Transport
for NSW

Road noise model validation guideline

August 2022

NSW GOVERNMENT

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Acknowledgement of Country

Transport for NSW acknowledges the traditional custodians of the land on which we work and live.

We pay our respects to Elders past and present and celebrate the diversity of Aboriginal people and their ongoing cultures and connections to the lands and waters of NSW.

Many of the transport routes we use today – from rail lines, to roads, to water crossings – follow the traditional Songlines, trade routes and ceremonial paths in Country that our nation's First Peoples followed for tens of thousands of years.

Transport for NSW is committed to honouring Aboriginal peoples' cultural and spiritual connections to the land, waters and seas and their rich contribution to society.

Document control

Document owner	Senior Specialist Noise
Consultant	N/A
Approved by	Executive Director, Environment and Sustainability
Branch / division	Environment and Sustainability / Safety, Environment and Regulation
Review date	July 2024
Parent procedure	N/A
Superseded documents	RMS Noise Model Validation Guideline

Versions

Version	Date	Amendment notes
1.0	Undated	Original Roads & Maritime document
1.1	Aug 2022	Rebranded from a Roads & Maritime document to Transport for NSW

Related policy and supporting information

- Transport Environment and Sustainability Policy
- Transport for NSW's EMF-NV-PR-0057 - Post-construction road noise assessment report procedure
- Transport for NSW's EMF-NV-GD-0025 Road Noise Criteria Guideline
- Transport for NSW's EMF-NV-GD-0024 Road Noise Mitigation Guideline

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Environment & Sustainability Management Framework

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1. NSW road noise modelling context

Road traffic noise models in NSW are regularly validated using simultaneous classified road traffic counts and noise loggers. This provides greater confidence in the recommendations and assessment completed using modelling.

In NSW and other parts of Australia we are in a unique situation compared to much of Europe and North America in that good correlation may easily be obtained between measured and predicted noise levels. This has allowed refined and robust design approaches to be developed with good understanding of modelling algorithm limitations.

Good correlation is obtained in NSW and much of Australia for a number of reasons. A significant factor is that the climate is relatively moderate compared to much of Europe where one location may experience a larger range in temperatures and ground conditions ranging from summer grass to frozen or snow covered ground.

Australian road surfaces for the most part are also not subjected to freeze thaw cycles or studded snow tyres which quickly cause degradation in road surface performance and acoustic characteristics. For the most part Australian drivers use ‘summer’ tyres all year rather than ‘winter’ and ‘summer’ tyres with different noise emission.

This means that Europe is largely reliant on modelling whereas NSW and much of Australia are able to make use of the benefits of reliably matching modelled and measured noise levels at any time of the year.

2. Why do we validate a road noise model?

The purpose of model validation is to demonstrate that the noise model is a reasonably accurate representation of the real world within the limitations of the algorithm. Validation can also show that where the limitations of the algorithm result in systematic error, this can be accounted for by calibration.

From Transport's perspective validation also serves as an overall check that all parameters and geometry have been correctly entered into the model and that the parameter values are appropriate.

In many aspects the validated existing noise model is the most important piece of modelling as after project construction it is the only detailed record of existing noise levels. Existing noise levels are very important in NSW as increases in noise level are one of the two triggers for noise mitigation. After project completion the noise levels from the project can be measured, whereas the existing noise levels before the project cannot.

3. What is error?

Error may be defined as the difference between measured and predicted noise level. An error of zero indicates that the model exactly predicts noise levels. Positive or negative error either indicates over or under prediction depending on the sign convention used.

Typically, this is presented in a report validation table such as below. Table 1 shows the differences between predicted and measured noise levels and the median differences.

Table 1: Example daytime validation table

Reference	Noise logging address	Daytime Noise Level $L_{Aeq(15\ hour)}$ (dBA)		
		Measured existing	Predicted existing	Predicted minus measured
NM1	Some Road	66.1	66.9	0.8
NM2	Some Road	68.0	67.0	-1.0
NM3	Some Road	55.0	56.3	1.3
Median difference				**0.8**

There are two types of error that Transport processes account for. The first is random scatter which has been the subject of many studies. Random error describes the distribution of error either side of a median of zero. It has been expressed mathematically as root-mean-square (rms) in the development work leading to the derivation of CoRTN by Delany et al and as standard deviation in the validation of CoRTN for Australian conditions by Samuels et al.

