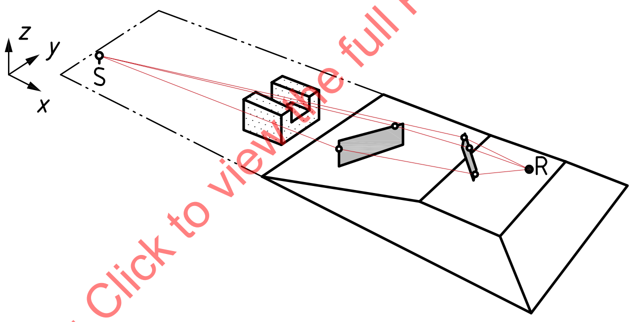


Figure 34 — 3D-presentation of scenario TC19

Tables 202 to 204 contain the input parameters (source, receiver, building and barriers), and Tables 205 to 219 show the intermediate and the final results.

Table 202 — Coordinates of source S and receiver R

Point	x (m)	y (m)	z (m)
S	10	10	1
R	200	30	14

Table 203 — Coordinates of screens (upper edges)

Screen No	x (m)	y (m)	z (m)
1	156,00	28,00	14,0
1	145,00	7,00	14,0
2	175,0	35,0	14,5
2	188,0	19,0	14,5

Table 204 — Coordinates of acoustically opaque objects (buildings)

Object No	Edge No	x (m)	y (m)	z (m)
1	1	100	24	12
1	2	118	24	12
1	3	118	30	12
1	4	100	30	12
2	5	110	15	7
2	6	118	15	7
2	7	118	24	7
2	8	110	24	7
3	9	100	9	12
3	10	118	9	12
3	11	118	15	12
3	12	100	15	12

Table 205 — Height profiles along the direct and the two lateral paths (homogeneous)

***z*-profile S-O**		***z*-profile O-R**		***z*-profile right**		***z*-profile left**	
u (m)	z (m)	u (m)	z (m)	u (m)	z (m)	u (m)	z (m)
0,00	0,00	171,66	9,34	0,00	0,00	0,00	0,00
100,55	0,00	175,97	10,00	110,03	0,00	93,44	0,00
100,55	7,00	191,05	10,00	135,03	3,85	93,44	12,00
108,60	7,00			176,56	10,00	109,23	12,00
108,60	0,00			179,68	10,00	109,23	0,00
110,61	0,00			195,96	10,00	111,26	0,00
145,34	5,31					166,88	8,46
						177,08	10,00
						192,38	10,00

Table 206 — Determination of G_{path} (homogeneous)

***G*-profile S -> O**				***G*-profile O -> R**			
from (m)	to (m)	length (m)	G	from (m)	to (m)	length (m)	G
0,00	40,22	40,22	0,9	0,00	19,39	19,39	0,2
40,22	100,55	60,33	0,5			G_{path}	0,20
100,55	108,60	8,04	0,00				
108,60	140,77	32,18	0,50				
140,77	145,34	4,57	0,2				
		G_{path}	0,57				

Table 207 — *G*-profile along the two lateral paths (homogeneous)

G-profile lateral right				*G*-profile lateral left			
from (m)	to (m)	length (m)	*G*	from (m)	to (m)	length (m)	*G*
0,00	40,01	40,01	0,9	0,00	40,46	40,46	0,9
40,01	135,03	95,02	0,5	40,46	93,44	52,98	0,5
135,03	140,22	5,19	0,5	93,44	109,23	15,79	0,0
140,22	179,67	39,45	0,2	109,23	141,60	32,37	0,5
179,67	195,96	16,28	0,2			G_{path}	0,46
		G_{path}	0,50				

Table 208 — *z*-profile (ground height) along the propagation path

z-profile S-R		
No	*u* (m)	*v* (m)
1	0,00	0,00
2	100,55	0,00
3	100,55	7,00
4	108,60	7,00
5	108,60	0,00
6	110,61	0,00
7	145,34	5,31
8	145,34	14,00
9	145,34	5,31
10	171,65	9,34
11	171,66	14,50
12	171,66	9,34
13	175,97	10,00
14	191,05	10,00

Table 209 — Mean ground plane MGP and averaged ground factors (homogeneous)

Parameter	S -> O_1	O_n -> R	S->R **right**	S->R **left**
a (MGP)	0,03	0,02	0,06	0,06
b (MGP) in m	-1,09	6,42	-2,92	-2,01
z_1 in m	2,09	4,76	3,92	3,00
z_2 in m	10,86	3,89	5,66	5,00
d_p in m	145,65	19,38	196,38	192,81
G_{path}	0,57	0,20	0,50	0,46
G'_{path}	0,78		0,62	0,55

Table 210 — Calculation of the path length differences δ

Parameter	S->R		S'->R		S->R'		Lateral right		Lateral left	
	(H)	(F)	(H)	(F)	(H)	(F)	(H)	(F)	(H)	(F)
No(O_1)	8	8	8	8	8	8	-	-	-	-
No(O_n)	11	11	11	11	11	11	-	-	-	-

Table 210 *(continued)*

Parameter	S->R		S'->R		S->R'		Lateral right		Lateral left	
	(H)	(F)	(H)	(F)	(H)	(F)	(H)	(F)	(H)	(F)
d	191,49	191,62	191,70	191,82	191,27	191,40	191,49	191,49	191,49	191,49
d_{ss}	145,92	145,98	146,23	146,29	145,92	145,98	135,34	135,34	167,27	167,27
d_{sr}	19,40	19,40	19,40	19,40	21,22	21,22	16,31	16,31	25,55	25,55
e	26,32	26,32	26,32	26,32	26,32	26,32	44,74	44,74	0,00	0,00
δ	0,15	0,08	0,25	0,18	2,19	2,12	4,90	4,90	1,33	1,33

Table 211 — Determination of $A_{\text{boundary,H}}$

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000
$\Delta_{\text{dif(S,R)}}$	6,67	8,83	11,68	14,56	17,43	20,35	23,31	26,29
$A_{\text{ground,(S,O)}}$	-0,67	-0,67	-0,67	-0,67	-0,67	-0,67	-0,67	-0,67
$A_{\text{ground,(O,R)}}$	-2,02	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40
$\Delta_{\text{dif(S',R)}}$	7,61	10,35	13,58	16,64	19,61	22,57	25,55	28,55
$\Delta_{\text{dif(S,R')}}$	14,32	18,51	22,43	25,77	28,86	31,89	34,91	37,92
$\Delta_{\text{ground(S,O)}}$	-0,60	-0,56	-0,54	-0,53	-0,52	-0,52	-0,52	-0,52
$\Delta_{\text{ground(O,R)}}$	-0,90	-0,86	-0,77	-0,73	-0,71	-0,70	-0,70	-0,70
A_{dif}	5,17	7,41	10,38	13,30	16,20	19,13	22,09	23,78
$A_{\text{ground(S,R)}}$	-	-	-	-	-	-	-	-
$A_{\text{boundary,H}}$	5,17	7,41	10,38	13,30	16,20	19,13	22,09	23,78

Table 212 — Determination of $A_{\text{boundary,F}}$

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000
$\Delta_{\text{dif(S,R)}}$	5,89	7,40	9,69	12,24	14,94	17,76	20,66	23,62
$A_{\text{ground,(S,O)}}$	-0,67	-0,67	-0,67	-0,67	-0,67	-0,67	-0,67	-0,67
$A_{\text{ground,(O,R)}}$	-2,08	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40
$\Delta_{\text{dif(S',R)}}$	7,00	9,39	12,40	15,35	18,27	21,21	24,17	27,16
$\Delta_{\text{dif(S,R')}}$	14,20	18,38	22,29	25,63	28,73	31,75	34,77	37,78
$\Delta_{\text{ground(S,O)}}$	-0,59	-0,53	-0,49	-0,47	-0,46	-0,45	-0,45	-0,45
$\Delta_{\text{ground(O,R)}}$	-0,86	-0,75	-0,62	-0,57	-0,55	-0,53	-0,53	-0,53
A_{dif}	4,44	6,12	8,57	11,19	13,93	16,77	19,68	22,64
$A_{\text{ground(S,R)}}$	-	-	-	-	-	-	-	-
$A_{\text{boundary,F}}$	4,44	6,12	8,57	11,19	13,93	16,77	19,68	22,64

Table 213 — Step by step and final results related to the propagation in the vertical plane

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000	
L_W in dB	93	93	93	93	93	93	93	93	
α_{atm}	0,12	0,41	1,04	1,93	3,66	9,66	32,77	116,88	
A_{atm} in dB	0,02	0,08	0,20	0,37	0,70	1,85	6,28	22,38	
A_{div} in dB	56,64	56,64	56,64	56,64	56,64	56,64	56,64	56,64	
$A_{\text{boundary,H}}$ in dB	5,17	7,41	10,38	13,30	16,20	19,13	22,09	23,78	
$A_{\text{boundary,F}}$ in dB	4,44	6,12	8,57	11,19	13,93	16,77	19,68	22,64	**Total**
L_{H} in dB	31,16	28,87	25,78	22,69	19,46	15,38	7,99	-9,81	34,43
L_{F} in dB	31,89	30,16	27,59	24,79	21,73	17,74	10,40	-8,67	35,66

Table 213 *(continued)*

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000	
L in dB	31,54	29,56	26,78	23,87	20,74	16,72	9,36	-9,20	35,08
A-weighting in dB	-26,2	-16,1	-8,6	-3,2	0,0	1,2	1,0	-1,1	
L_A in dB	5,34	13,46	18,18	20,67	20,74	17,92	10,36	-10,30	26,01

