



## **THE NORDTEST METHOD OF QUALITY ASSURANCE OF ENVIRONMENTAL NOISE CALCULATION METHODS IN SOFTWARE – PRACTICAL EXPERIENCES**

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### **ABSTRACT**

When determining the uncertainty of an environmental noise calculation result, an assessment of the quality of the implementation of the used method in the software is required. Here, Nordtest Method Framework for the Verification of Environmental Noise Calculation Software ACOU107 (2001) may prove useful. This describes a framework to verify that software intended for calculation of environmental noise levels conforms with a specific calculation method. The verification process requires a number of standard test cases for each method, with known, certified calculation results and accepted tolerances. The method was developed for Nordic calculation but, in principle, can be applied to all other methods. Thus, in 2004, the Brüel & Kjær Prediction Partnership decided to comply with it for all methods implemented in their software – Predictor Type 7810 and Lima Type 7812.

This paper briefly describes:

- The contents of the method
- How it can be used to help determine uncertainty
- The practical experiences faced when implementing the method for the quality assurance of software

The definition of the certifying authority for each method, accreditation of testing laboratories and the suitability of the certificate and the result comparison form for various methods are not included in this paper.

## 1 INTRODUCTION - WHAT IS NORDTEST METHOD ACOU107?

### 1.1 Background and scope

The Nordtest Environmental Noise Calculation Software Verification Method ACOU107 [1], published in 2001 (in the paper referred to as “Nordtest”), describes how to verify, certify and declare the conformity of environmental noise calculation software with a specific calculation method. It is a framework document designed for use with the Nordic calculation methods for noise from road, rail or air traffic, industrial plants or shooting ranges, etc. and is designed for all software, whether commercial, financed by an authority or developed in-house.

The objective is to verify that the software’s results are in accordance with the calculation method. If authorities agree to the verification method, they may decide to issue certificates or labels for verified products. However, this is not covered by the method.

The verification process is based on a number of standard test cases for each specific calculation method, with known, certified calculation results and accepted tolerances.

It is assumed that the calculation method itself has already been validated as giving results corresponding to measurement results and that test examples, with certified results and accepted tolerances, have been developed. Although not explicitly described, it must also be assumed that the method itself is free from various interpretations and ambiguous algorithms. However it is common knowledge that the implementation of standards into software implies considerable interpretation [2].

### 1.2 Short description of the verification method

The software certification process described in the method is shown in Fig. 1. First, the calculation method is developed along with a set of test cases, with certified results and accepted tolerances, and a ‘Result Comparison Form’. Consensus on the test case results and accepted tolerances is obtained in a group of experts.

Once the new method has been implemented in software, the manufacturer fills out the ‘Result Comparison Form’ and a ‘Declaration of Conformity’ and submits the forms to the certifying authority (e.g. the National Environmental Protection Agency in the country of the software developer). The form uniquely identifies the software. The manufacturer encloses documentation of the calculations performed or states that the authority will receive such documentation upon request. This documentation shall ensure that the calculation results are fully traceable. The manufacturer declares that unless explicitly specified in the ‘Result Comparison Form’, the software is applicable to any situation covered by the calculation method.

If the authorities find the results acceptable, the software is certified for use (in this case, in all Nordic countries), the software manufacturer is permitted to label the software as being compliant with the method and the ‘Result Comparison Form’ is then made public. The test procedure and subsequent approval is to be repeated for every new release of the software.