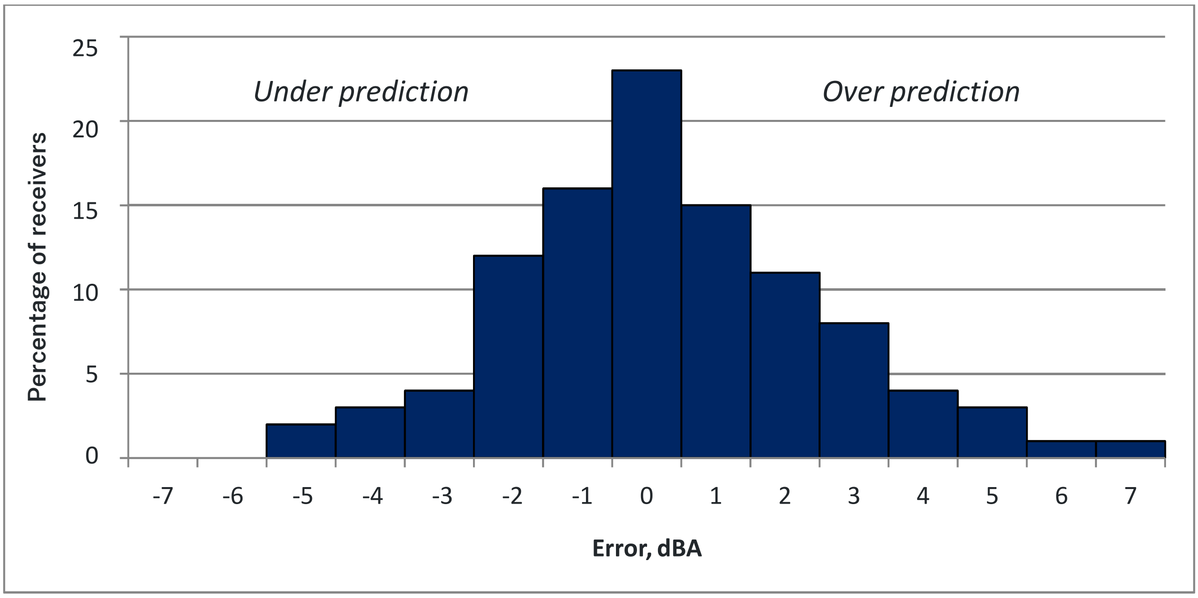
Root-mean-square and standard deviation are both measures of scatter and are similar where the median error is zero. However, an important difference is that, while the actual scatter does not change with median error, this may alter the measure of scatter when using rms. In contrast, when using standard deviation as a measure of scatter, the value of standard deviation does not change with median error.

Delany et al reports rms error of 2.0dBA for free field with good quality data (328 sample sites) and 2.5dBA (2064 sample sites) in more complex situations which may include facades. Samuels et al reports standard deviation of 1.8dBA for free field (55 sample sites) levels and 2.5dBA for façade levels (61 sample sites).

The second type of error is median error where the median error does not equal zero. Median error does not affect scatter. The work by Samuels et al also identified correction terms to correct for median error under Australian conditions when using CoRTN in the 1980s. Work by Kean also identified potential corrections for CoRTN with higher heavy vehicle percentages at night. Samuels reports -1.7dBA for façade levels and - 0.7dBA for free field levels based on daytime L10(18hr). Kean reported between +0.5dBA to +1.0dBA for night time traffic with high heavy vehicle percentages at freeway speeds and potential temperature effects. Transport through review of numerous projects confirms that night time noise levels require separate corrections to the daytime.

Figure 1 shows the typical difference between measured and predicted noise levels for a calibrated noise model with median error of 0dBA on a large urban Sydney road project (1796 sample sites). It shows that there is random scatter with standard deviation of around 2dBA. It shows slight skew towards over prediction in the tail, perhaps due to the exclusion of residential fence details.

Figure 1: Typical difference between measured and predicted noise levels



Note that median error can be problematic on a road project since it changes the noise levels at all locations and impacts on the design of mitigation. Random scatter, while appearing to be significant, can be more easily addressed at individual locations during post construction compliance checks. In most locations over prediction of noise levels due to random scatter does not result in additional noise mitigation as the noise level must also be above the criteria and have increased enough to trigger mitigation.

3.1 How is error managed?

Transport processes applied at the initial concept development of a potential road, at the environmental approval, the detail design and post construction operational compliance coordinate to manage the effects of random and median error as the road project transitions from an early concept to an operational road.

Aspects that need to be managed are the cumulative effects of error and uncertainty around model inputs. These can have a big effect on correctly identifying community impact, cost of mitigation and mitigation triggers.