Table 214 — Ground attenuation related to lateral propagation paths

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000
Lateral right								
w (H)	0,00	0,00	0,00	0,02	0,13	0,70	3,46	15,82
C_f (H)	204,75	223,53	212,65	88,09	10,70	1,43	0,29	0,06
$A_{ground,H}$ in dB	-1,13	-1,13	-0,97	-0,65	-1,13	-1,13	-1,13	-1,13
w (F)	0,00	0,00	0,00	0,01	0,08	0,40	2,07	9,97
C_f (F)	201,41	215,78	228,09	136,20	24,26	2,53	0,48	0,10
$A_{ground,F}$ in dB	-1,13	-1,13	-1,13	-1,13	-1,13	-1,13	-1,13	-1,13
lateral left								
w (H)	0,00	0,00	0,00	0,02	0,10	0,51	2,61	12,30
C_f (H)	198,93	214,98	219,72	113,73	17,06	1,95	0,38	0,08
$A_{ground,H}$ in dB	-1,35	-1,35	-1,35	1,32	-1,35	-1,35	-1,35	-1,35
w (F)	0,00	0,00	0,00	0,01	0,06	0,34	1,77	8,65
C_f (F)	196,96	209,53	225,50	149,30	30,69	3,06	0,56	0,12
$A_{ground,F}$ in dB	-1,35	-1,35	-1,35	-1,35	-1,35	-1,35	-1,35	-1,35

Table 215 — Calculation of the linear partial levels related to the right lateral path (homogeneous)

Lateral right (H)									
f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**	
L_W in dB	93	93	93	93	93	93	93	93	
α_{atm} (10°,70%)	0,12	0,41	1,04	1,93	3,66	9,66	32,77	116,88	
A_{atm} in dB	0,02	0,08	0,20	0,38	0,72	1,90	6,44	22,95	
A_{div} in dB	56,64	56,64	56,64	56,64	56,64	56,64	56,64	56,64	
$A_{ground,H}$ in dB	-1,13	-1,13	-0,97	-0,65	-1,13	-1,13	-1,13	-1,13	
$\Delta_{dif,H}$ in dB	18,69	22,74	26,20	29,33	32,37	35,39	38,40	41,41	
A_H in dB	74,23	78,33	82,07	85,71	88,61	92,80	100,35	119,88	**Total**
L_H in dB	18,77	14,67	10,93	7,29	4,39	0,20	-7,35	-26,88	21,01

Table 216 — Calculation of the linear partial levels related to the right lateral path (favourable)

Lateral right (F)								
f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**
L_W in dB	93	93	93	93	93	93	93	93
α_{atm} (10°,70%)	0,12	0,41	1,04	1,93	3,66	9,66	32,77	116,88
A_{atm} in dB	0,02	0,08	0,20	0,38	0,72	1,90	6,44	22,95
A_{div} in dB	56,64	56,64	56,64	56,64	56,64	56,64	56,64	56,64
$A_{ground,F}$ in dB	-1,13	-1,13	-1,13	-1,13	-1,13	-1,13	-1,13	-1,13
$\Delta_{dif,F}$ in dB	18,69	22,74	26,20	29,33	32,37	35,39	38,40	41,41

Table 216 *(continued)*

Lateral right (F)									
f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**	
A_F in dB	74,23	78,33	81,92	85,23	88,61	92,80	100,35	119,88	**Total**
L_F in dB	18,77	14,67	11,08	7,77	4,39	0,20	-7,35	-26,88	21,05

Table 217 — Calculation of the linear partial levels related to the left lateral path (homogeneous)

Lateral left (H)									
f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**	
L_W in dB	93	93	93	93	93	93	93	93	
α_{atm} (10°,70%)	0,12	0,41	1,04	1,93	3,66	9,66	32,77	116,88	
A_{atm} in dB	0,02	0,08	0,20	0,37	0,71	1,86	6,32	22,54	
A_{div} in dB	56,64	56,64	56,64	56,64	56,64	56,64	56,64	56,64	
$A_{ground,H}$ in dB	-1,35	-1,35	-1,35	1,32	-1,35	-1,35	-1,35	-1,35	
$\Delta_{dif,H}$ in dB	11,08	13,52	16,24	19,09	22,02	24,99	27,98	30,98	
A_H in dB	66,40	68,90	71,73	77,43	78,01	82,14	89,59	108,80	**Total**
L_H in dB	26,60	24,10	21,27	15,57	14,99	10,86	3,41	-15,80	29,69

Table 218 — Calculation of the linear partial levels related to the left lateral path (favourable)

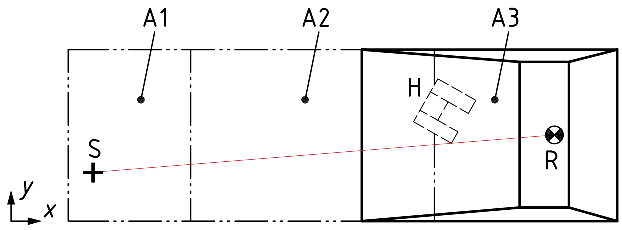
Lateral left (F)									
f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**	
L_W in dB	93	93	93	93	93	93	93	93	
α_{atm} (10°,70%)	0,12	0,41	1,04	1,93	3,66	9,66	32,77	116,88	
A_{atm} in dB	0,02	0,08	0,20	0,37	0,71	1,86	6,32	22,54	
A_{div} in dB	56,64	56,64	56,64	56,64	56,64	56,64	56,64	56,64	
$A_{ground,F}$ in dB	-1,35	-1,35	-1,35	-1,35	-1,35	-1,35	-1,35	-1,35	
$\Delta_{dif,F}$ in dB	11,08	13,52	16,24	19,09	22,02	24,99	27,98	30,98	
A_F in dB	66,40	68,90	71,73	74,75	78,01	82,14	89,59	108,80	**Total**
L_F in dB	26,60	24,10	21,27	18,25	14,99	10,86	3,41	-15,80	29,83

Table 219 — Partial and total sound pressure levels for all three propagation paths

f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**	**Total**
L_A in dB over top	5,34	13,46	18,18	20,67	20,74	17,92	10,36	-10,30	26,01
L_A in dB right	-7,43	-1,43	2,41	4,34	4,39	1,40	-6,35	-27,98	9,88
L_A in dB left	0,40	8,00	12,67	13,91	14,99	12,06	4,41	-16,90	20,04
L_A in dB	6,72	14,66	19,34	21,58	21,84	19,00	11,42	-9,38	27,08

6.2.21 TC20 — Ground with spatially varying heights and acoustic properties

This test case, shown in Figure 35, can be compared with the next test case TC21 (ground model and source - receiver are identical). Contour lines and geometry of areas of constant ground factor G are the same as in TC05 (Tables 16 and 17).



Key

S source

R receiver

H object/building

A1 area with G = 0,9

A2 area with G = 0,5

A3 area with G = 02

Figure 35 — Ground with spatially varying heights and acoustic properties

Table 220 contains the input parameters (source and receiver position), and Tables 221 to 223 show the intermediate and the final results.

Table 220 — Coordinates of source S and receiver R

Point	x (m)	y (m)	z (m)
S	10	10	1
R	200	25	14

Table 221 — z-profile (ground height) along the propagation path

z-profile S-R		
No	u (m)	v (m)
1	0,00	0,00
2	110,34	0,00
3	175,54	10,00
4	190,59	10,00

Table 222 — Ground attenuation (in frequency bands where no diffraction is relevant)

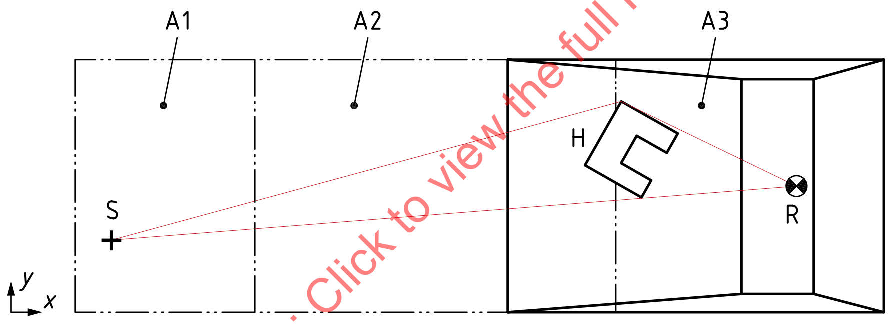
f in Hz	63	125	250	500	1 000	2 000	4 000	8 000
w (H)	1,6E-04	8,8E-04	4,9E-03	0,03	0,15	0,76	3,76	17,01
C_f (H)	199,65	218,28	203,92	80,61	9,46	1,31	0,27	0,06
$A_{ground,H}$ in dB	-1,06	-1,06	-1,06	-1,06	-1,06	-1,06	-1,06	-1,06
w (F)	0,00	0,00	0,00	0,01	0,08	0,42	2,16	10,35
C_f (F)	195,99	210,11	221,65	131,04	23,06	2,42	0,46	0,10
$A_{ground,F}$ in dB	-1,06	-1,06	-1,06	-1,06	-1,06	-1,06	-1,06	-1,06

Table 223 — Step by step and final results related to the propagation in the vertical plane

f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**	
L_W in dB	93	93	93	93	93	93	93	93	
α_{atm}	0,12	0,41	1,04	1,93	3,66	9,66	32,77	116,88	
A_{atm} in dB	0,02	0,08	0,20	0,37	0,70	1,85	6,26	22,33	
A_{div} in dB	56,62	56,62	56,62	56,62	56,62	56,62	56,62	56,62	
$A_{boundary,H}$ in dB	-1,06	-1,06	-1,06	-1,06	-1,06	-1,06	-1,06	-1,06	
$A_{boundary,F}$ in dB	-1,06	-1,06	-1,06	-1,06	-1,06	-1,06	-1,06	-1,06	**Total**
L_H in dB	37,41	37,35	37,23	37,06	36,73	35,59	31,17	15,10	44,91
L_F in dB	37,41	37,35	37,23	37,06	36,73	35,59	31,17	15,10	44,91
L in dB	37,41	37,35	37,23	37,06	36,73	35,59	31,17	15,10	44,91
A-weighting in dB	-26,2	-16,1	-8,6	-3,2	0,0	1,2	1,0	-1,1	
L_A in dB	11,21	21,25	28,63	33,86	36,73	36,79	32,17	14,00	41,61

6.2.22 TC21 — Building on ground with spatially varying heights and acoustic properties

This scenario, shown in Figures 36 and 37, differs from TC20 only by the building H (no reflections are considered).



