# SOPRANOISE – in-situ inspection procedure for airborne sound insulation properties of existing noise barriers

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**Abstract**
In the frame of the SOPRANOISE project (funded by CEDR in the Transnational Road Research Programme 2018), the goal of work package 3 was to develop an in-situ inspection procedure which exploits the possibilities of visual examinations to obtain first indications on the effect of degradations on the airborne sound insulation of existing noise barriers. Based on a review – including a survey among CEDR member states – and a simplified theoretical framework, an acoustic inspection protocol has been designed, which allows a quick assessment of possible effects of leaks on the airborne sound insulation of noise barriers. After filling in the protocol, an estimation of the consequences of detected leaks is given. Depending on the properties and position of the leak, a "critical radius of influence" is calculated, up to which the leak has a non-negligible effect on the airborne sound insulation, and an acoustic rating is indicated. From this quick assessment, it is possible to evaluate where it is advisable to apply further testing, i.e. either by using a "quick" measurement (also developed by SOPRANOISE) or measurements according to the standards EN 1793.

**Keywords:** noise barrier, performance, degradation, inspection, EN 1793.

## 1 Introduction

EN 1793-5 [1] and -6 [2] are the relevant European standards for characterizing the intrinsic sound absorption and airborne sound insulation performance of noise barriers under direct sound field conditions. However, they require expert users and rather lengthy tests which could also be affected by practical limitations (e.g. weather conditions, safety, accessibility…). This can limit their use alongside roads. To facilitate the acoustical investigation of noise barriers, both "quick measurement methods" (being easier, faster and safer than the full methods according to the standards) and qualitative in-situ inspections procedures can provide important additions.

Thus, in order to improve the characterisation and systematic control of the acoustic performance of a noise barrier, the SOPRANOISE project pursues a progressive approach consisting of three steps: (1) in-situ inspections, (2) quick measurement methods and (3) full measurement methods according to EN 1793-5 [1] and -6 [2]. The present manuscript summarises the outcomes of work package 3 (WP 3). The main goal of WP 3 was to elaborate step (1), to demonstrate up to what extent in-situ inspections can yield fair indications on the acoustic performances of installed noise barriers and to establish an inspection method for the qualitative assessment of the possible effect of degradations in noise barriers.

It is important to note that the inspection tool described here is not intended to be used for the legal approval of newly built noise barriers, as this can occur only if quantitative measurements are carried out.

WP 3 started off with a review of existing inspection tools and procedures. A questionnaire was circulated among the CEDR member states (covering European Road Authorities and Research Institutes) to gather information about existing inspection routines and knowledge/experiences on different aspects of the acoustic performance of noise barriers. See Section 2.

After defining the demands on the inspection method, the development process began. This is presented in Section 3. Originating from a simplified theoretical approach, an approximative calculation method was implemented. In a subsequent testing phase, the resulting acoustic inspection protocol has proven to yield a clear and realistic approximation of the degradation effect due to leaks in a noise barrier. Moreover, the overall effect of changes in the airborne sound insulation as well as in the sound absorption was examined in several specific scenario calculations, which qualitatively underline the importance of a constant high value for the insertion loss of a noise barrier during its lifetime.

In a last step, the scope for the application of the in-situ inspection procedure was defined – see Section 4 – and the relevant user-oriented documents, including all information necessary to carry out and understand and apply the inspection procedure, were drafted.

# 2 Review of existing in-situ inspection tools

To review the assessment procedures existing in different countries, a questionnaire was set up and sent to the European Road Authorities and Research Institutes. The questions were supposed to retrieve the knowledge and experiences on different aspects of the acoustic performance of existing noise barriers, and see how and to which extent noise barrier inspections are already carried out – in particular considering acoustical aspects. More concretely, the relevant questions addressed the following topics:

- Theoretical models for noise barriers describing the impact of defects on sound insulation and absorption or other investigations, which allow conclusions about the intrinsic properties of noise barriers based on the description of defects.
- Acoustic investigations on damaged/aged noise barriers or databases, in which information about the performance (loss) of damaged/aged noise barriers can be extracted.
- Procedures/best-practices for a first visual/aural inspection of old noise barriers and corresponding assessment methods.

## 2.1 Existing inspection routines

The results of the review (covering the answers to the questionnaire and a literature study) are briefly summarised in Table 1. It became evident that in general there is a large interest of having an assessment method for a structured maintenance of noise barriers, in order to achieve a long lifecycle and ensure a high acoustic performance.