3.2 Causes of median error

Based on review of road projects it is the Transport noise team's experience that significant median error is mostly likely caused by incorrect model inputs or incorrect noise logger processing than the road in question differing significantly from standard Australian conditions. In Transport's experience it is also less likely that significant median error is due to chance from a small sample size of logging locations than due to incorrect model inputs.

The theoretical number of loggers required to determine the median error with a certain degree of accuracy are detailed in AUSTROADS report AP-T12 2002, An Approach to the Validation of Road Traffic Noise Models. However, in practice, a good degree of certainty can be obtained with fewer loggers through good logger placement and additional data processing.

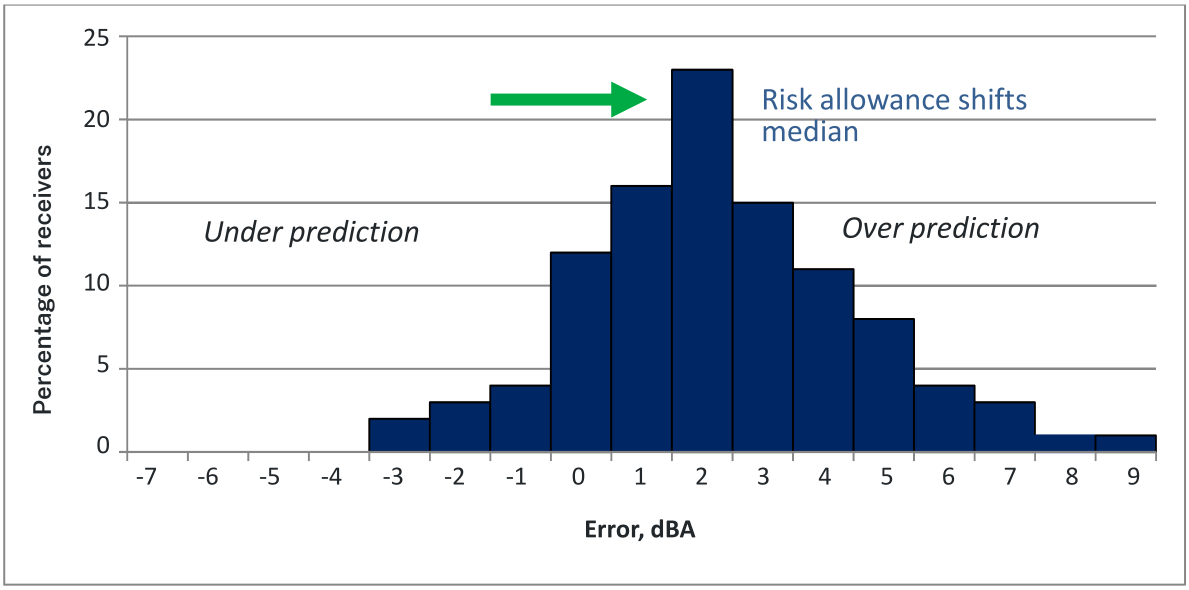
On some occasions there may be enough receivers that are all similarly affected by the same propagation loss error to cause median error in the result table. In this instance separate catchments may be required to evaluate catchment based median error if the issue cannot be addressed by localised refinement of the model. An example of this may be an error in shielding or differences in ground type.

3.3 Use of median error

Median error may be deliberately introduced to manage risk. In engineering this is known as a safety factor, however for noise assessments Transport uses the term risk allowance. The risk allowance shifts the median so that on average the noise model over predicts noise levels. This reduces the chance that, due to random error at compliance, a receiver will be over the noise criteria. It can also be used to manage some uncertainty around noise source levels terms such as future traffic volumes and speeds which affect median noise levels.

The following Figure 2 shows an example with a 2.0dB risk allowance. This reduces the risk that a number of residences exceed criteria on compliance by shifting the distribution so that on average noise levels are over predicted.

Figure 2: Effort of risk allowance



The decision to use a risk allowance is a decision made on individual projects and is typically included where judgement shows that the cost of a small number of additional noise treatments, due to over prediction, is less than the management and reputational cost of providing additional noise mitigation after the road is operational. It is most commonly used on rural projects where the risk allowance adds a few extra houses onto the noise mitigation list. On urban projects it is more common for Transport to request a sensitivity analysis to identify the number of receivers that may need to be mitigated if the noise level is under or overestimated as a measure of compliance risk after project completion.