Key

S source

R receiver

H building

A1 area with G = 0.9

A2 area with G = 0.5

A3 area with G = 0.2

Figure 36 — Scenario of TC20 with inserted U-shaped object

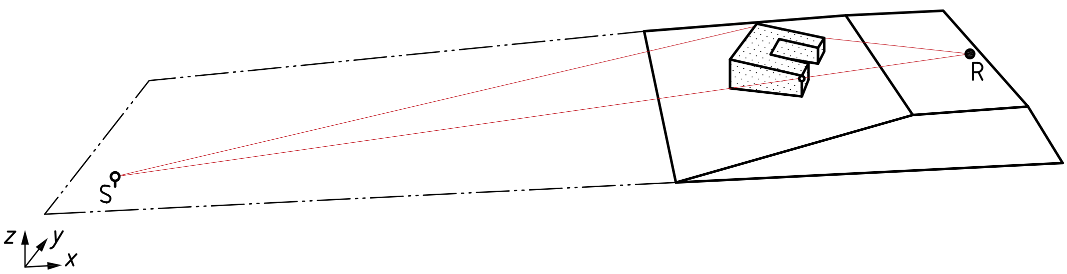


Figure 37 — 3D-presentation of scenario TC21

Table 224 contains the additional input parameters (building), and Tables 225 to 242 show the intermediate and the final results.

Table 224 — Coordinates of acoustically opaque objects (buildings)

Object No	**Edge** No	*x* (m)	*y* (m)	*z* (m)
1	1	167,2	39,5	11,5
1	2	151,6	48,5	11,5
1	3	141,1	30,3	11,5
1	4	156,7	21,3	11,5
1	5	159,7	26,5	11,5
1	6	151,0	31,5	11,5
1	7	155,5	39,3	11,5
1	8	164,2	34,3	11,5

Table 225 — Height profiles along the direct and the two lateral paths (homogeneous)

***z*-profile S-O**		***z*-profile O-R**		***z*-profile right**		***z*-profile left**	
u (m)	*z* (m)	*u* (m)	*z* (m)	*u* (m)	*z* (m)	*u* (m)	*z* (m)
0,00	0,00	146,75	11,50	0,00	0,00	0,00	0,00
110,34	0,00	147,26	11,50	110,33	0,00	114,00	0,00
146,75	5,58	147,26	5,66	147,10	5,64	146,72	4,86
		175,54	10,00	175,54	10,00	183,89	10,00
		190,59	10,00	190,59	10,00	200,57	10,00

Table 226 — Determination of G_{path} (homogeneous)

***G*-profile** S -> O				***G*-profile** O -> R			
from (m)	to (m)	length (m)	*G*	from (m)	to (m)	length (m)	*G*
0,00	40,12	40,12	0,9	0,00	0,51	0,51	0
40,12	140,44	100,31	0,5	0,51	43,84	43,33	0,20
140,44	146,75	6,32	0,20			G_{path}	0,20
		G_{path}	0,60				

Table 227 — G-profile along the two lateral paths (homogeneous)

***G*-profile lateral right**				***G*-profile lateral left**			
from (m)	to (m)	length (m)	*G*	from (m)	to (m)	length (m)	*G*
0,00	40,12	40,12	0,9	0,00	41,45	41,45	0,9
40,12	140,42	100,30	0,5	41,45	145,09	103,64	0,5
140,42	147,10	6,68	0,2	145,09	146,72	1,63	0,2
147,10	190,59	43,49	0,2	146,72	200,56	53,85	0,2
		G_{path}	0,5			G_{path}	0,5

Table 228 — *z*-profile (ground height) along the propagation path

No	*z*-profile S-R *u* (m)	*v* (m)
1	0,00	0,00
2	110,34	0,00
3	146,75	5,58
4	146,75	11,50
5	147,26	11,50
6	147,26	5,66
7	175,54	10,00
8	190,59	10,00

Table 229 — Mean ground plane MGP and averaged ground factors (homogeneous)

Parameter	S -> O_1	O_n -> R
a (MGP)	0,02	0,10
b (MGP) in m	-1,04	-8,64
z_1 in m	2,04	5,10
z_2 in m	9,07	3,12
d_p in m	146,96	43,87
G_{path}	0,60	0,20
G'_{path}	0,77	

Table 230 — Mean ground plane MGP and averaged ground factors (favourable)

Parameter	S -> R	S -> O_1	O_n -> R
a (MGP)	0,06	0,02	0,11
b (MGP) in m	-2,84	-1,10	-10,12
z_1 in m	3,84	2,10	5,28
z_2 in m	6,12	8,93	3,00
d_p in m	191,02	147,48	43,34
G_{path}	0,50	0,59	0,20
G'_{path}	0,65	0,76	

Table 231 — Coordinates of mirror points (homogeneous)

Mirror points	*u* (m)	*v* (m)
S' (S -> R)	-	-
R' (S -> R)	-	-
S' (S -> O)	0,10	-3,08
R' (O -> R)	191,23	7,79

Table 232 — Coordinates of mirror points (favourable)

Mirror points	u (m)	v (m)
S' (S -> R)	0,43	-6,66
R' (S -> R)	191,28	1,79
S' (S -> O)	0,10	-3,21
R' (O -> R)	191,25	8,04

Table 233 — Calculation of the path length differences δ

Parameter	S->R		S'->R		S->R'		Lateral right		Lateral left	
	(H)	(F)	(H)	(F)	(H)	(F)	(H)	(F)	(H)	(F)
No(O_1)	4	5	4	5	4	5	-		-	
No(O_n)	4	5	4	5	4	5	-		-	
d	191,03	191,16	191,26	191,39	191,35	191,51	191,03		191,03	
d_{ss}	147,13	147,69	147,38	147,95	147,13	147,69	147,44		147,05	
d_{sr}	43,91	43,40	43,91	43,40	44,63	44,13	43,60		53,94	
e	0,00	0,00	0,00	0,00	0,00	0,00	0,00		0,00	
δ	0,00	-0,06	0,03	-0,04	0,41	0,31	0,00		9,95	

Table 234 — Ground attenuation (in frequency bands where no diffraction is relevant)

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000
w (H)	-	-	-	-	-	-	-	-
C_f (H)	-	-	-	-	-	-	-	-
$A_{ground,H}$ in dB	-	-	-	-	-	-	-	-
w (F)	0,00	0,00	-	0,01	0,08	0,42	2,15	10,33
C_f (F)	195,98	210,08	-	131,26	23,14	2,43	0,46	0,10
$A_{ground,F}$ in dB	-1,06	-1,06	-	-1,06	-1,06	-1,06	-1,06	-1,06

Table 235 — Check of the "Rayleigh-Criterion" (favourable)

Parameter	Favourable							
	63	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**
O (No of edge in z-profile)	5,00	5,00	-	-	-	-	-	-
$-\lambda/20$	-0,27	-0,14	-	-	-	-	-	-
S-R	191,16	191,16	-	-	-	-	-	-
d_{ss} (S-D-R)	147,69	147,69	-	-	-	-	-	-
d_{sr} (S-D-R)	43,40	43,40	-	-	-	-	-	-
δ_D	-0,06	-0,06	-	-	-	-	-	-
$\delta_D > -\lambda/20$?	yes	yes	-	-	-	-	-	-
S*-R*	191,60	191,60	-	-	-	-	-	-
d_{ss} (S*-D-R*)	147,95	147,95	-	-	-	-	-	-
d_{sr} (S*-D-R*)	44,13	44,13	-	-	-	-	-	-
δ_D*	0,47	0,47	-	-	-	-	-	-
$\lambda/4-\delta_D$*	0,88	0,21	-	-	-	-	-	-

Table 235 *(continued)*

Parameter	Favourable							
	63	125	250	500	1 000	2 000	4 000	8 000
$\delta_D > (\lambda/4 - \delta_D^*)$?	no	no	-	-	-	-	-	-
R-Criterion OK?	no	no	-	-	-	-	-	-