Databases of road buildings including noise barriers exist in some countries and rudimental information about the acoustic characteristics is provided therein. Yet, details on the acoustic performance or current acoustic condition are lacking.

Table 1 – Summary of existing in-situ inspection tools

| Country | Database (incl. acoustics?) | Monitoring | Evaluation of condition | Special attention to current acoustical state |
|---|---|---|---|---|
| CEDR | N/A | An inspection of newly built NB for acceptance and a frequent monitoring is required. | N/A | Investigations on the effect of defects are mentioned. |
| Germany | Extensive database of all road buildings, including all building parts of the structure, characteristics (also acoustical), individually definable queries, statistical analysis of overall data with data output. Reports. Photos. | Continuously. Different frequency dependent on complexity of inspection. According to DIN 1076. Catalogue of defects for harmonisation. | Automated evaluation by algorithm after detection of defects (incl. number and extent). Score from 1,0 to 4,0 (one decimal place). Output: Assigned period of time to resolve defect dependent on score. | N/A |
| Wallonia | Database of existing NB, including acoustic characteristics. Reports. Photos. | Continuously. Different frequency dependent on complexity of inspection. "Illustration of the defects" for harmonisation. | Appraisal into a four-step "Health indicator" (A-D) by inspector after data check. Tools for statistical analysis of defects. Visual overview of occurance of defects. | N/A |
| Flanders | N/A | Frequently every two years by drive-along inspections (70km/h). | N/A | N/A |
| Estonia | Database of existing NB, including acoustic characteristics. | Frequently every four years. Definitions to identify condition state (1-4) for different material. | Formula to calculate a condition Index (0-100%) as composition of every single element unit. | Frequent measurements are intended. |
| Austria | N/A | N/A | By calculations and statistics together with measurements according to EN 1793-5, -6. | Quick method for assessing the acoustical state of a whole NB section. |
| Sweden | N/A | Frequently every year. | N/A | Investigations on the effect of defects have been carried out. |
| Ireland | Database of existing NB, including acoustic characteristics. | N/A | Traffic light system for categorisation of state (green, yellow, red). | Recently started and ongoing investigations on used NB. |
| Switzerland | N/A | Frequently every ~5 years. Documentation of typical defects. | 5 (6 with "no record") level to determine the acoustical state of the NB (very good, good, acceptable, bad, very bad). | Yes. Calculations or measurements are carried out if state of NB is bad or very bad. Investigation on the effect of defects have been carried out. |

Regular inspections of noise barriers are being carried out in most countries and different procedures for an evaluation of their condition are generally available. However, these inspections mainly cover stability and safety issues and do not have a specific focus on the acoustic performance. Several countries are setting up more elaborate inspection procedures since a few years to have a better basis for managing the maintenance of their noise barriers.

Theoretical models describing the impact of leaks on airborne sound insulation and/or sound absorption are unknown and not used by the European Road Authorities. Regarding the effect of leaks and recommendations on inspections and monitoring, the CEDR technical report from 2017 [3] has been frequently referred to by the participants of the questionnaire.

## 2.2 Requirements for an in-situ inspection

The aspects from the review were considered in order to frame a profile of requirements for an acoustic assessment based on visual inspections on site. These considerations formed the starting point for the development of the in-situ inspection procedure:

- An in-situ inspection of the acoustic performance has to be conceptualized as an add-on in a way that it can be **implemented into existing inspection procedures** and be in accordance with the inspection regulations with respect to frequency, categorisation, reporting etc.
- The basic recommendations and information published in the CEDR technical report from 2017 [3] are of high value for inspectors of noise barriers. The **list of key areas** for visual inspections serves as a good basis for localising damages relevant for the assessment of the acoustic performance of a noise barrier.
- The inspection is supposed to yield a **first approximate estimation** about the possible degradation of the acoustic performance of a noise barrier **without carrying out actual acoustic measurements**. It is meant to represent the first step (out of three) for giving a first evaluation of possible degradations

of the airborne sound insulation and clarify which noise barrier sections have to be investigated further on in more detail by measurements.

- The required **effort** for the inspection should be **minimal** and **no additional tools** should be required. All relevant aspects for the acoustic assessment should be filled out directly on site.
- A common feature in the inspection procedures is the **categorisation of the noise barrier condition** into different levels with different action plans, depending on the degree of damage or degradation. This concept is transferred to the in-situ inspection procedure proposed here.
- The basis for the qualitative assessment should be provided by a **physical approach**, allowing to approximate the acoustic consequences of leaks in a noise barrier.