3.4 Causes of scatter error

If noise levels are evaluated over a sufficiently long time period, the main cause of scatter is due to the limitations of the algorithm and a practical noise model to accurately account for all aspects of propagation loss. Areas where algorithms and models commonly simplify propagation loss include ground effect, vegetation, reflection, diffraction and atmospheric loss. When assessed over a short period of time, variance in individual vehicle noise emission, atmospheric conditions and low-level extraneous noise may give rise to random error.

In some instances, localised source level error due to inconsistent road surfaces or unusual or inconsistent traffic flow may give error at a receiver location. This may appear as random error where it only affects one receiver. However, this is a source level error and would give rise to median error if logging was completed at multiple receivers in this location. This should be identified when accounting for error at each logging location.

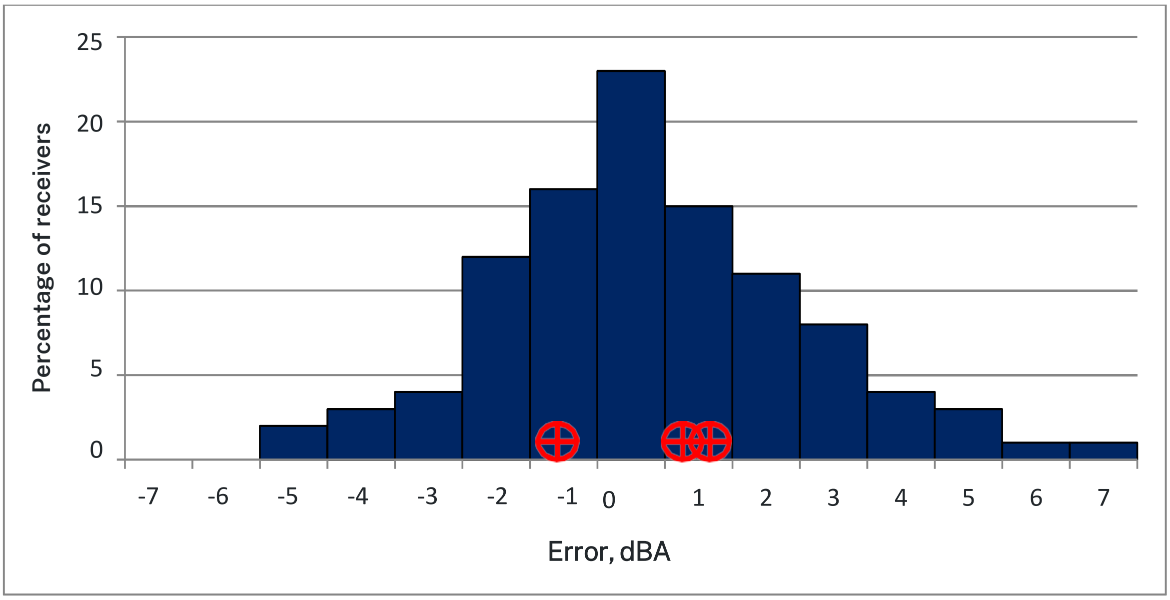
The key component that may be used to calibrate propagation loss, assuming all other inputs are correct, is the proportion of soft ground entered into CoRTN. This corrects situations where noise levels are under predicted at close distances and over predicted at greater distances or vice versa. When calibrated the spread of the scatter may be reduced assuming the receivers are all located at different distances from the road or with different intermediate ground surfaces.

4. Does a model need calibration?

This is the question that is asked each time a validation table is produced. Before calibration is undertaken there needs to be strong justification, supported by a physical explanation, of why the median error of the sample is significantly different from 0dB. The reason for requiring strong justification and a physical explanation is that there needs to be a high degree of certainty that calibration is required. While calibration may reduce error at the sample logging locations it may make error worse at other locations on the road project.

For example, if we plot the daytime noise levels from Table 1 onto Figure 1 we get the following in Figure 3. While the daytime median error of the sample was 0.8dB this may have been due to the small sample size. If more loggers were used then the distribution below may have been produced with a median of 0dB.

