DOI: 10.61782/fa.2025.0718

FORUM ACUSTICUM EURONOISE 2025

QUALITY ASSURANCE AND MODELING LIMITATIONS IN NOISE EMISSION CONTROL USING ISO 9613-2 AND ISO 17534

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ABSTRACT

The calculation of noise emissions according to ISO 9613-2 is an established method for estimating sound propagation and serves as the foundation for noise emission control. However, the standard offers limited capabilities for modeling complex acoustic scenarios, particularly in accounting for sound transmission through obstacles such as walls and other semi-transparent objects.
Users of simulation software like SoundPLAN often aim for more detailed modeling to accurately represent specific properties of walls or other obstacles. These requirements go beyond the standardized assumptions of ISO 9613-2 and necessitate adaptations to the official calculation methods in the simulation software.
ISO 17534 provides an important framework for software quality assurance by ensuring transparency and comparability of the software products used. However, advanced modeling and calculation approaches, such as those for sound transmission, can compromise the comparability of results if standardized procedures are not established.
This contribution highlights the challenges and opportunities in modeling sound transmission through obstacles, the limitations of ISO 9613-2 in this context, and the role of ISO 17534 in ensuring the quality and validity of simulation results.

Keywords: *sound transmission, ISO 9613-2, quality assurance, A-QNS.*

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1. INTRODUCTION

In the area of noise prediction, software developers are confronted with a conflict between the requirements of quality assurance and the wishes of the users. On the one hand, the quality assurance process, in accordance with standards such as ISO 17534, requires that software solutions comply with standardized test tasks for specific regulations, such as ISO 9613-2, and deliver comparable results within a specified tolerance range. This ensures transparency, comparability, and consistency between different software products in terms of the calculated noise levels.
On the other hand, users are increasingly demanding more detailed and specific modeling that goes beyond the capabilities of existing standards. This includes, for example, the precise consideration of transmission through walls, reflections on slanted surfaces, the simulation of horizontal obstacles such as the roofs of gas stations, or the consideration of tunnel openings. These extensions, however, go beyond the scope of the standards defined in official test tasks and therefore fall outside the scope of standards-based quality assurance.
For software developers, this necessitates a delicate balance: there is the requirement to ensure compliance with standards and the comparability of results. At the same time, the commitment to meeting the practical needs of the users in order to enable realistic and practice-oriented simulations is essential. One approach is to develop optional, well-documented extensions that provide users with additional options without compromising standards-compliant quality assurance.

2. QUALITY ASSURANCE OF SOFTWARE FOR CALCULATING SOUND

The quality assurance of simulation software such as SoundPLAN does not entail the testing or validation of the quality or accuracy of official guidelines, including

ISO 9613-2 and similar standards. As a software developer, it is incumbent upon us to acknowledge the validity of the assumptions inherent in these standards. Any interrogation of these assumptions must therefore be confined to the standardization process. Once published, however, they are binding and are considered the established standard.

Instead, quality assurance focuses on ensuring that different software products with the same input scenarios produce identical results within a defined range of variations. This approach fosters the principles of comparability and consistency among various software solutions. This procedure is specified in ISO/TR 17534 Parts 1 and 2 and provides clear requirements for the verification and validation of calculation results.

For software developers, the existence of official test tasks for the calculation methods to be implemented constitutes a significant advantage. These are typically either provided directly by the creators of the guidelines or developed by specific committees.

Examples are the official test tasks for the German RLS-19, Schall 03 or the Scandinavian NORD2000, which are provided by the respective guideline authorities. Another possibility is test tasks developed by expert committees, as described in ISO/TR 17534 Parts 3 and 4 for ISO 9613-2:1996 and CNOSSOS-EU. In addition, the German Federal Environmental Agency (Umweltbundesamt) provides specific test tasks, e.g. for BUB - the German version of CNOSSOS-EU. Such standardized test tasks make implementation and quality assurance much easier, as they create a uniform basis for validating and comparing software solutions.

However, if no official tests are available, the need to resort to in-house testing arises. This means a lot of extra work, as these test scenarios must be developed and ideally checked by hand to ensure that the implementation is correct. This additional work is not only time-consuming but also carries the risk that the results are less comparable due to the lack of external reference values. In addition, there is always a risk that the same "errors of reasoning" or interpretations that were made when the rules and regulations were translated into software code will be made when the test items are developed internally, especially if this is done by the same person. Therefore, this should always be done by different people, further increasing the effort.