# 3 Implementation and testing of the in-situ inspection procedure

The acoustic inspection protocol is implemented as an *Excel* document, consisting of five worksheets. When performing a noise barrier inspection, the inspector can use this *Excel* document on site to assess the acoustic condition of the noise barrier. After filling in all detected leaks and damages, it immediately returns the result of a first acoustic evaluation: depending on the properties and position of the leak, the so-called "critical radius" will be calculated. This defines the critical area, in which the leaks have a non-negligible effect. Correspondingly, a "traffic light" rating is assigned to each inspected noise barrier field, where green means "acceptable acoustic condition", yellow represents "questionable acoustic condition" and red means "acoustically defective".

## 3.1 Theoretical background of the acoustic assessment

The calculation of the critical radius behind a leak in a noise barrier and the corresponding acoustic (traffic light) rating are based on an extended sound propagation model – fully presented in the SOPRANOISE deliverable D2.2 [4].

In the presence of a leak, an acoustical critical area behind the noise barrier is formed, in which the influence of the transmission through leak (described by the sound level $L_{m,t}$) is dominant over the diffraction across the top of the barrier (described by the sound level $L_{m,b}$). In this area the sound insulation of the barrier is reduced significantly. Beyond this area, the effect from the leak is negligible and the reduction of the sound insulation is not critical any more. The criticality condition $\xi$ reads

$$\xi = L_{m,t} - L_{m,b} + 10 \text{ dB}. \qquad (1)$$

For $\xi > 0$ dB the specific receiver point lies within the acoustical critical area, where the diminished sound insulation due to the leak is relevant. For $\xi < 0$ dB the presence of the leak has no significant influence on the sound immission. In other words, the condition $\xi = 0$ defines the border (or radius) of the critical area with dominant impact of the leak. See Figure 1.

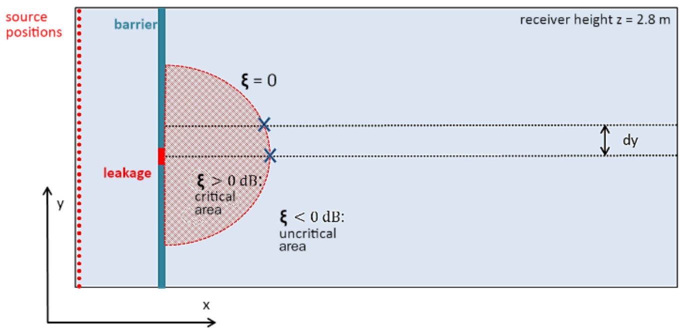



Figure 1 – Illustration of the acoustical critical area behind a noise barrier with a leak

In order to model the transmission through a barrier induced by a leak, the formulas found in the German guidelines for noise protection at roads (RLS-90) [5] were used and extended. In short, the general idea is that the leak is regarded as a point source which is "fed" by a line source (road). This point source emits a hemispherical sound wave into the area behind the barrier. The sound power of its contribution is reduced according to the transmission loss caused when passing through the barrier. The detailed contributions to $L_{m,b}$ and $L_{m,t}$ are stated in the SOPRANOISE deliverable D2.2 [4].

The underlying geometry for the calculation of the critical radius is shown in Figure 2 as a side view. For a better practicability, some simplifications are made:

- Only the closest lane to the noise barrier is considered as emission sound source, situated at 0.5 m above the ground.
- The noise barrier is situated at a distance of 7.6 m from the centre of this lane. In cases without emergency lane this distance reduces to 5.1 m.
- A two-dimensional description is chosen, i.e. source, leak and receiver are assumed to be in line perpendicular to each other.
- The receiver is assumed to be at 2.8 m above the ground.

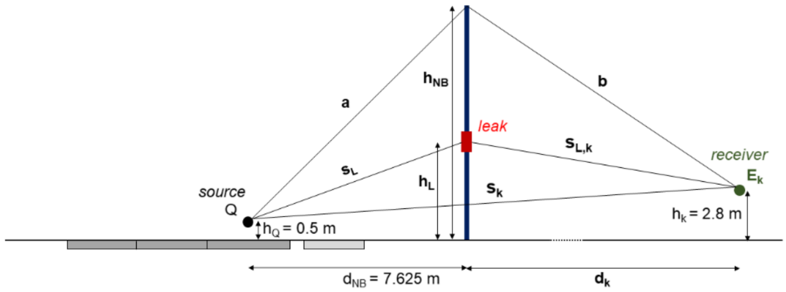



Figure 2 - Underlying geometry for the calculation of the critical radius

By exploiting the underlying geometry within the approach of the criticality condition, the problem is reduced to one unknown variable and can be solved numerically. As a measure for the acoustical severity of a leak, the so-called critical radius is obtained. For the full derivation of how the critical radius is calculated, the interested reader is referred to the SOPRANOISE deliverable D3.1 [6].