Figure 3: Possible population distribution for sample logging location values



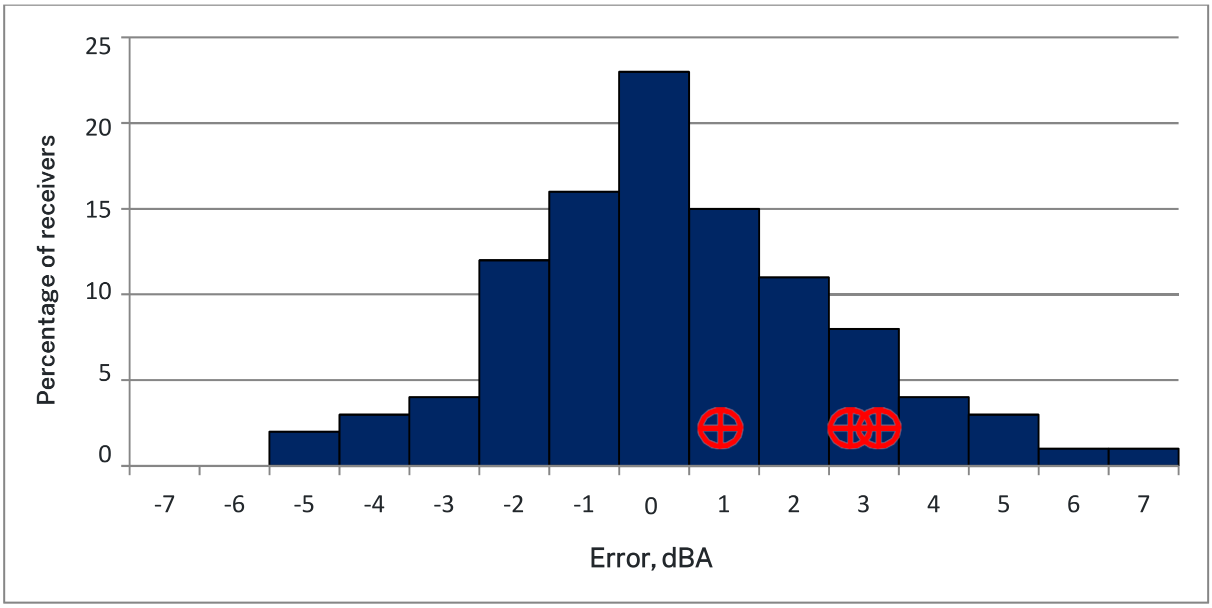
A common situation is that the validation table (see Table 2) shows that the noise model significantly over predicts noise levels at the logging locations.

Table 2: Example validation table with possible over prediction

Reference	Noise logging address	Daytime Noise Level $L_{Aeq(15\ hour)}$ (dBA)		
		Measured existing	Predicted existing	Predicted minus measured
NM1	Some Road	66.1	66.9	0.8
NM2	Some Road	68.0	67.0	-1.0
NM3	Some Road	55.0	56.3	1.3
Median difference				**0.8**

The question that needs to be answered is whether this potential over prediction is due to chance and the model is actually fine as is indicated in Figure 4.

Figure 4: Logger sample not representative



Or is calibration required and the model is actually over predicting at all locations by 2dBA as is shown in Figure 5, and calibration is required to produce the result shown in Figure 6?