Table 236 — Determination of $A_{boundary,H}$

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000
$\Delta_{dif(S,R)}$	4,81	4,85	4,92	5,06	5,34	5,84	6,69	8,02
$A_{ground,(S,O)}$	-0,70	-0,70	-0,70	-0,70	-0,70	-0,70	-0,70	-0,70
$A_{ground,(O,R)}$	-0,47	-1,57	-2,41	-2,41	-2,41	-2,41	-2,41	-2,41
$\Delta_{dif(S',R)}$	5,08	5,37	5,89	6,78	8,15	10,03	12,34	14,95
$\Delta_{dif(S,R')}$	7,81	9,55	11,77	14,33	17,09	19,97	22,92	25,89
$\Delta_{ground(S,O)}$	-0,68	-0,66	-0,63	-0,58	-0,51	-0,44	-0,37	-0,32
$\Delta_{ground(O,R)}$	-0,33	-0,95	-1,18	-0,91	-0,69	-0,53	-0,42	-0,35
A_{dif}	3,80	3,24	3,11	3,58	4,13	4,87	5,90	7,35
$A_{ground(S,R)}$	-	-	-	-	-	-	-	-
$A_{boundary,H}$	3,80	3,24	3,11	3,58	4,13	4,87	5,90	7,35

Table 237 — Determination of $A_{boundary,F}$

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000
$\Delta_{dif(S,R)}$	0,00	0,00	0,64	0,00	0,00	0,00	0,00	0,00
$A_{ground,(S,O)}$	-	-	-0,71	-	-	-	-	-
$A_{ground,(O,R)}$	-	-	-2,40	-	-	-	-	-
$\Delta_{dif(S',R)}$	-	-	2,86	-	-	-	-	-
$\Delta_{dif(S,R')}$	-	-	10,88	-	-	-	-	-
$\Delta_{ground(S,O)}$	-	-	-0,55	-	-	-	-	-
$\Delta_{ground(O,R)}$	-	-	-0,81	-	-	-	-	-
A_{dif}	-	-	-0,72	-	-	-	-	-
$A_{ground(S,R)}$	-1,06	-1,06	-	-1,06	-1,06	-1,06	-1,06	-1,06
$A_{boundary,F}$	-1,06	-1,06	-0,72	-1,06	-1,06	-1,06	-1,06	-1,06

Table 238 — Step by step and final results related to the propagation in the vertical plane

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000	
L_W in dB	93	93	93	93	93	93	93	93	
α_{atm}	0,12	0,41	1,04	1,93	3,66	9,66	32,77	116,88	
A_{atm} in dB	0,02	0,08	0,20	0,37	0,70	1,85	6,26	22,33	
A_{div} in dB	56,62	56,62	56,62	56,62	56,62	56,62	56,62	56,62	
$A_{boundary,H}$ in dB	3,80	3,24	3,11	3,58	4,13	4,87	5,90	7,35	
$A_{boundary,F}$ in dB	-1,06	-1,06	-0,72	-1,06	-1,06	-1,06	-1,06	-1,06	**Total**
L_H in dB	32,56	33,06	33,07	32,43	31,54	29,66	24,22	6,70	40,10
L_F in dB	37,41	37,36	36,90	37,07	36,74	35,59	31,18	15,11	44,86
L in dB	35,63	35,72	35,39	35,34	34,88	33,57	28,96	12,68	43,10
A-weighting in dB	-26,2	-16,1	-8,6	-3,2	0,0	1,2	1,0	-1,1	
L_A in dB	9,43	19,62	26,79	32,14	34,88	34,77	29,96	11,58	39,68

Table 239 — Ground attenuation related to lateral propagation paths

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000
Lateral right								
w (H)	0,00	0,00	0,00	0,03	0,15	0,76	3,76	17,00
C_f (H)	199,64	218,28	203,93	80,63	9,47	1,31	0,27	0,06
$A_{ground,H}$ in dB	-1,06	-1,06	-1,06	-1,06	-1,06	-1,06	-1,06	-1,06
w (F)								
C_f (F)								
$A_{ground,F}$ in dB								
lateral left								
w (H)	0,00	0,00	0,00	0,02	0,13	0,70	3,48	15,89
C_f (H)	209,75	229,14	216,34	87,81	10,49	1,42	0,29	0,06
$A_{ground,H}$ in dB	-1,12	-1,12	-1,02	-0,79	-1,12	-1,12	-1,12	-1,12
w (F)								
C_f (F)								
$A_{ground,F}$ in dB								

Table 240 — Calculation of the linear partial levels related to the right lateral path (homogeneous)

Lateral right (H)									
f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**	
L_W in dB	93	93	93	93	93	93	93	93	
α_{atm} (10°,70%)	0,12	0,41	1,04	1,93	3,66	9,66	32,77	116,88	
A_{atm} in dB	0,02	0,08	0,20	0,37	0,70	1,85	6,26	22,33	
A_{div} in dB	56,62	56,62	56,62	56,62	56,62	56,62	56,62	56,62	
$A_{ground,H}$ in dB	-1,06	-1,06	-1,06	-1,06	-1,06	-1,06	-1,06	-1,06	
$\Delta_{dif,H}$ in dB	4,78	4,79	4,81	4,84	4,92	5,06	5,33	5,82	
A_H in dB	60,37	60,44	60,57	60,78	61,18	62,47	67,15	83,71	**Total**
L_H in dB	32,63	32,56	32,43	32,22	31,82	30,53	25,85	9,29	40,04

Table 241 — Calculation of the linear partial levels related to the left lateral path (homogeneous)

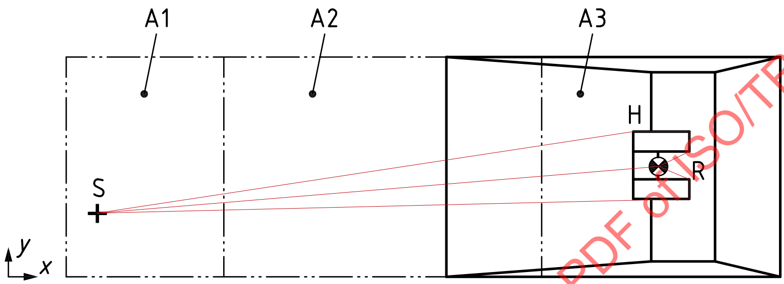
Lateral left (H)									
f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**	
L_W in dB	93	93	93	93	93	93	93	93	
α_{atm} (10°,70%)	0,12	0,41	1,04	1,93	3,66	9,66	32,77	116,88	
A_{atm} in dB	0,02	0,08	0,21	0,39	0,74	1,94	6,59	23,49	
A_{div} in dB	56,62	56,62	56,62	56,62	56,62	56,62	56,62	56,62	
$A_{ground,H}$ in dB	-1,12	-1,12	-1,02	-0,79	-1,12	-1,12	-1,12	-1,12	
$\Delta_{dif,H}$ in dB	18,85	21,74	24,71	27,70	30,70	33,70	36,71	39,72	
A_H in dB	74,38	77,32	80,52	83,92	86,93	91,14	98,79	118,71	**Total**
L_H in dB	18,62	15,68	12,48	9,08	6,07	1,86	-5,79	-25,71	21,51

Table 242 — Partial and total sound pressure levels for all three propagation paths

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000	Total
L_A in dB over top	9,43	19,62	26,79	32,14	34,88	34,77	29,96	11,58	39,68
L_A in dB right	3,42	13,45	20,82	26,01	28,81	28,72	23,84	5,18	33,61
L_A in dB left	-10,59	-3,44	0,87	2,87	3,06	0,05	-7,81	-29,82	8,39
L_A in dB	10,44	20,58	27,78	33,09	35,84	35,73	30,91	12,48	40,64

6.2.23 TC22 — Building with receiver backside on ground with spatially varying heights and acoustic properties

This test case, shown in Figures 38 and 39, includes a receiver position at the backside of a U-type building — the consideration of lateral diffraction in such cases can be checked. Contour lines and geometry of areas of constant ground factor *G* are the same as in TC05 (Tables 16 and 17).



Key

S source

R receiver

H building

A1 area with $G = 0,9$

A2 area with $G = 0,5$

A3 area with $G = 0,2$

Figure 38 — Scenario with inserted U-shaped building with receiver backside

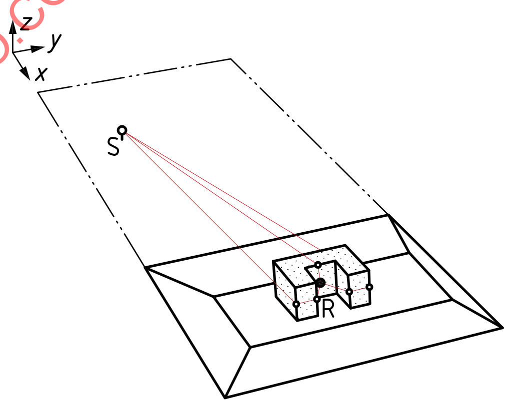


Figure 39 — 3D-presentation of scenario TC22

Tables 243 and 244 contain the modified and new input parameters (source, receiver and building), and Tables 245 to 260 show the intermediate and the final results.