The A-QNS (Association for the Quality Assurance of Noise Propagation Software) was founded to ensure the quality, comparability and transparency of software products for sound immission prediction. The initiative arose from the growing need to establish binding standards and test procedures for the standard-compliant implementation of calculation methods such as ISO 9613-2, CNOSSOS-EU, RLS19 or Schall 03. The main reasons for its establishment were:

1. Ensure standards compliance:
   with the increasing number of sound calculation software products, the challenge has been to ensure that all programs implement the calculation guidelines correctly and consistently. A-QNS ensures that software products use the same input data to produce comparable results.
2. Promotion of transparency:
   in approval procedures, environmental impact assessments and other official processes, it is essential that the calculation results are comprehensible and trustworthy. The A-QNS provides an objective basis for the evaluation of software solutions through tests and certificates.
3. Development of test tasks:
   many standards and guidelines do not contain complete test tasks for software validation. The A-QNS is working on the creation of such tasks in order to be able to test software products independently. Examples include the validation of the acoustic reference model K1 according to RVS 04.02.11-2021 and ÖAL No. 28-2021.
4. Independent quality assurance:
   the establishment of an independent association has created a central body that performs quality assurance impartially and independently of individual software vendors.
5. Cooperation and standardization:
   The association promotes cooperation between software developers, users, authorities and standardization bodies in order to support the further development and standardization of calculation methods and test procedures.

The foundation of the A-QNS was therefore an important step towards creating a reliable basis for the development and testing of software in an increasingly complex technical and regulatory environment. The aim is to increase both user confidence and the acceptance of calculation results in legal and planning contexts.

3. MODELING BEYOND THE LIMITS OF THE STANDARD

Users of simulation software such as SoundPLAN often require more detailed modeling that goes beyond the standardized assumptions of ISO 9613-2:2024. The focus is on specific properties such as the transmission of sound through walls or other obstacles. There is also a desire for more detailed simulation of obstacles, for example to accurately account for reflections from slanted surfaces such as roofs or inclined walls. Another common simulation request concerns horizontal obstacles such as gas station roofs, bridges, or similar structures. This is where the ISO 9613-2:2024 guideline has its limitations, as it only takes into account diffraction above and to the side of objects but does not take into account underside diffraction. Reflections from such horizontal surfaces are also not considered in this standard, although they may play a role in practice.
To meet these partially justified user requirements, it is necessary to adapt the official calculation methods in the simulation software. However, this means that the calculated results are, strictly speaking, outside the calculation standard used and the scope of official quality assurance, since such extensions can be implemented differently by software developers.

4. EXTENSION EXAMPLE - TRANSMISSION THROUGH WALLS

A recurrent request received by software developers involves the extension of the calculation methodology for sound transmission through shielding objects such as walls. This subject is of particular pertinence to mobile noise control solutions in scenarios such as moving construction sites, temporary events, machine enclosures, noise protection cabins, room partitions, and demolition work. These applications necessitate the development of advanced models capable of accurately assessing sound transmission through a diverse range of often temporary obstacles. The existing calculation methods are often found to be insufficient and require further development of the methodology to achieve more realistic and reliable results.
To illustrate this point, this paper demonstrates the integration of this user requirement into the ISO 9613-2:2024 standard. It is important to acknowledge that ISO 9613-2:2024 calculates three paths from the source to the receiver when a screen edge intersects the line of sight between the two objects. These paths include the direct path over the screen edge and the path that goes around both sides of the screen (horizontal extension). The calculated barrier attenuation, D_z, is frequency-dependent and is largely determined by the difference between the direct sound path and the detour via the shielding edge (z).

$$D_z = 10lg\left[1+\left(2+\left(\frac{C_2}{\lambda}\right)C_3 z\right)K_{met}\right]dB \quad for\ z > z_{min} \tag{1}$$

For the lateral detours, K_{met} is set to one in the formula. In the subsequent step, the attenuation due to a barrier, including possible corrections (A_{bar}) for the three paths is calculated separately based on D_z. This results in a combined A_{bar} through energetic summation. To take the transmission of a wall into account, D_z of the vertical sound path must be adjusted. The calculation of the lateral paths around the obstacle and the basic procedure remains unchanged. Three different cases must be considered.

a) The line of sight between the source and receiver is not interrupted.
b) The line of sight between the source and receiver is interrupted by several screens.
c) The line of sight between the source and receiver is interrupted by one screen.

