Transport noise
Measurement uncertainty

NZ TRANSPORT AGENCY
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GOOD PRACTICE GUIDE

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Uncertainty in noise measurements

All measurement results have an inherent uncertainty or inaccuracy about their true value. In the case of noise measurements, the source and propagation path are examples of areas of uncertainty. Knowledge of uncertainty factors will assist with the interpretation of the measurement results, indicate differences which may not be significant and identify areas where greater detail can improve assessments. Section 5.4.3 of NZS 6806 recommends the use of uncertainty budgets, and this good practice guide describes typical sources of uncertainty in road-traffic noise measurement and how to calculate a budget. An example is shown overleaf. These procedures are based on the guide book by Craven and Kerry, as referenced by NZS 6806.

Sources and level of uncertainty

The potential sources of uncertainty in a measurement of road-traffic noise include the following:

- Variations in the traffic flow and number of heavy goods vehicles compared to the values assumed for these parameters. For example, if the road typically carries 22,000 vehicles per day, what is the level of traffic during the measurement period?
- Weather conditions, especially the wind as it will influence the noise level at the measurement point depending on direction and speed.
- The position of the measurement point in relation to the source. What is the accuracy of the source to receiver distance measurement?

Identifying all the sources and magnitudes of the uncertainties provides a means of quantifying the total uncertainty of a measurement (the 'uncertainty budget') and also a method to minimise some of them, thus improving the accuracy of the final result.

Assessing the level of uncertainty in a measurement results in two quantities:

- The 'confidence interval' or 'uncertainty' – the margin within which the true value can be said to lie (eg ± 3 dB)
- The 'level of confidence' – the number expressing the degree of confidence in the uncertainty result (eg 95%)

Thus a measured noise level of $L_{Aeq(24h)}$ 57 dB with these levels of uncertainty would be quoted as:

$L_{Aeq(24h)}$ 57 dB ± 3 dB with a confidence level of 95%

For ease of reading, it is not necessary to repeat this full notation every time a noise level is stated in a road-traffic noise assessment report.

Uncertainty budget

To obtain the level of uncertainty, the procedure below is carried out.

List all sources of measurement uncertainty

(source, propagation path, receiver)

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Determine the magnitude of each uncertainty

Either: calculate from repeated measurements,
or estimate based on experience,
or use a figure from literature.

⇩

Convert uncertainty into decibels

⇩

Calculate the standard uncertainty for each source of uncertainty $u_1, u_2, u_3, \ldots$

The standard uncertainty for a normal distribution is:

$$u = \frac{s}{\sqrt{n}}$$

where s is the estimated standard deviation of a set of n samples.

The standard uncertainty for a rectangular distribution is:

$$u = \frac{x}{\sqrt{3}}$$

for $\pm x$ uncertainty.

⇩

Calculate the combined uncertainty u_c

$$u_c = \sqrt{u_1^2 + u_2^2 + u_3^2 + \cdots}$$

⇩

Calculate the expanded uncertainty U

$$U = ku_c$$

(coverage factor k = 2 for 95% confidence limits)

Example

This is an example of an uncertainty budget for a road-traffic noise measurement, carried out as part of the assessment of an altered road in accordance with NZS 6806. Measurements of the existing road-traffic noise were made at the façade of a building. The potential sources of uncertainty have been identified and categorised under source, transmission path and receiver.

The magnitude of the traffic flow uncertainty is the variation from the Annual Average Daily Traffic (AADT). In this case it is estimated it could vary by ± 1000 vehicles per day (vpd). This uncertainty can be reduced by making measurements of traffic flow during the noise survey.

Calculations of the traffic noise level have been made with 22,000 ± 1000 vpd. This results in a noise level uncertainty of ± 0.2 dB.

A rectangular distribution of uncertainty means that the real value can fall anywhere between the uncertainty magnitude with equal probability.

The standard uncertainty for a rectangular distribution is: $u = \frac{x}{\sqrt{3}}$ [For a normal distribution the standard uncertainty is: $u = \frac{s}{\sqrt{n}}$]

NZTA research report 446 provides guidance on variation due to weather.

There should be no change in ground and topography during a survey. The report should describe these conditions at the time of the measurements.

This relates to the accuracy of the source to receiver distance measurement, and uncertainty in repositioning the microphone for any repeat measurements.

Source of uncertainty	Magnitude of uncertainty	Conversion of uncertainty to dB	Distribution	Standard uncertainty dB
Source				
Traffic flow	1000 in 22,000 vpd	0.2 dB	Rectangular	0.11 dB
% HGV and Mean speed	5% at 90km/hr to 15% at 110km/hr	3.1 dB	Rectangular	1.79 dB
Transmission path				
Weather	3.0 dB	3.0 dB	Rectangular	1.73 dB
Ground	No change	-	-	-
Topography	No change	-	-	-
Receiver				
Position	2m in 100m	0.1 dB	Rectangular	0.05 dB
Instrumentation	1.9 dB	1.9 dB	Rectangular	1.10 dB
Background	< 0.1 dB	-	-	-
Façade reflection	1.0 dB	1.0 dB	Rectangular	0.58 dB
Combined uncertainty ($u_c = \sqrt{u_1^2 + u_2^2 + u_3^2 + \cdots}$)				2.78 dB
Expanded uncertainty ($U = ku_c$, $k=2$ for 95% confidence)				**5.57 dB**

The uncertainty of a Class 1 sound level meter under practical measurement conditions.

The road-traffic noise dominated the measurement.

The uncertainty in the reflected noise from the façade, which depends on the construction. The standard façade correction is 2.5 dB, and the uncertainty is estimated as ± 1.0 dB.

The result of this uncertainty assessment is that the measured noise level has an uncertainty of ± 5.6 dB with a confidence level of 95%

Further information on uncertainty can be obtained in:

N.J. Craven and G. Kerry. *A good practice guide on the sources and magnitude of uncertainty arising in the practical measurement of environmental noise*. University of Salford. 2001.

V.K. Dravitzki, R.J. Jackett and C.W.B. Wood. *The variability of road traffic noise and implications for compliance with the noise conditions of roading designations*. NZTA research report 446. 2011

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