Table 243 — Coordinates of source S and receiver R

Point	x (m)	y (m)	z (m)
S	10	10	1
R	187,05	25	14

Table 244 — Coordinates of acoustically opaque objects (buildings)

Object No	Edge No	x (m)	y (m)	z (m)
1	1	197,0	36,0	20,0
1	2	179,0	36,0	20,0
1	3	179,0	15,0	20,0
1	4	197,0	15,0	20,0
1	5	197,0	21,0	20,0
1	6	187,0	21,0	20,0
1	7	187,0	30,0	20,0
1	8	197,0	30,0	20,0

Table 245 — Height profiles along the direct and the two lateral paths (homogeneous)

***z*-profile** S-O		***z*-profile** O-R		***z*-profile** right		***z*-profile** left	
u (m)	z (m)	u (m)	z (m)	u (m)	z (m)	u (m)	z (m)
0,00	0,00	177,64	10,00	0,00	0,00	0,00	0,00
110,39	0,00	177,68	10,00	110,04	0,00	111,29	0,00
169,60	9,08			175,06	10,00	170,99	9,08
				187,07	10,00	176,99	10,00
				193,08	10,00	188,99	10,00
				203,80	10,00	195,00	10,00
						206,14	10,00

Table 246 — Determination of G_{path} (homogeneous)

***G*-profile** S -> O				***G*-profile** O -> R			
from (m)	to (m)	length (m)	G	from (m)	to (m)	length (m)	G
0,00	40,14	40,14	0,9	0,00	0,05	0,05	0,2
40,14	140,50	100,36	0,5			G_{path}	0,20
140,50	169,61	29,10	0,20				
		G_{path}	0,54				

Table 247 — *G*-profile along the two lateral paths (homogeneous)

***G*-profile lateral right**				***G*-profile lateral left**			
from (m)	to (m)	length (m)	G	from (m)	to (m)	length (m)	G
0,00	40,01	40,01	0,9	0,00	40,47	40,47	0,9
40,01	140,05	100,04	0,5	40,47	141,65	101,18	0,5

Table 247 *(continued)*

G-profile lateral right				*G*-profile lateral left			
from (m)	to (m)	length (m)	*G*	from (m)	to (m)	length (m)	*G*
140,05	187,07	47,02	0,2	141,65	170,99	29,34	0,2
187,07	193,08	6,01	0,2	170,99	188,99	18,00	0,2
193,08	203,80	10,73	0,2	188,99	195,00	6,01	0,2
		G_{path}	0,48	195,00	206,14	11,14	0,2
						G_{path}	0,48

Table 248 — *z*-profile (ground height) along the propagation path

z-profile S-R		
No	*u* (m)	*v* (m)
1	0,00	0,00
2	110,39	0,00
3	169,60	9,08
4	169,61	20,00
5	177,63	20,00
6	177,64	10,00
7	177,68	10,00

Table 249 — Mean ground plane MGP and averaged ground factors (homogeneous)

Parameter	S -> O_1	O_n -> R	S->R **right**	S->R **left**
a (MGP)	0,04	0,00	0,06	0,06
b (MGP) in m	-2,06	10,00	-3,05	-3,05
z_1 in m	3,06	10,00	4,04	4,04
z_2 in m	14,75	4,00	4,93	4,93
d_p in m	170,26	0,05	204,22	206,55
G_{path}	0,54	0,20	0,48	0,48
G'_{path}	0,79		0,58	0,58

Table 250 — Coordinates of mirror points (homogeneous)

Mirror points	*u* (m)	*v* (m)
S' (S -> O)	0,26	-5,11
R' (O -> R)	177,68	6,00

Table 251 — Calculation of the path length differences *δ*

Parameter	S->R		S'->R		S->R'		**Lateral right**		**Lateral left**	
	(H)	(F)	(H)	(F)	(H)	(F)	(H)	(F)	(H)	(F)
No(O_1)	4	4	4	4	4	4	-	-	-	-
No(O_n)	5	5	5	5	5	5	-	-	-	-
d	178,16	178,28	178,45	178,56	177,75	177,87	178,16	178,16	178,16	178,16
d_{ss}	170,67	170,77	171,19	171,30	170,67	170,77	187,57	187,57	171,44	171,44
d_{sr}	6,00	6,00	6,00	6,00	14,00	14,00	10,75	10,75	11,16	11,16

Table 251 *(continued)*

Parameter	S->R		S'->R		S->R'		Lateral right		Lateral left	
	(H)	(F)	(H)	(F)	(H)	(F)	(H)	(F)	(H)	(F)
e	8,03	8,03	8,03	8,03	8,03	8,03	6,01	6,01	24,06	24,06
δ	6,54	6,52	6,78	6,76	14,94	14,93	26,17	26,17	28,51	28,51

Table 252 — Determination of $A_{boundary,H}$

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000
$\Delta_{dif(S,R)}$	17,34	20,76	25,01	29,48	33,28	36,55	39,63	42,66
$A_{ground,(S,O)}$	-0,64	-0,64	-0,64	-0,64	-0,64	-0,64	-0,64	-0,64
$A_{ground,(O,R)}$	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40
$\Delta_{dif(S',R)}$	17,49	20,91	25,17	29,64	33,43	36,70	39,78	42,81
$\Delta_{dif(S,R')}$	20,79	24,29	28,58	33,06	36,87	40,14	43,22	46,25
$\Delta_{ground(S,O)}$	-0,63	-0,63	-0,63	-0,63	-0,63	-0,63	-0,63	-0,63
$\Delta_{ground(O,R)}$	-1,68	-1,67	-1,66	-1,66	-1,66	-1,66	-1,66	-1,66
A_{dif}	15,03	18,46	22,71	22,71	22,71	22,71	22,71	22,71
$A_{ground(S,R)}$	-	-	-	-	-	-	-	-
$A_{boundary,H}$	15,03	18,46	22,71	22,71	22,71	22,71	22,71	22,71

Table 253 — Determination of $A_{boundary,F}$

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000
$\Delta_{dif(S,R)}$	17,33	20,75	25,00	29,47	33,27	36,54	39,62	42,65
$A_{ground,(S,O)}$	-0,64	-0,64	-0,64	-0,64	-0,64	-0,64	-0,64	-0,64
$A_{ground,(O,R)}$	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40	-2,40
$\Delta_{dif(S',R)}$	17,48	20,90	25,16	29,63	33,43	36,70	39,78	42,80
$\Delta_{dif(S,R')}$	20,79	24,28	28,58	33,06	36,86	40,13	43,21	46,24
$\Delta_{ground(S,O)}$	-0,63	-0,63	-0,63	-0,63	-0,63	-0,63	-0,63	-0,63
$\Delta_{ground(O,R)}$	-1,68	-1,67	-1,66	-1,66	-1,66	-1,66	-1,66	-1,66
A_{dif}	15,02	18,45	22,71	22,71	22,71	22,71	22,71	22,71
$A_{ground(S,R)}$	-	-	-	-	-	-	-	-
$A_{boundary,F}$	15,02	18,45	22,71	22,71	22,71	22,71	22,71	22,71

Table 254 — Step by step and final results related to the propagation in the vertical plane

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000	
L_W in dB	93	93	93	93	93	93	93	93	
α_{atm}	0,12	0,41	1,04	1,93	3,66	9,66	32,77	116,88	
A_{atm} in dB	0,02	0,07	0,19	0,34	0,65	1,72	5,84	20,82	
A_{div} in dB	56,02	56,02	56,02	56,02	56,02	56,02	56,02	56,02	
$A_{boundary,H}$ in dB	15,03	18,46	22,71	22,71	22,71	22,71	22,71	22,71	
$A_{boundary,F}$ in dB	15,02	18,45	22,71	22,71	22,71	22,71	22,71	22,71	**Total**
L_H in dB	21,93	18,45	14,09	13,93	13,62	12,55	8,43	-6,55	25,11
L_F in dB	21,94	18,46	14,09	13,93	13,62	12,55	8,43	-6,55	25,12
L in dB	21,94	18,46	14,09	13,93	13,62	12,55	8,43	-6,55	25,12
A-weighting in dB	-26,2	-16,1	-8,6	-3,2	0,0	1,2	1,0	-1,1	
L_A in dB	-4,26	2,36	5,49	10,73	13,62	13,75	9,43	-7,65	18,64

Table 255 — Ground attenuation related to lateral propagation paths

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000
Lateral right								
w (H)	0,00	0,00	0,00	0,02	0,11	0,60	3,00	13,93
C_f (H)	212,03	230,71	226,18	101,93	13,28	1,67	0,33	0,07
$A_{\text{ground,H}}$ in dB	-1,25	-1,25	-1,03	0,77	-1,25	-1,25	-1,25	-1,25
w (F)	0,00	0,00	0,00	0,01	0,07	0,38	1,96	9,49
C_f (F)	209,34	224,10	237,46	143,50	25,94	2,69	0,51	0,11
$A_{\text{ground,F}}$ in dB	-1,25	-1,17	-1,25	-1,25	-1,25	-1,25	-1,25	-1,25
lateral left								
w (H)	0,00	0,00	0,00	0,02	0,11	0,59	2,96	13,76
C_f (H)	214,41	233,28	228,92	103,46	13,51	1,70	0,34	0,07
$A_{\text{ground,H}}$ in dB	-1,26	-1,26	-1,05	0,86	-1,26	-1,26	-1,26	-1,26
w (F)	0,00	0,00	0,00	0,01	0,07	0,38	1,96	9,49
C_f (F)	211,78	226,80	240,03	144,13	25,83	2,69	0,51	0,11
$A_{\text{ground,F}}$ in dB	-1,26	-1,18	-1,26	-1,26	-1,26	-1,26	-1,26	-1,26

Table 256 — Calculation of the linear partial levels related to the right lateral path (homogeneous)

Lateral right (H)									
f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**	
L_W in dB	93	93	93	93	93	93	93	93	
α_{atm} (10°,70%)	0,12	0,41	1,04	1,93	3,66	9,66	32,77	116,88	
A_{atm} in dB	0,02	0,08	0,21	0,39	0,75	1,97	6,70	23,88	
A_{div} in dB	56,02	56,02	56,02	56,02	56,02	56,02	56,02	56,02	
$A_{\text{ground,H}}$ in dB	-1,25	-1,25	-1,03	0,77	-1,25	-1,25	-1,25	-1,25	
$\Delta_{\text{dif,H}}$ in dB	23,08	26,38	30,38	34,93	39,06	42,50	45,63	48,67	
A_{H} in dB	77,88	81,24	85,57	92,12	94,57	99,24	107,10	127,33	**Total**
L_{H} in dB	15,12	11,76	7,43	0,88	-1,57	-6,24	-14,10	-34,33	17,42