In the proposed extension of ISO 9613-2:2024 implemented in SoundPLANnoise, all three cases are considered and treated accordingly. This paper focuses on case c), with a screen that intersects the line of sight, which is the most relevant in practice. The following calculation steps are necessary:

1. Determination of a rubber band (connection between source and receiver) across the screen without taking into account the sound transmission. This results geometrically in z>0, d_{ss} and d_{sr} and finally the diffraction reduction, in this case called $D_{z,No,TL}$.
2. Determination of a multipath through the base of the screen, with z_{TL}, $d_{ss,TL}$ and $d_{sr,TL}$. Where z_{TL} takes values less than zero when the base point is below the line of sight. This results in the new diffraction reduction for the base point $D_{z,TL}$.
3. Considering the sound reduction index (R), the two diffraction reductions are then energetically combined to give the final D_z.

$$D_z = -10\log\left(10^{\left(-\frac{D_{z,No,TL}}{10}\right)} + 10^{\left(-\frac{D_{z,TL}-R}{10}\right)}\right) \tag{2}$$

This adjustment reduces D_z and takes into account the additional energy reaching the receiver through the screen. The calculation is performed for each frequency band and only minimally interferes with the basic ISO 9613-2:2024 procedure by adjusting D_z.

5. REAL APPLICATION: BUILDING SERVICES ON THE ROOF WITH ACOUSTIC BLINDS

Noise-intensive building services located on the roofs of buildings often cannot be completely enclosed due to the need for ventilation. In inner-city areas, this often leads to considerable noise pollution for residents and the surrounding area. In such cases, acoustic louvers are often used to reduce the noise sufficiently while ensuring air circulation at the same time. However, their acoustic performance is limited, particularly at low frequencies, where the low mass of the materials reduces their effectiveness. This type of noise control highlights the need for accurate modelling in order to more realistically estimate and optimize the sound insulation effect.

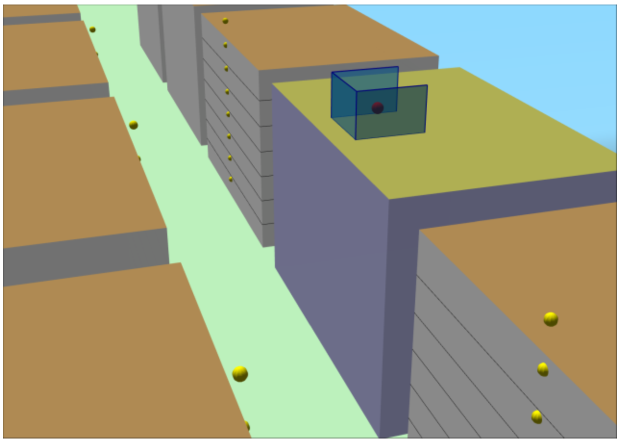

Figure 1. 3D-view of the acoustic model with the acoustic louvers around the noise source.

For the sound source, a spectrum from the literature was used that realistically describes the characteristic emissions for the application under consideration. In our example, a typical product with the following sound transmission loss was used for the acoustic louvers.

Table 1. Spectral sound transmission loss of the considered acoustic louvers.

Frequency [Hz]	125	250	500	1000	2000	4000
STL [dB]	5,0	8,0	9,0	12,0	9,0	7,0

As expected, the 'solid' wall variant with unlimited sound insulation (in accordance with the guidelines) results in significantly lower levels in the surrounding area than the variant with no wall. On the opposite façade, there is a reduction of between 8 and 19 dB, depending on the floor.

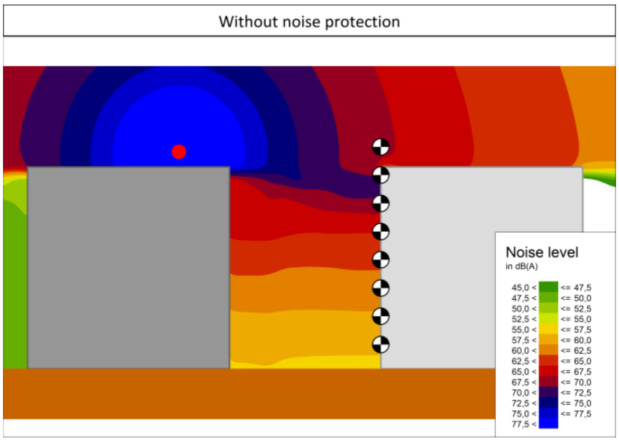

Figure 2. Noise dispersion in the cross-section without acoustic louvers.