It is important to remember that the result of the acoustic inspection is not supposed to be exact and cannot substitute measurements, because it relies on several assumptions and does have a large uncertainty. Instead, it yields a first estimation of the acoustical consequences of a leak and suggests where it is advisable to measure. A reproduction of the exact geometry on site is not expedient and will not yield notable improvements of the acoustic assessment via the inspection.

### 3.2 Superposition of leaks

The theoretical calculation model is formulated for the case of a single leak in a noise barrier. Generally, more than one damage can occur at a noise barrier. Several leaks might be located within the same noise barrier field (e.g. horizontal acoustic elements with missing sealings one above the other) or close to one another, affecting neighbouring noise barrier fields.

In these cases, the critical radius and acoustic rating calculated for an individual leak is of limited significance. It gives a measure for the acoustic degradation due to this specific leak, but it does not yield a correct overall acoustic assessment at the respective noise barrier field if surrounding leaks are not considered. To close this gap in the acoustic assessment, a superposition of the effect from several neighbouring leaks is included. This superposition is based on a weighting function for the summation of the critical radii of different leaks in dependence of their distance to one another.

### 3.3 Overall effects of degradation on sound propagation

A more global approach within a simple sound propagation model has been applied to investigate the effect of the intrinsic properties of noise barriers on the sound immission level behind and in front of the noise barrier. The sound pressure level behind a noise barrier was calculated for varying sound reduction index R to model the influence of the degradation of the transmission loss on the acoustic performance. Changes in the reflection loss RL were considered in three distinct situations: **(1)** for the case of a single noise barrier (acting as a partial reflector), **(2)** adding an additional second noise barrier (acting as a shield by assuming an infinite transmission loss) in parallel to the (partially) reflecting noise barrier of case (1), and **(3)** (multiple) reflections between a noise barrier and lorries passing by, since these have an influence on the noise level behind the barrier.[1]

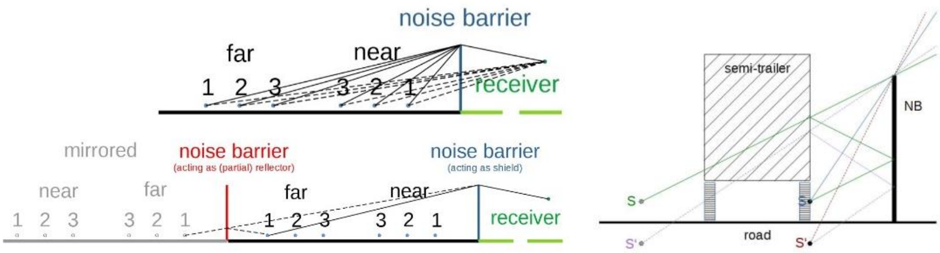



Figure 3 – Sketch of the scenarios for the investigation of the overall effects of degradation

The calculations show that the effect of losing transmission loss (e.g. due to aging or small holes) can be regarded as minor problem far away from a noise barrier of moderate height. However, for high noise barriers, changes of the transmission loss can cause a serious problem, also far away from the noise barrier. The higher the noise barrier, the more important is a constant high transmission loss over the lifetime of the noise barrier.

The consequences of degradations in the reflection loss of a noise barrier for its overall acoustical performance are also essential. The investigations show that with decreasing reflection loss, the level in front of the noise barrier is increasing. This increase can amount to a maximum value of 3 dB in the limit of infinite distance of the receiver (doubling of the noise source), For multiple traffic lanes this behaviour is comparable.

In the presence of an additional parallel noise barrier, acting as a full shield, the height of this shielding noise barrier also plays a role. The higher the additional shielding noise barrier on the other side of the road (in parallel to the original noise barrier, see Figure 3), the more important is a constant high reflection loss over the lifetime of the original noise barrier. In other words, if the shielding noise barrier is low, a decrease of the reflection loss will not have a significant effect on its acoustical performance. Regarding multiple lanes (e.g. broad motorways), the model has shown that the influence of a diminishing reflection loss over time is less, but also gains importance with increasing height of a shielding noise barrier.