Table 257 — Calculation of the linear partial levels related to the right lateral path (favourable)

Lateral right (F)									
f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**	
L_W in dB	93	93	93	93	93	93	93	93	
α_{atm} (10°,70%)	0,12	0,41	1,04	1,93	3,66	9,66	32,77	116,88	
A_{atm} in dB	0,02	0,08	0,21	0,39	0,75	1,97	6,70	23,88	
A_{div} in dB	56,02	56,02	56,02	56,02	56,02	56,02	56,02	56,02	
$A_{\text{ground,F}}$ in dB	-1,25	-1,17	-1,25	-1,25	-1,25	-1,25	-1,25	-1,25	
$\Delta_{\text{dif,F}}$ in dB	23,08	26,38	30,38	34,93	39,06	42,50	45,63	48,67	
A_{F} in dB	77,88	81,31	85,36	90,10	94,57	99,24	107,10	127,33	**Total**
L_{F} in dB	15,12	11,69	7,64	2,90	-1,57	-6,24	-14,10	-34,33	17,48

Table 258 — Calculation of the linear partial levels related to the left lateral path (homogeneous)

Lateral left (H)									
f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**	
L_W in dB	93	93	93	93	93	93	93	93	
α_{atm} (10°,70%)	0,12	0,41	1,04	1,93	3,66	9,66	32,77	116,88	
A_{atm} in dB	0,03	0,08	0,22	0,40	0,76	2,00	6,77	24,16	
A_{div} in dB	56,02	56,02	56,02	56,02	56,02	56,02	56,02	56,02	
$A_{ground,H}$ in dB	-1,26	-1,26	-1,05	0,86	-1,26	-1,26	-1,26	-1,26	
$\Delta_{dif,H}$ in dB	24,81	29,30	33,41	36,85	39,98	43,03	46,04	49,06	
A_H in dB	79,60	84,14	88,60	94,13	95,50	99,78	107,58	127,97	**Total**
L_H in dB	13,40	8,86	4,40	-1,13	-2,50	-6,78	-14,58	-34,97	15,30

Table 259 — Calculation of the linear partial levels related to the left lateral path (favourable)

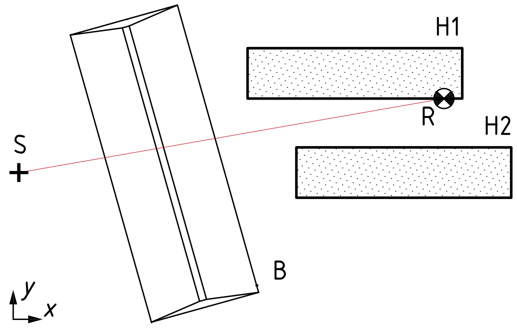
Lateral left (F)									
f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**	
L_W in dB	93	93	93	93	93	93	93	93	
α_{atm} (10°,70%)	0,12	0,41	1,04	1,93	3,66	9,66	32,77	116,88	
A_{atm} in dB	0,03	0,08	0,22	0,40	0,76	2,00	6,77	24,16	
A_{div} in dB	56,02	56,02	56,02	56,02	56,02	56,02	56,02	56,02	
$A_{ground,F}$ in dB	-1,26	-1,18	-1,26	-1,26	-1,26	-1,26	-1,26	-1,26	
$\Delta_{dif,F}$ in dB	24,81	29,30	33,41	36,85	39,98	43,03	46,04	49,06	
A_F in dB	79,60	84,22	88,39	92,01	95,50	99,78	107,58	127,97	**Total**
L_F in dB	13,40	8,78	4,61	0,99	-2,50	-6,78	-14,58	-34,97	15,37

Table 260 — Calculation of the A-weighted sound pressure level

f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**	
L_H(vert) in dB	21,93	18,45	14,09	13,93	13,62	12,55	8,43	-6,55	
L_H(right) in dB	15,12	11,76	7,43	0,88	-1,57	-6,24	-14,10	-34,33	
L_H(left) in dB	13,40	8,86	4,40	-1,13	-2,50	-6,78	-14,58	-34,97	
L_H(tot) in dB	23,23	19,67	15,31	14,27	13,85	12,66	8,48	-6,54	
L_F(vert) in dB	21,94	18,46	14,09	13,93	13,62	12,55	8,43	-6,55	
L_F(right) in dB	15,12	11,69	7,64	2,90	-1,57	-6,24	-14,10	-34,33	
L_F(left) in dB	13,40	8,78	4,61	0,99	-2,50	-6,78	-14,58	-34,97	
L_F(tot) in dB	23,24	19,66	15,36	14,46	13,85	12,66	8,48	-6,54	**Total**
L in dB	23,24	19,66	15,33	14,37	13,85	12,66	8,48	-6,54	26,18
A-weighting in dB	-26,2	-16,1	-8,6	-3,2	0	1,2	1	-1,1	
L_A in dB	-2,96	3,56	6,73	11,17	13,85	13,86	9,48	-7,64	18,93

6.2.24 TC23 — Two buildings behind an earth-berm on flat ground with homogeneous acoustic properties

The aim of this and the following two test cases is to check the combination of diffraction and reflection with different modelling approaches. The ground factor of the terrain is spatially constant with $G = 0$. The surface of the earth berm is porous ($G = 1$). The facades of the building are acoustically characterized by an absorption coefficient of $\alpha = 0,2$. The test case is shown in Figures 40 and 41.



Key

S source
R receiver
H*n* buildings
B earth-berm

Figure 40 — Scenario earth-berm and 2 buildings H1 and H2 — Receiver in front of H1

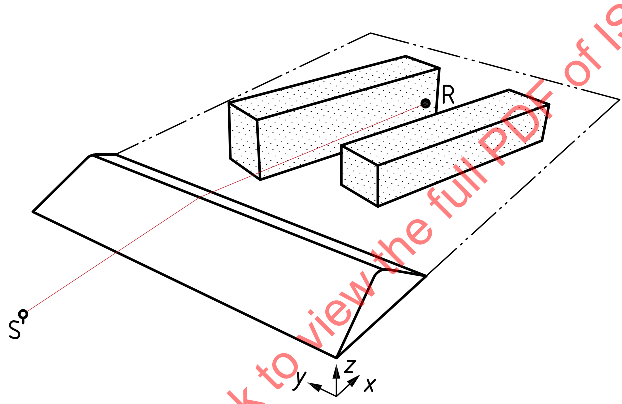


Figure 41 — 3D-presentation of scenario TC23

Tables 261 to 263 contain the input parameters, and Tables 264 to 275 show the intermediate and the final results.

Table 261 — Coordinates of source S and receiver R

Point	x (m)	y (m)	z (m)
S	38	14	1
R	107	25,95	4

Table 262 — Contour lines to describe the shape of the ground surface

No	x_1 (m)	y_1 (m)	z_1 (m)	x_2 (m)	y_2 (m)	z_2 (m)
1	30	-14	0	122	-14	0
2	122	-14	0	122	45	0
3	122	45	0	30	45	0
4	30	45	0	30	-14	0
5	59,60	-9,87	0,00	76,84	-5,28	0,00
6	76,84	-5,28	0,00	63,71	41,16	0,00

Table 262 *(continued)*

No	x_1 (m)	y_1 (m)	z_1 (m)	x_2 (m)	y_2 (m)	z_2 (m)
7	63,71	41,16	0,00	46,27	36,28	0,00
8	46,27	36,28	0,00	59,60	-9,87	0,00
9	46,27	36,28	0,00	54,68	37,59	5,00
10	54,68	37,59	5,00	55,93	37,93	5,00
11	55,93	37,93	5,00	63,71	41,16	0,00
12	59,60	-9,87	0,00	67,35	-6,83	5,00
13	67,35	-6,83	5,00	68,68	-6,49	5,00
14	68,68	-6,49	5,00	76,84	-5,28	0,00
15	54,68	37,59	5,00	67,35	-6,83	5,00
16	55,93	37,93	5,00	68,68	-6,49	5,00

Table 263 — Coordinates of acoustically opaque objects (buildings)

Object No	**Edge** No	x (m)	y (m)	z (m)
1	1	75,0	34,0	9,0
1	2	110,0	34,0	9,0
1	3	110,0	26,0	9,0
1	4	75,0	26,0	9,0
2	5	83,0	18,0	8,0
2	6	118,0	18,0	8,0
2	7	118,0	10,0	8,0
2	8	83,0	10,0	8,0

Table 264 — *z*-profile (ground height) along the propagation path

z-profile S-R		
No	u (m)	v (m)
1	0,00	0,00
2	14,21	0,00
3	22,64	5,00
4	23,98	5,00
5	32,30	0,00
6	70,03	0,00

Table 265 — *z*-profiles (ground-height) related to the vertical propagation plane (homogeneous)

z-profile S-O		*z*-profile O-R	
u (m)	z (m)	u (m)	z (m)
0,00	0,00	23,98	5,00
14,21	0,00	32,30	0,00
22,64	5,00	70,03	0,00

Table 266 — *z*-profiles (ground-height) related to the vertical propagation plane (favourable)

***z*-profile** S-O		***z*-profile** O-R	
u (m)	*z* (m)	*u* (m)	*z* (m)
0,00	0,00	22,64	5,00
14,21	0,00	23,98	5,00
22,64	5,00	32,30	0,00
		70,03	0,00

Table 267 — Determination of G_{path} (homogeneous)