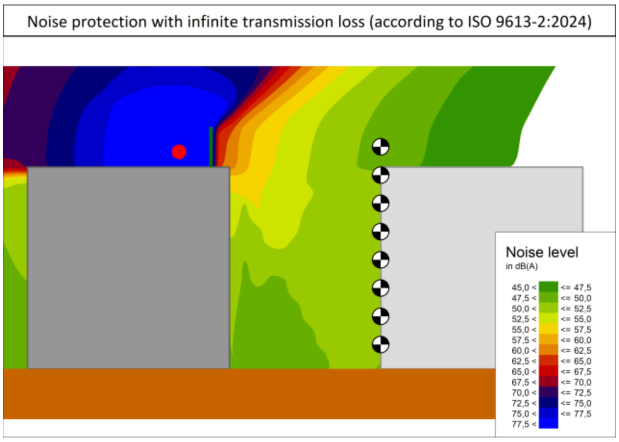

Figure 3. Noise dispersion in the cross-section with acoustic louvers (infinite transmission loss assumed).

The next variant was calculated using a wall with the real sound insulation of the acoustic louvers and the adapted algorithms. The resulting level reduction is only between 5 and 14 dB.

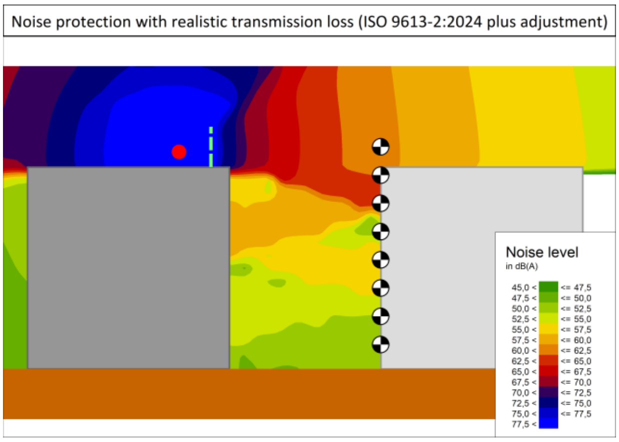

Figure 4. Noise dispersion in the cross-section with acoustic louvers (realistic transmission loss according to Table 1).

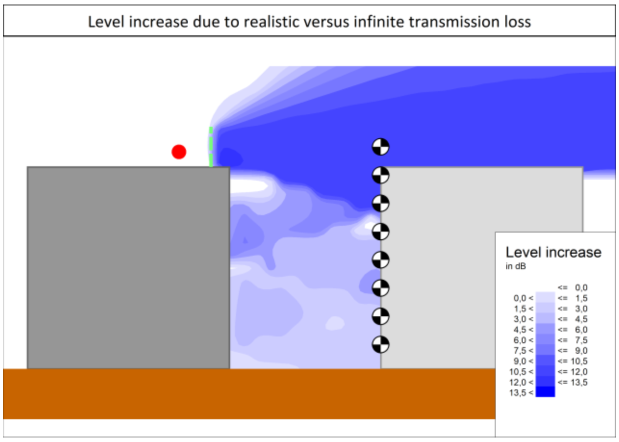

Figure 5. Noise level increase in the cross-section resulting from the realistic transmission loss of the acoustic louvers.

At some points, the passage of sound through the louvers will increase the level by up to 12 dB compared to a wall without a passage, while at other points it will be virtually 0 dB. The effect is highly dependent on height, as reflections play a significant role in this geometric situation. Above the roof, where there are no reflections, the reduction due to the semi-transparent wall is approximately 7 dB, which is roughly equivalent to the average sound reduction of the acoustic blinds.

The implemented extension of ISO 9613-2 in SoundPLANnoise allow for a more accurate modelling of the real acoustic conditions and emphasizes the importance of realistic sound insulation parameters in the simulation of special situations.