Further scenario calculations show that for the special case of multiple reflections between the dolly of an articulated lorry and the noise barrier, significant effects occur under certain conditions. If the noise barrier is of comparable height with the dolly, the reflection loss of the noise barrier will be relevant for the sound pressure level behind the noise barrier. Considering multiple lanes, reflections between noise barrier and lorries have a lower effect on the sound pressure level behind the noise barrier: only noise barriers with low reflection loss (as the usual sound reflective barriers are) have a noteworthy effect on the noise level behind the noise barrier. Generally, the pass-by sound level (especially for heavy vehicles) of course also depends also on the temporal and the spectral dimensions (time t and frequency f).

All in all, the investigations on the interplay between the intrinsic barrier properties and the sound immission level behind and in front of the noise barrier have shown which scenarios are acoustically relevant in the case of damaged or aged barrier conditions.

[1] The terms "behind" and "in front" of the noise barrier are used with respect to the side of the road traffic. In other words, by "behind" we refer to the "shielded zone" and by "in front" we refer to the "unshielded zone".

### 3.4 Description of the in-situ acoustic inspection protocol

The general information about the location (road name, direction, coordinates etc.) of the noise barrier is entered on the first sheet **'Location'** (cf. Figure 4), mainly as free text. Except for the information about the emergency lane, all inputs here are for identification purposes only.

All Information on the materials used in the design of the noise barrier are protocolled in the second sheet **'Construction'** (cf. Figure 4). The calculation itself is independent from the inputs made in this sheet. However, records on the noise barrier construction might be helpful for further investigations or cause studies.

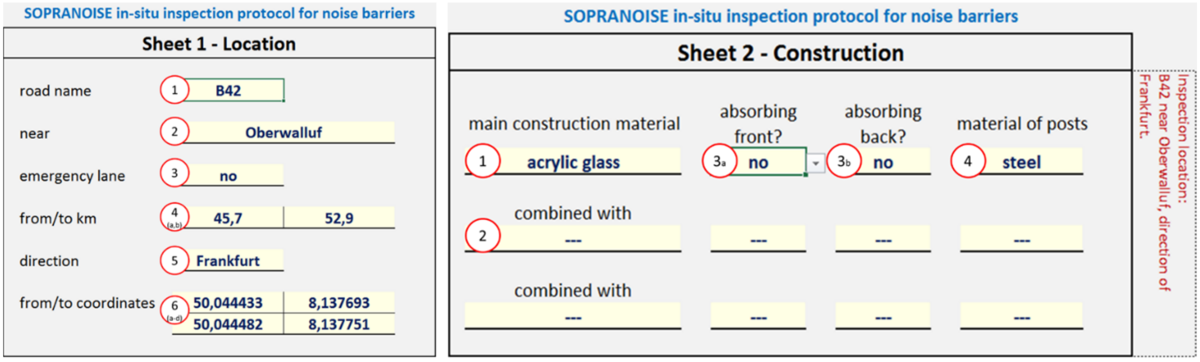
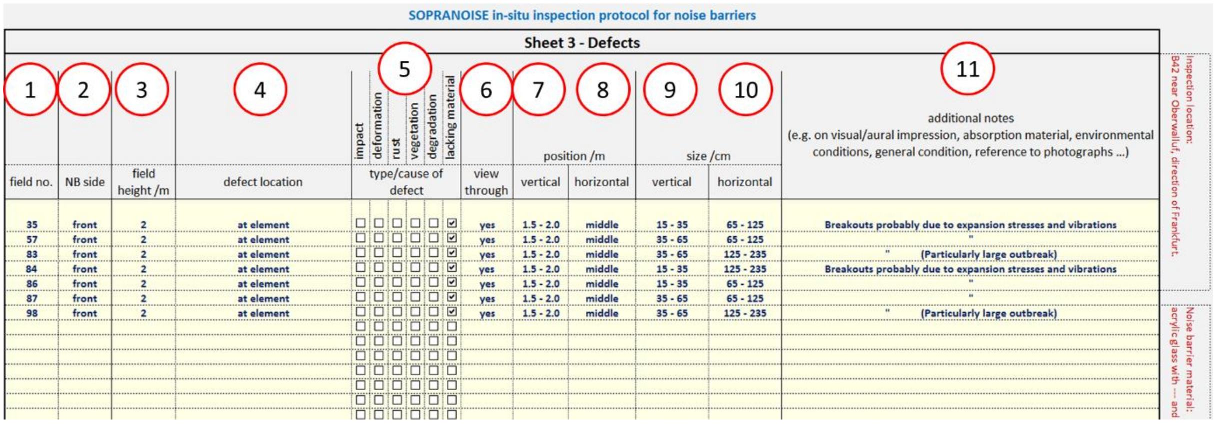



Figure 4 – First and second input sheet 'Location' and 'Construction' with exemplary entries

The third sheet **'Defects'** (cf. Figure 5) is the central input sheet of the in-situ acoustic inspection protocol. All information on the detected defects (barrier field height, position and size of the leak, transparency etc.) are filled in here. The table allows to record up to 50 different defects. Most inputs have to be selected from a dropdown list or via check boxes. This makes the actual inspection process faster and easier to handle on site.