***G*-profile** S -> O				***G*-profile** O -> R			
from (m)	to (m)	length (m)	*G*	from (m)	to (m)	length (m)	*G*
0,00	14,21	14,21	0	0,00	8,33	8,33	1
14,21	22,64	8,43	1	8,33	46,05	37,72	0,00
		G_{path}	0,37			G_{path}	0,18

Table 268 — Mean ground plane MGP and averaged ground factors (homogeneous)

Parameter	S -> O_1	O_n -> R
a (MGP)	0,19	-0,05
b (MGP) in m	-1,17	2,89
z_1 in m	2,13	3,35
z_2 in m	1,94	4,73
d_p in m	22,99	46,04
G_{path}	0,37	0,18
G'_{path}	0,07	

Table 269 — Mean ground plane MGP and averaged ground factors (favourable)

Parameter	S -> O_1	O_n -> R
a (MGP)	0,19	-0,06
b (MGP) in m	-1,17	3,51
z_1 in m	2,13	2,91
z_2 in m	1,94	4,91
d_p in m	22,99	47,36
G_{path}	0,37	0,20
G'_{path}	0,07	

Table 270 — Coordinates of mirror points (homogeneous)

Mirror points	*u* (m)	*v* (m)
S' (S -> O)	0,78	-3,19
R' (O -> R)	69,54	-5,46

Table 271 — Coordinates of mirror points (favourable)

Mirror points	u (m)	v (m)
S' (S -> O)	0,78	-3,19
R' (O -> R)	69,41	-5,80

Table 272 — Calculation of the path length differences

Parameter	S->R		S'->R		S->R'	
	(H)	(F)	(H)	(F)	(H)	(F)
$No(O_1)$	3	3	3	3	3	3
$No(O_n)$	4	3	4	3	4	3
d	70,09	70,11	69,62	69,64	69,84	69,75
d_{ss}	22,99	22,99	23,35	23,35	22,99	22,99
d_{sr}	46,06	47,40	46,06	47,40	46,75	48,00
e	1,34	0,00	1,34	0,00	1,34	0,00
δ	0,30	0,29	1,12	1,11	1,24	1,24

Table 273 — Determination of $A_{boundary,H}$

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000
$A_{dif(S,R)}$	7,17	8,69	10,78	13,46	16,98	21,34	25,53	29,05
$A_{ground,(S,O)}$	-1,02	-0,08	-0,73	-2,79	-2,79	-2,79	-2,79	-2,79
$A_{ground,(O,R)}$	-0,28	-1,00	-2,46	-2,46	-2,46	-2,46	-2,46	-2,46
$A_{dif(S',R)}$	10,54	12,93	15,67	18,78	22,56	27,04	31,28	34,81
$A_{dif(S,R')}$	10,86	13,28	16,05	19,18	22,97	27,46	31,70	35,22
$A_{ground(S,O)}$	-0,71	-0,05	-0,42	-1,62	-1,58	-1,56	-1,55	-1,55
$A_{ground(O,R)}$	-0,18	-0,60	-1,42	-1,36	-1,32	-1,30	-1,30	-1,29
A_{dif}	6,28	8,04	8,93	10,48	14,09	18,48	22,15	22,16
$A_{ground(S,R)}$	-	-	-	-	-	-	-	-
$A_{boundary,H}$	6,28	8,04	8,93	10,48	14,09	18,48	22,15	22,16

Table 274 — Determination of $A_{boundary,F}$

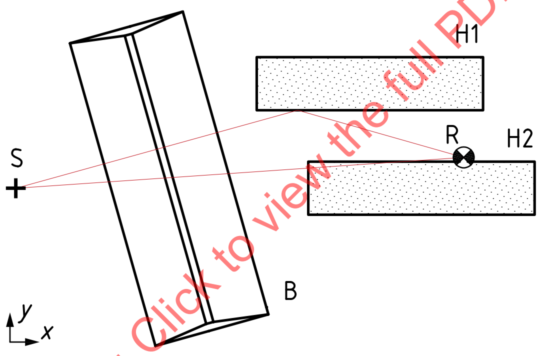
f in Hz	63	125	250	500	1 000	2 000	4 000	8 000
$A_{dif(S,R)}$	7,10	8,59	10,59	12,99	15,66	18,49	21,41	24,37
$A_{ground,(S,O)}$	-0,96	-0,13	-1,09	-2,79	-2,79	-2,79	-2,79	-2,79
$A_{ground,(O,R)}$	-0,54	-1,28	-2,39	-2,39	-2,39	-2,39	-2,39	-2,39
$A_{dif(S',R)}$	10,51	12,87	15,53	18,36	21,27	24,23	27,22	30,22
$A_{dif(S,R')}$	10,86	13,27	15,96	18,81	21,73	24,70	27,68	30,68
$A_{ground(S,O)}$	-0,66	-0,08	-0,64	-1,61	-1,57	-1,55	-1,54	-1,53
$A_{ground(O,R)}$	-0,35	-0,77	-1,37	-1,30	-1,27	-1,25	-1,24	-1,24
A_{dif}	6,09	7,74	8,59	10,07	12,82	15,69	18,63	21,60
$A_{ground(S,R)}$	-	-	-	-	-	-	-	-
$A_{boundary,F}$	6,09	7,74	8,59	10,07	12,82	15,69	18,63	21,60

Table 275 — Step by step and final results related to the propagation in the vertical plane

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000	
L_W in dB	93	93	93	93	93	93	93	93	
α_{atm}	0,12	0,41	1,04	1,93	3,66	9,66	32,77	116,88	
A_{atm} in dB	0,01	0,03	0,07	0,14	0,26	0,68	2,30	8,19	
A_{div} in dB	47,91	47,91	47,91	47,91	47,91	47,91	47,91	47,91	
$A_{boundary,H}$ in dB	6,28	8,04	8,93	10,48	14,09	18,48	22,15	22,16	
$A_{boundary,F}$ in dB	6,09	7,74	8,59	10,07	12,82	15,69	18,63	21,60	**Total**
L_H in dB	38,80	37,02	36,08	34,47	30,75	25,93	20,64	14,74	43,26
L_F in dB	38,99	37,32	36,42	34,88	32,01	28,72	24,16	15,29	43,69
L in dB	38,90	37,17	36,26	34,68	31,42	27,54	22,75	15,02	43,48
A-weighting in dB	-26,2	-16,1	-8,6	-3,2	0,0	1,2	1,0	-1,1	
L_A in dB	12,70	21,07	27,66	31,48	31,42	28,74	23,75	13,92	36,56

6.2.25 TC24 — Two buildings behind an earth-berm on flat ground with homogeneous acoustic properties – receiver position modified

Compared to test case TC23, only the receiver position is modified and reflection comes into play. The model is the same as in TC23 except for the receiver position. This test case is shown in Figures 42 and 43.



Key

S source

R receiver

Hn buildings

B earth-berm

Figure 42 — Scenario with earth-berm and 2 buildings H1 and H2 — Receiver in front of H2

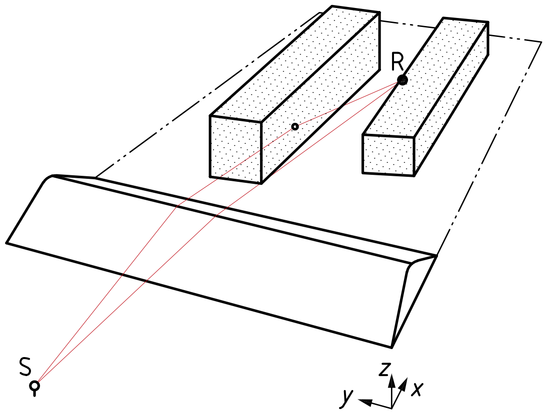


Figure 43 — 3D-presentation of scenario TC24

Table 276 contains the new receiver position, and Tables 277 to 298 show the intermediate and the final results.

Table 276 — Coordinates of source S and receiver R

Point	x (m)	y (m)	z (m)
S	38	14	1
R	106	18,5	4

Table 277 — z-profiles (ground-height) related to the vertical propagation plane (homogeneous)

z-profile S-O		z-profile O-R	
u (m)	z (m)	u (m)	z (m)
0,00	0,00	60,58	0,00
14,46	0,00	68,15	0,00
23,03	5,00		

Table 278 — Determination of G_{path} (homogeneous)

G-profile S -> O				G-profile O -> R			
from (m)	to (m)	length (m)	G	from (m)	to (m)	length (m)	G
0,00	14,46	14,46	0	0,00	7,57	7,57	0
14,46	23,03	8,56	1			G_{path}	0,00
		G_{path}	0,37				

Table 279 — z-profile (ground height) along the propagation path

z-profile S-R		
No	u (m)	v (m)
1	0,00	0,00
2	14,46	0,00

Table 279 *(continued)*

z-profile S-R		
No	*u* (m)	*v* (m)
3	23,03	5,00
4	24,39	5,00
5	32,85	0,00
6	45,10	0,00
7	45,10	6,00
8	60,58	6,00
9	60,58	0,00
10	68,15	0,00

Table 280 — Mean ground plane MGP and averaged ground factors (homogeneous)

Parameter	S -> O_1	O_n -> R
a (MGP)	0,18	0,00
b (MGP) in m	-1,17	0,00
z_1 in m	2,13	6,00
z_2 in m	1,94	4,00
d_p in m	23,37	7,57
G_{path}	0,37	0,00
G'_{path}	0,07	

Table 281 — Coordinates of mirror points (homogeneous)