6. REAL APPLICATION: TEMPORARY NOISE PROTECTION MEASURES DURING CONSTRUCTION WORK

Construction work in urban areas often causes considerable noise pollution for residents and the surrounding area. Temporary noise barriers or curtains, which can be installed quickly, are an effective way of reducing noise. In the situation studied, work is carried out with a hammer drill on scaffolding attached to an external facade at a height of 11 m. The grey floorboards of the scaffolding are shown in the figure but were not considered in the noise simulation.

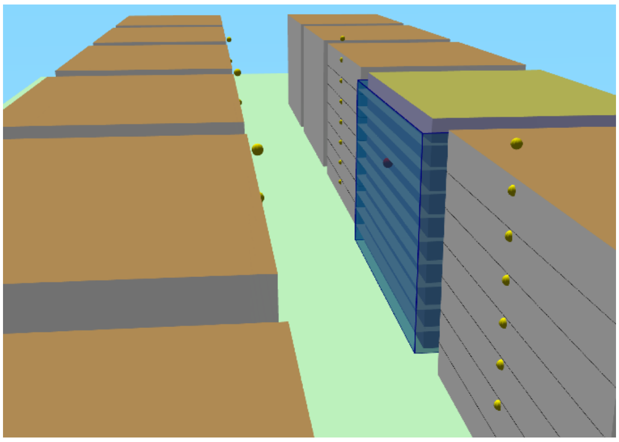

Figure 6. 3D-view of the acoustic model with the noise protection curtain around the scaffoldings.

The product CISILENT Typ L of Calenberg Ingenieure was used as sound insulation curtain. This mobile curtain has excellent acoustic properties, making it particularly suitable for temporary applications such as construction sites and events. Its sound absorbing and insulating properties offer an effective reduction of noise pollution in various application scenarios.

Table 2. Sound transmission loss of the sound insulation curtain.

Frequency [Hz]	125	250	500	1000	2000	4000
STL [dB]	13,2	15,5	17,6	19,0	20,0	24,0

At a computation height of 4 m above ground, there are large reductions of around 20 dB in the relevant area (e.g. road canyon). This result is to be expected, as the algorithm quickly reaches the maximum diffraction limit of 20 dB defined in the guideline due to the large extra path length.

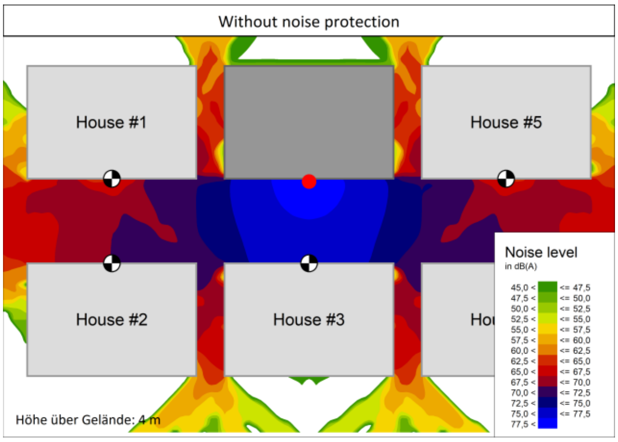

Figure 7. Noise dispersion without sound insulation curtains.

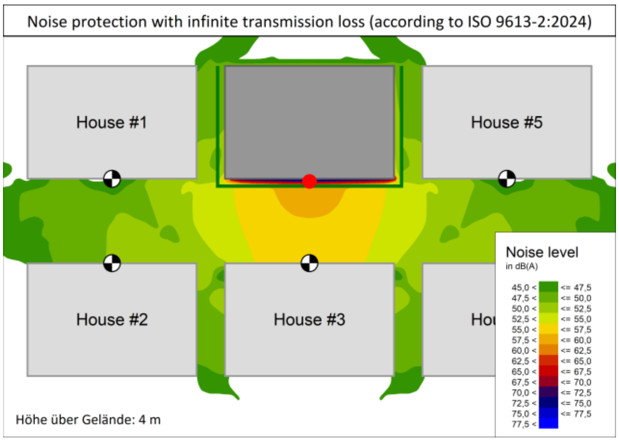

Figure 8. Noise dispersion with sound insulation curtains (infinite transmission loss assumed).