SOPRANOISE in-situ inspection protocol for noise barriers

Sheet 3 - Defects

| 1 field no. | 2 NB side | 3 field height /m | 4 defect location | 5 type/cause of defect: impact | deformation | rust | vegetation | degradation | lacking material | 6 view through | 7 position /m vertical | 8 position /m horizontal | 9 size /cm vertical | 10 size /cm horizontal | 11 additional notes (e.g. on visual/aural impression, absorption material, environmental conditions, general condition, reference to photographs ...) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 35 | front | 2 | at element | ☐ | ☐ | ☐ | ☐ | ☐ | ☑ | yes | 1.5 - 2.0 | middle | 15 - 35 | 65 - 125 | Breakouts probably due to expansion stresses and vibrations |
| 57 | front | 2 | at element | ☐ | ☐ | ☐ | ☐ | ☐ | ☑ | yes | 1.5 - 2.0 | middle | 35 - 65 | 65 - 125 | " |
| 83 | front | 2 | at element | ☐ | ☐ | ☐ | ☐ | ☐ | ☑ | yes | 1.5 - 2.0 | middle | 35 - 65 | 125 - 235 | " (Particularly large outbreak) |
| 84 | front | 2 | at element | ☐ | ☐ | ☐ | ☐ | ☐ | ☑ | yes | 1.5 - 2.0 | middle | 15 - 35 | 125 - 235 | Breakouts probably due to expansion stresses and vibrations |
| 86 | front | 2 | at element | ☐ | ☐ | ☐ | ☐ | ☐ | ☑ | yes | 1.5 - 2.0 | middle | 15 - 35 | 65 - 125 | " |
| 87 | front | 2 | at element | ☐ | ☐ | ☐ | ☐ | ☐ | ☑ | yes | 1.5 - 2.0 | middle | 35 - 65 | 65 - 125 | " |
| 98 | front | 2 | at element | ☐ | ☐ | ☐ | ☐ | ☐ | ☑ | yes | 1.5 - 2.0 | middle | 35 - 65 | 125 - 235 | " (Particularly large outbreak) |

Inspection location: B42 near Oberwalluf, direction of Frankfurt.
Noise barrier material: acrylic glass with --- and

Figure 5 – Third input sheet 'Defects' with exemplary entries

The fourth sheet **'Acoustic assessment'** (cf. Figure 6) presents the result of the acoustic inspection and is a pure output sheet, where each considered noise barrier field is listed with the assessed acoustic condition and a critical radius of influence. Two different types of acoustic assessment are included: on the left, the result of the calculation is given for each noise barrier field individually. From this, the severity (in the acoustic sense) of a single leak becomes evident. For a comprehensive overall acoustic assessment, the superposition of leaks close to each other has to be considered. An approximation for such an overall assessment is given on the right of the 'Acoustic assessment' sheet.

SOPRANOISE in-situ inspection protocol for noise barriers

**Sheet 4 - Acoustic assessment**

| Assessment for each NB field individually | | | Estimated overall assessment (superposition) | | |
|---|---|---|---|---|---|
| field no. | acoustic condition | critical radius /m | field no. | acoustic condition | critical radius /m |
| 35 | G | 5 | 35 | G | 5 |
| 57 | G | 9 | 57 | G | 9 |
| 83 | Q | 17 | 83 | Q | 33 |
| 84 | G | 8 | 84 | Q | 34 |
| 86 | G | 3 | 86 | Q | 32 |
| 87 | G | 9 | 87 | Q | 29 |
| 98 | Q | 17 | 98 | Q | 17 |
| | | | | | 0 |
| | | | | | 0 |
| | | | | | 0 |
| | | | | | 0 |

Inspection location:
B42 near Oberwalluf, direction of Frankfurt.