Mirror points	*u* (m)	*v* (m)
S' (S -> O)	0,76	-3,20
R' (O -> R)	68,15	-4,00

Table 282 — Calculation of the path length differences

Parameter	S->R		S'->R		S->R'	
	(H)	(F)	(H)	(F)	(H)	(F)
No(O_1)	3	3	3	3	3	3
No(O_n)	8	8	8	8	8	8
d	68,21	68,23	67,77	67,78	68,33	68,35
d_{ss}	23,37	23,37	23,72	23,72	23,37	23,37
d_{sr}	7,83	7,83	7,83	7,83	12,54	12,54
e	37,57	37,57	37,57	37,57	37,57	37,57
δ	0,56	0,55	1,36	1,35	5,16	5,14

Table 283 — Determination of $A_{boundary,H}$

f in Hz	**63**	**125**	**250**	**500**	**1 000**	**2 000**	**4 000**	**8 000**
$\Delta_{dif(S,R)}$	10,18	13,64	16,95	20,02	23,02	26,01	29,00	32,01
$A_{ground,(S,O)}$	-1,05	-0,09	-0,69	-2,79	-2,79	-2,79	-2,79	-2,79
$A_{ground,(O,R)}$	-3,00	-3,00	-3,00	-3,00	-3,00	-3,00	-3,00	-3,00
$\Delta_{dif(S',R)}$	13,22	17,14	20,64	23,79	26,82	29,83	32,84	35,85

Table 283 *(continued)*

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000
$A_{dif(S,R')}$	18,53	22,73	26,34	29,53	32,59	35,61	38,62	41,63
$A_{ground(S,O)}$	-0,75	-0,06	-0,46	-1,90	-1,90	-1,89	-1,89	-1,89
$A_{ground(O,R)}$	-1,27	-1,17	-1,14	-1,12	-1,12	-1,11	-1,11	-1,11
A_{dif}	8,16	12,40	15,36	16,99	20,00	22,00	22,00	22,00
$A_{ground(S,R)}$	-	-	-	-	-	-	-	-
$A_{boundary,H}$	8,16	12,40	15,36	16,99	20,00	22,00	22,00	22,00

Table 284 — Determination of $A_{boundary,F}$

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000
$A_{dif(S,R)}$	10,11	13,55	16,86	19,93	22,92	25,91	28,91	31,91
$A_{ground,(S,O)}$	-0,98	-0,14	-1,05	-2,79	-2,79	-2,79	-2,79	-2,79
$A_{ground,(O,R)}$	-3,00	-3,00	-3,00	-3,00	-3,00	-3,00	-3,00	-3,00
$A_{dif(S',R)}$	13,19	17,10	20,60	23,75	26,79	29,79	32,80	35,81
$A_{dif(S,R')}$	18,52	22,72	26,33	29,52	32,58	35,60	38,61	41,62
$A_{ground(S,O)}$	-0,70	-0,10	-0,70	-1,89	-1,89	-1,88	-1,88	-1,88
$A_{ground(O,R)}$	-1,27	-1,17	-1,13	-1,11	-1,11	-1,10	-1,10	-1,10
A_{dif}	8,15	12,29	15,04	16,92	19,93	22,02	22,02	22,02
$A_{ground(S,R)}$	-	-	-	-	-	-	-	-
$A_{boundary,F}$	8,15	12,29	15,04	16,92	19,93	22,02	22,02	22,02

Table 285 — Step by step and final results related to the propagation in the vertical plane

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000	
L_W in dB	93	93	93	93	93	93	93	93	
α_{atm}	0,12	0,41	1,04	1,93	3,66	9,66	32,77	116,88	
A_{atm} in dB	0,01	0,03	0,07	0,13	0,25	0,66	2,24	7,97	
A_{div} in dB	47,68	47,68	47,68	47,68	47,68	47,68	47,68	47,68	
$A_{boundary,H}$ in dB	8,16	12,40	15,36	16,99	20,00	22,00	22,00	22,00	
$A_{boundary,F}$ in dB	8,15	12,29	15,04	16,92	19,93	22,02	22,02	22,02	**Total**
L_H in dB	37,16	32,90	29,89	28,20	25,07	22,67	21,09	15,35	39,75
L_F in dB	37,17	33,00	30,22	28,27	25,14	22,65	21,07	15,33	39,82
L in dB	37,16	32,95	30,06	28,23	25,11	22,66	21,08	15,34	39,79
A-weighting in dB	-26,2	-16,1	-8,6	-3,2	0,0	1,2	1,0	-1,1	
L_A in dB	10,96	16,85	21,46	25,03	25,11	23,86	22,08	14,24	31,05

Table 286 — z-profiles (ground-height) related to the vertical propagation plane (homogeneous) — Reflection

***z*-profile** S-O		***z*-profile** O-R	
u (m)	z (m)	u (m)	z (m)
0,00	0,00	23,84	5,00
14,13	0,00	32,13	0,00
22,51	5,00	43,53	0,00
		70,74	0,00

Table 287 — *z*-profiles (ground-height) related to the vertical propagation plane (favourable) — Reflection

z-profile S-O		*z*-profile O-R	
u (m)	*z* (m)	*u* (m)	*z* (m)
0,00	0,00	22,51	5,00
14,13	0,00	23,84	5,00
22,51	5,00	32,13	0,00
		43,53	0,00
		70,74	0,00

Table 288 — Determination of G_{path} (homogeneous) — Reflection

G-profile S -> O				*G*-profile O -> R			
from (m)	to (m)	length (m)	*G*	from (m)	to (m)	length (m)	*G*
0,00	14,13	14,13	0	0,00	8,29	8,29	1
14,13	22,51	8,38	1	8,29	19,70	11,40	0,00
		G_{path}	0,37	19,70	46,90	27,21	0,00
						G_{path}	0,18

Table 289 — Determination of G_{path} (favourable) — Reflection

G-profile S -> O				*G*-profile O -> R			
from (m)	to (m)	length (m)	*G*	from (m)	to (m)	length (m)	*G*
0,00	14,13	14,13	0,0	0,00	9,62	9,62	1,0
14,13	22,51	8,38	1,0	9,62	21,02	11,40	0,0
		G_{path}	0,37	21,02	48,23	27,21	0,0
						G_{path}	0,20

Table 290 — Mean ground plane MGP and averaged ground factors (homogeneous) — Reflection

Parameter	S -> O_1	O_n -> R
a (MGP)	0,19	-0,05
b (MGP) in m	-1,17	2,80
z_1 in m	2,13	3,38
z_2 in m	1,94	4,72
d_p in m	22,86	46,90
G_{path}	0,37	0,18
G'_{path}	0,07	

Table 291 — Mean ground plane MGP and averaged ground factors (favourable) — Reflection

Parameter	S -> O_1	O_n -> R
a (MGP)	0,19	-0,06
b (MGP) in m	-1,17	3,41
z_1 in m	2,13	2,96

Table 291 *(continued)*

Parameter	S -> O_1	O_n -> R
z_2 in m	1,94	4,90
d_p in m	22,86	48,20
G_{path}	0,37	0,20
G'_{path}	0,07	

Table 292 — Coordinates of mirror points (homogeneous) — Reflection

Mirror points	*u* (m)	*v* (m)
S' (S -> O)	0,78	-3,19
R' (O -> R)	70,27	-5,43

Table 293 — Coordinates of mirror points (favourable) — Reflection

Mirror points	*u* (m)	*v* (m)
S' (S -> O)	0,78	-3,19
R' (O -> R)	70,14	-5,77

Table 294 — Calculation of the path length differences — Reflection

Parameter	S->R		S'->R		S->R'	
	(H)	(F)	(H)	(F)	(H)	(F)
No(O_1)	3	3	3	3	3	3
No(O_n)	4	3	4	3	4	3
d	70,80	70,82	70,33	70,34	70,56	70,49
d_{ss}	22,86	22,86	23,22	23,22	22,86	22,86
d_{sr}	46,92	48,24	46,92	48,24	47,59	48,84
e	1,33	0,00	1,33	0,00	1,33	0,00
δ	0,30	0,29	1,13	1,13	1,22	1,22

Table 295 — Determination of $A_{boundary,H}$ — Reflection

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000
$A_{dif(S,R)}$	7,18	8,71	10,80	13,49	17,00	21,36	25,56	29,08
$A_{ground,(S,O)}$	-1,01	-0,08	-0,75	-2,79	-2,79	-2,79	-2,79	-2,79
$A_{ground,(O,R)}$	-0,27	-0,94	-2,47	-2,47	-2,47	-2,47	-2,47	-2,47
$\Delta_{dif(S',R)}$	10,58	12,96	15,71	18,82	22,59	27,07	31,31	34,85
$\Delta_{dif(S,R')}$	10,80	13,22	15,98	19,11	22,88	27,37	31,61	35,15
$\Delta_{ground(S,O)}$	-0,70	-0,05	-0,43	-1,62	-1,58	-1,56	-1,55	-1,55
$\Delta_{ground(O,R)}$	-0,18	-0,57	-1,45	-1,38	-1,34	-1,32	-1,32	-1,32
A_{dif}	6,30	8,09	8,93	10,49	14,08	18,48	22,13	22,14
$A_{ground(S,R)}$	-	-	-	-	-	-	-	-
$A_{boundary,H}$	6,30	8,09	8,93	10,49	14,08	18,48	22,13	22,14

Table 296 — Determination of $A_{boundary,F}$ — Reflection

f in Hz	63	125	250	500	1 000	2 000	4 000	8 000
$\Delta_{dif(S,R)}$	7,12	8,61	10,62	13,02	15,69	18,52	21,44	24,40
$A_{ground,(S,O)}$	-0,95	-0,13	-1,10	-2,79	-2,79	-2,79	-2,79	-2,79