Additionally, there is a slight correction of the levels due to other sound paths, such as reflections and lateral paths. These effects contribute to the level reductions deviating slightly from the theoretical maximum but remain within the limits of the modelled calculation methodology. By adapting the ISO 9613-2:2024 algorithms in SoundPLANnoise to the real sound insulation, the following picture emerges. The level reduction is now about 19 dB. This result correlates very well with the real sound insulation of the noise barrier, considering that additional effects such as reflections and diffracted sound paths can occur.

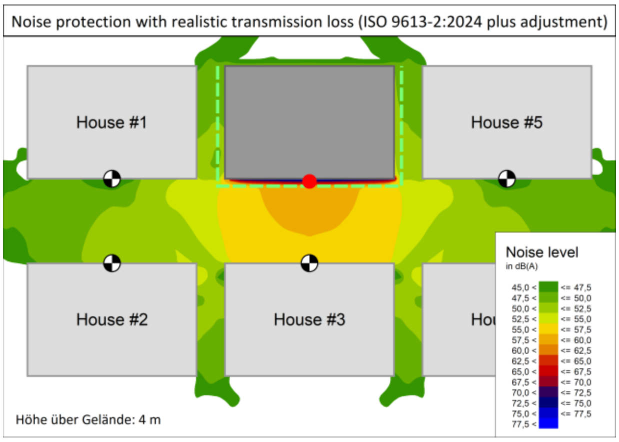

Figure 9. Noise dispersion with sound insulation curtains (realistic transmission loss according to Table 2).

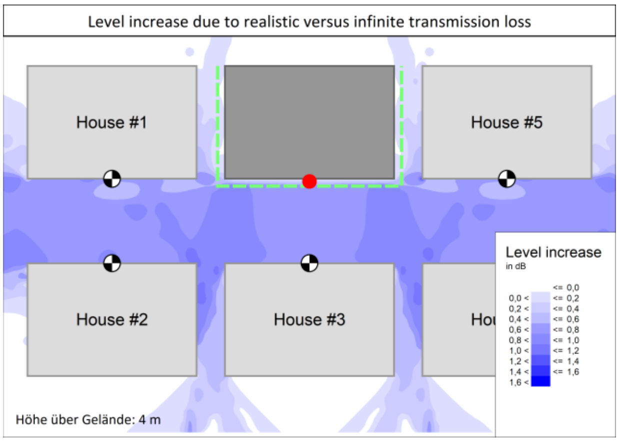

Figure 10. Noise level increase resulting from the realistic transmission loss of the sound insulation curtains.

The proposed adaptation of ISO 9613-2:2024 allows also in this case a more accurate modelling of the real acoustic conditions. In this case, however, the change in predicted results is rather small, around 1 dB, and has very little impact on the results. This is due to the high sound attenuation of the product used, which is close to the maximum diffraction limit of 20 dB.

7. CONCLUSION

The tested extension of ISO 9613-2:2024 by an additional term for the consideration of the sound insulation of walls leads to qualitatively meaningful results. It should only be used by the assessor/acoustician on a case-by-case basis, as the changes in the results are only relevant if the sound insulation is below the maximum diffraction limit of 20 dB. In such cases, a result can be calculated that is a much better estimation of the reality, as otherwise the level reduction would be overestimated by the assessor and complaints could later be made due to excessive noise pollution. Despite the successful extension of ISO 9613-2:2024 in SoundPLANnoise to include an additional term to account for sound insulation, comparability between different software products remains a key challenge. To address this issue from a quality assurance perspective, the following actions are critical:

1. Transparent quality assurance by the software developer:
   the software developer should clearly document which internal and external quality assurance measures are performed. This information should be openly available to users and should include an overview of the test tasks performed.
2. Documentation by assessors:
   assessors should document the software used in their reports, including the version number and quality checks performed. If the calculation settings differ from those recommended by the software developer, it should be noted.
3. Declaration of standard deviations:
   if objects or methods are used in the calculation models that exceed the limits of the standards, this should be clearly indicated and justified in the documentation of the results by both the software developers and the expert.

In addition, software developers should work together to fill gaps in existing standards and to address user requirements in a unified approach. This could be done through committees such as ISO/TC 43/SC 1/WG 56 or the A-QNS group. A revision of the propagation guidelines could also be used to make progress. However, it has been shown that such committees often work slowly and have to deal with conflicting interests, which makes quick innovations difficult. Regardless, it is essential that all interested parties have access to relevant information and documentation to ensure fair competition, transparency and comparability.

8. REFERENCES

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