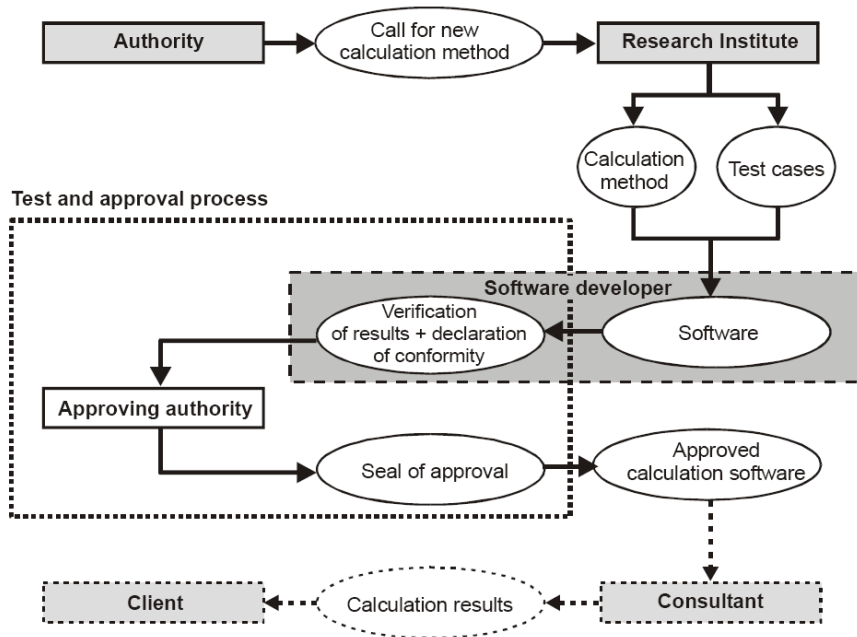


Fig 1 The verification process

## 2 HOW IT CAN BE USED TO HELP DETERMINE UNCERTAINTY?

The uncertainty in environmental noise calculations can be categorised as that due to the model/method, the input, error propagation and evaluation data [3]. Uncertainties due to the implementation of methods in calculation software are included in the first category. The verification that the software calculates the correct results within documented tolerances can be used to quantify the uncertainty term. This can be done in several ways, for example:

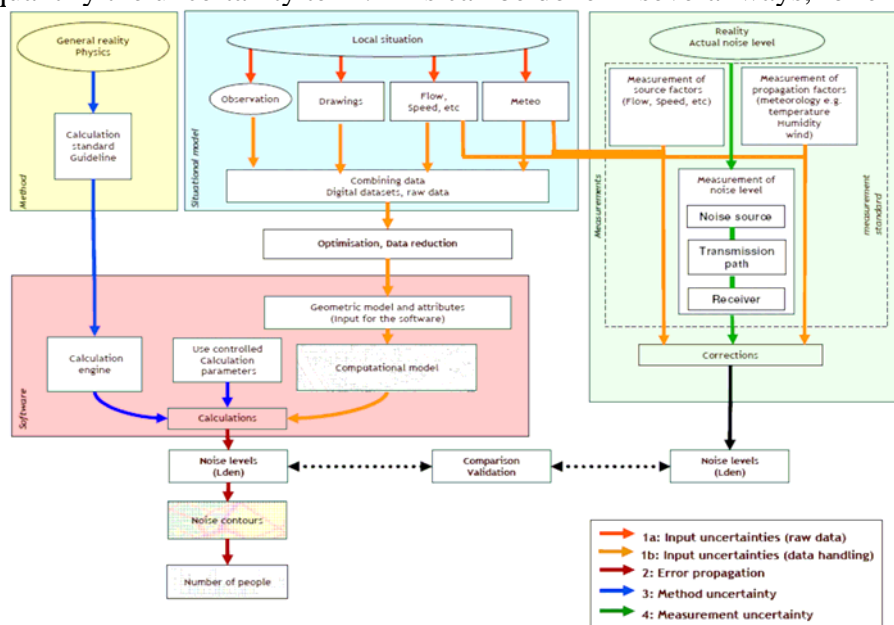


Fig 2 Uncertainty in environmental noise calculations (Hinton et al)

- Base the uncertainty on the average tolerance of all test cases
- Base the uncertainty on a weighted average tolerance of the most frequently occurring test cases
- Base the uncertainty on an evaluation of the complexity of the situation compared to the expected tolerances, and the quality of the input data and simplifications made by the user and within the software. However, this includes terms concerning input data and should be noted in order to avoid over-assessment

Research into this topic is required.

### 3 PRACTICAL EXPERIENCES WHEN IMPLEMENTING THE METHOD FOR THE QUALITY ASSURANCE OF SOFTWARE

#### 3.1 Background

Traditionally, the following test procedures are followed for defining a growing test set with situations made to be calculated for each new version of the software for each version of the software:

- Situations that can be calculated by hand covering all separate attenuation terms
- Situations for regression and stability tests covering small and large models
- Situations for checking solved errors
- Situations for new modelling functionality

In 2004, the Brüel & Kjær Prediction Partnership decided to comply with it for all methods implemented in their software – Predictor Type 7810 and Lima Type 7812. First, we investigated whether Nordtest could be used with various calculation methods (see Table 1).

Table 1. An overview of selected methods, the availability of test cases and tolerances.