Figure 6 – Fourth sheet 'Acoustic assessment' with exemplary output results

The traffic light rating of the acoustic condition is based on the inspection inputs made on the first three sheets. The meaning of the colours is as follows:

- Green = acceptable acoustic condition, non-priority actions required for airborne sound insulation. No conclusion possible for sound absorption.
- Yellow = questionable acoustic condition, further testing could be required for assessing the effective airborne sound insulation (e.g. passing on to quick measurement method).
- Red = defective acoustic condition regarding airborne sound insulation, repairing required.

In the fifth and last sheet **'Settings'**, the inspector has the possibility to change a few global parameters. In general, modifications are not necessary here, since the default values serve as a good approximation within the accuracy of the method. Nevertheless, in exceptional cases it can be useful to change some of the global settings. The customisable parameters are: size of the noise barrier field, thresholds specifying the trigger values of the critical radius for the acoustic traffic light rating, distance from the noise barrier to the first traffic lane, for the case with and without emergency lane in between.

### 3.5 Testing of the in-situ acoustic inspection protocol

From June to October 2020, acoustic in-situ inspections of noise barriers in the federal states of North Rhine-Westphalia, Baden-Württemberg and Hesse were carried out. One of these inspections was part of a planned regular inspection. Long sections of motorways were investigated and searched for damages at noise barriers. Apart from this, we also received information on the specific location of damaged noise barriers from road authorities. We were allowed to accompany one of the regular inspections and carry out the acoustic assessment with the inspection protocol developed herein.

The test inspections showed and confirmed that through-holes in noise barriers with a size in the single-digit centimetre range have only minor acoustic consequences, even though they appear to be visually conspicuous. Here, the results obtained with the *acoustic* in-situ inspection protocol confirmed the impressions gathered during the visual and aural inspections. Even at distances of less than one metre, where vehicles driving on the motorway could be seen through the holes, no level increase was perceived aurally compared to the basic noise level. Only for holes with a length of 20 cm to 30 cm, level increases could be heard directly behind the noise barrier. But even holes of this larger size, if they occur individually and isolated, have a negligible level-increasing effect at a distance of several metres behind the barrier. Yet, when such damages or defects occur regularly, for example due to subsidence of the soil over several noise barrier fields, they can be perceived aurally and/or evaluated analytically even at greater distances.

# 4 User documents and scope

Two descriptive documents were created to accompany the inspection protocol itself and provide all information necessary to carry out and understand the inspection procedure. The manual is a step-by-step instruction (including an example and screenshots) of how to fill in the inspection protocol, and the short description explains the theoretical background of the calculation and the functionality of the different parts of the Excel protocol file. Potential inspectors should always have access to these documents to ensure a regular execution of the method and a correct understanding of the results. Both the manual and the short description are included in the SOPRANOISE deliverable D3.1 [7].

The scope of application for the SORPANOISE 3-step approach is summarised in Figure 7**Fehler! Verweisquelle konnte nicht gefunden werden.**. Initially, it is necessary to define the reason for the planned noise barrier investigation. For the approval of a newly built noise barrier (i.e. for legal reasons which require quantified values of intrinsic characteristics $DL_{RI}$ and $DL_{SI}$), the only way is to carry out measurements according to the EN 1793 standards.