Method	# Test cases	Tolerances
BS5228	2	No
CRTN	18	No
CRN	14	No
DAL 32	2	No
Harmonoise [4]	45	No
NMPB	1	No
ÖAL 28	12	+/-0.2
ÖAL30 ÖNORM S5011	13	+/-0.2
RLS90 (TEST 94)	30	Yes
RVS 3.02	17	+/-0.2
SCHALL03	23	Yes
ECAC.29 (1997)	1	Various tolerances
RLM2	No	N/A
SRM2	No	N/A
ISO 9613	No	N/A

### 3.2 The availability of test cases

A major presumption for using the Nordtest method is the availability of test cases. This is seldom the case. For some methods, independent test cases are available, e.g. for the German RLS 90 and SCHALL 03 methods. However, most of the methods do not have independently developed test cases defined and some, including several key methods such as ISO 9613 and ECAC Doc 29, no test cases exist at all.

For those methods without test cases, we decided to define our own corporate set of test cases that should be used for both softwares. We recommend that the software supplier shall, on request, provide the data sets of the test examples along with the delivered software.

### 3.3 Requirements for test cases

Nordtest states that the test cases shall be sufficiently comprehensive and designed to ensure that **all parts** of the calculation method are tested, and that particularly **critical parts** of the prediction method are thoroughly covered. The **number** of test cases required depends on the method complexity. Nordtest suggests that 10 to 20 receiver positions are sufficient. A single test case is defined as an **unambiguous description** of the noise source, the receiver and their surroundings which influence the sound transmission path, plus an **interval of noise levels** defined as correct (certified) results of calculation with these parameters as an input.

We experienced several issues on all of the above key factors. For some regulations there are **too few** test cases for accurate test of implementation in software. For example, the NMPB only has 1 test case.

Several test cases were **ambiguous**. For example, of the test cases described in the 18 annexes of the CRTN method, at least 12 annexes contain unclear or ambiguous issues [5]. Some test cases are only given as a graphic map on paper. The exact coordinates are therefore not known and thus cannot be reproduced exactly apart from adjusting the position to achieve the desired result – surely not the intention of the test case

Some of the test cases for a single method even **contradicted** each other. Others describe ideal situations that cannot be calculated, such as an angle of sight of 180 degrees requiring infinite models

Not all methods have test cases that include defined result **tolerances** (e.g. Harmonoise). For these, we assumed that the tolerance is implicitly defined to the decimal place given in the result (e.g. if a result is defined as 68.1 dB, then the tolerance is implicitly 0.05 dB due to rounding).

As an aside, defining result tolerances is difficult. For the test cases for the German road and rail methods, this range had been defined on the basis of 2 different step-widths (angles) of the ray tracing. Since then, it has been shown, using other test cases, that such an approach with changed ray tracing increment will not always cover the range of possible results that are actually calculated in accordance with the regulation. Thus, it should be made very clear that any results outside a defined range of results should be seen as correct provided that completely provable, detailed documentation shows that the calculation is in accordance with the method. Otherwise, test cases receive a higher legal status than the method itself. Nordtest covers this eventuality by allowing exceptions in the Result Comparison Form.

For the Austrian methods, general test cases had been developed in coordination with the software developers to avoid ambiguous descriptions.

For our products, we used the available test cases, supplemented by a sufficient number of suitable test cases with unambiguous descriptions and intervals of correct noise levels, defined by the two development teams, in line with the Nordtest principles. For the more complex methods, the number of test cases was increased.

#### 4 CONCLUSION

The Nordtest Method Framework for the Verification of Environmental Noise Calculation Software ACOU107 (2001) is an important development in ensuring the quality of independent implementations of methods by verifying that environmental noise calculation software conforms with calculation methods.

However, experience has shown that there are difficulties in implementing the method for the quality assurance of software due to a lack of conformance of test cases with the requirements in the Nordtest method in all aspects including an **insufficient** number and extent of test cases, **ambiguous** test cases that even **contradicted** each other and, importantly, a lack of defined result **tolerances**. This makes it difficult to determine the quality of the implementation of the used method in the software and, thus, its effect on the uncertainty of an environmental noise calculation result.

The definition of the certifying authority for each method, accreditation of testing laboratories and the suitability of the certificate and the result comparison form for various methods are subjects may also be investigated.

As the Nordtest method states, “In their effort to ensure high quality and reliability in noise level calculation the authorities should have test examples developed – with certified results and accepted tolerances – in parallel with or subsequent to calculation method development.”

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