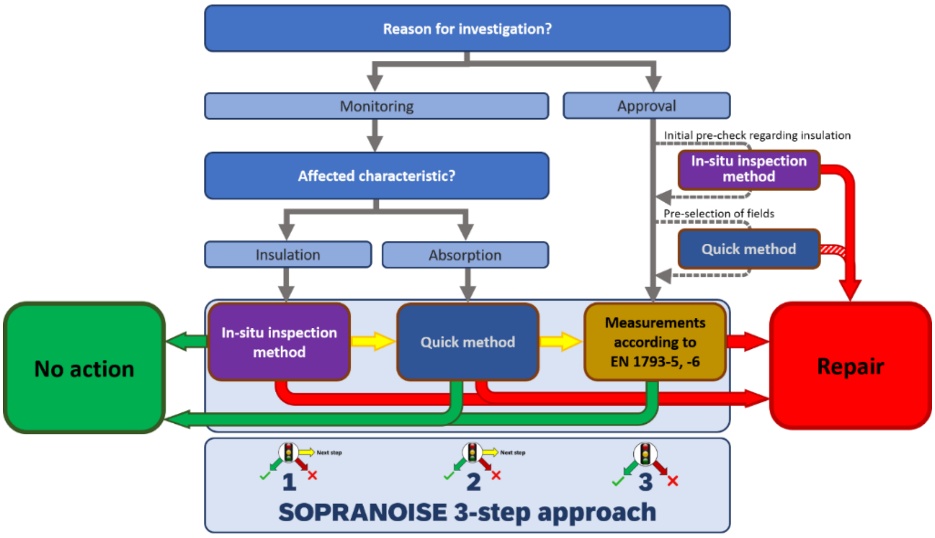



Figure 7 – Flow chart visualising the scope of the SOPRANOISE 3-step approach

Since approvals according to EN 1793 standards can be expensive and time-consuming – especially for long noise barriers – it is advisable to first carry out in-situ inspections and/or measurements via the quick method. With the in-situ inspection, apparent defects can be found and directly rejected, and sampling via the quick method also allows a fair pre-selection of relevant locations for the actual approval.

The 3-step approach comes into action when a noise barrier investigation is planned within a monitoring process of an existing noise barrier. For the evaluation of sound absorption properties, it is unavoidable to carry out acoustic measurements via the quick method (step 2). No conclusions about the degradation of sound absorption characteristics can be drawn from in-situ inspections only. The purpose of in-situ inspections (step 1) is to obtain useful indications and spot out major defects, in order to deliver a very quick and relevant estimation of the degradation of the insertion loss of the noise barrier (due to a diminished sound insulation). This facilitates the follow-up monitoring and maintenance of installed noise barriers, considering its insertion loss performance. In-situ inspections do not give a quantitative value of airborne sound insulation. The acoustic rating obtained via the in-situ inspection method identifies defects with negligible consequences for the insertion loss (green rating), defects which surely have to be repaired (red rating) and defects which require an actual assessment via acoustic measurements (yellow rating). This case establishes the transition to step 2, i.e. the quick measurement method, which will be the output of WP 4 of SOPRANOISE.

# 5 Conclusions

The SOPRANOISE 3-step approach optimises the assessment of the acoustic performance of noise barriers by exploiting a progressive evaluation strategy. The different stages of the method come into play under well-defined conditions and thereby help to realise much more systematic tests, improve the understanding of acoustic performance losses and consequently the sustainability of noise barriers. However, it is important to note that neither the in-situ inspection procedure nor the quick measurement method can substitute the conformity test according to the EN 1793 standards.

With the completion of WP 3 of the SOPRANOISE project, the first stage of the progressive 3-step approach is fully developed. The result is a practice-oriented in-situ inspection procedure for the approximation of the degradation effect in the acoustic insertion loss of a noise barrier due to leaks. Its potential and features are: (1) a simple and fast application, (2) easy to integrate into existing inspection procedures, (3) a physics-based approach, (4) a well-defined scope of application, and (5) a clear and transparent documentation for users.

In the remaining tasks of the SOPRANOISE project, further practical testing will be carried out in parallel to the application of the quick measurement method in WP 4. This will elucidate the connection between both steps and see how the inspection results can indicate the preferred locations for the application of the quick method.

# Acknowledgements

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# References

[1] CEN, European Standard EN 1793-5:2016+AC:2018: *Road traffic noise reducing devices - Test method for determining the acoustic performance - Part 5: Intrinsic characteristics - In situ values of sound reflection under direct sound field conditions*, 2018.

[2] CEN, European Standard EN 1793-6:2018: *Road traffic noise reducing devices - Test method for determining the acoustic performance - Part 6: In situ values of airborne sound insulation under direct sound field conditions*, 2018.

[3] Vanhooreweder, B.; Marcocci, S.; De Leo, A. *Technical Report 2017-2 - State of the art in managing road traffic noise: noise barriers*, CEDR, 2017.

[4] Strigari, F.; Bartolomaeus, W. *SOPRANOISE report D2.2, Chapter T2.3 - Influence of acoustic degradation of noise barriers on the total noise reduction*, https://www.enbf.org/sopranoise/outcome/, 2021.

[5] German Federal Minister of Transport, RLS-90 - Richtlinien für den Lärmschutz an Straßen (*Guidelines for the noise protection at roads*), Ausgabe 1990, Berichtigter Nachdruck, 1992.

[6] Chudalla, M.; Strigari, F.; Bartolomaeus, W. *SOPRANOISE report D3.1, Chapter T3.2 - Development and testing of methods based on in-situ inspection*, https://www.enbf.org/sopranoise/outcome/, 2021.

[7] Chudalla, M.; Strigari, F.; Bartolomaeus, W. *SOPRANOISE report D3.1, Chapter T3.3 - Description of the in-situ inspection tools and reporting*, https://www.enbf.org/sopranoise/outcome/, 2021.