Figure 5: Model over predicting noise levels

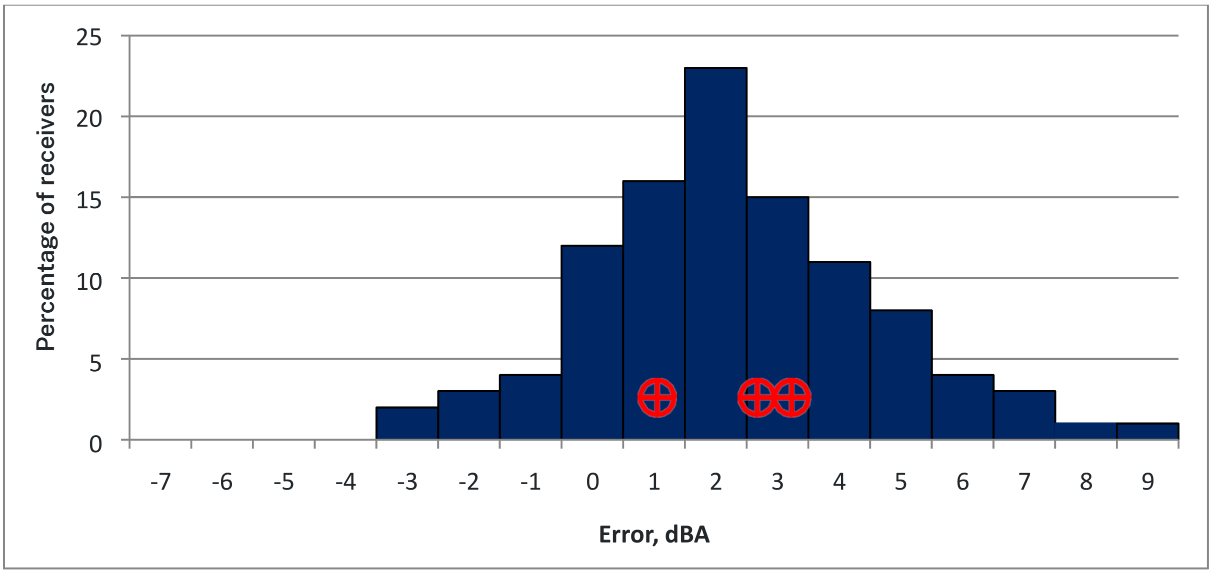
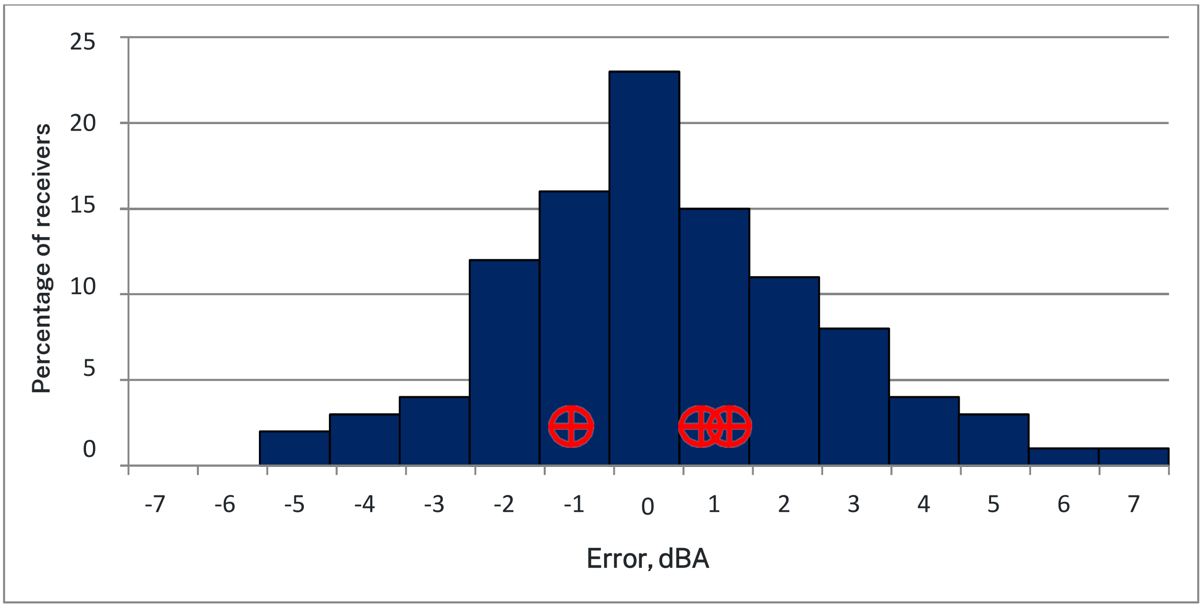


Figure 6: Model calibrated



In practice, Transport's experience, based on numerous projects large and small over many years, is that the chance that the situation in Figure 5 (or the opposite and under predicting) occurs is low in situations where:

- Model uses standard factors for NSW approaches to L_{Aeq} modelling.
- Model input parameters and geometry have been audited and verified as being appropriate.
- A three-source height model is used particularly where heavy vehicle percentages are greater than 10%.
- All lanes of traffic have been individually modelled with three source heights per lane (particularly where heavy vehicle percentage is greater than 10%). Each source being located in the centre of each lane.
- Desktop/spreadsheet calculations have been used to verify the noise model.
- Correct road surface corrections have been used and verified during logging.
- Simultaneous noise logging and classified traffic count data with measured speeds have been correctly processed. The representative speed used for validation should be justified.
- The model has been validated under free-flowing traffic conditions by excluding corresponding periods of unusual traffic flow or temporarily reduced traffic speed from the noise and traffic loggers. This type of traffic flow differs from that used to derive the empirical based equations in most algorithms. Note that a secondary validation step may be required to identify a calibration for non- free flowing conditions.
- At each logging location the difference between measured day and night time noise levels are similar to the differences predicted by the noise model.
- Logging includes free field measurement locations within 30m of the road (no closer than 10m) and having unobstructed line of sight to approximately 150 degrees of road and tyre interface to verify representative road traffic source levels.
- Logging locations provide a representative measurement of receiver noise levels and the impact of the project.
- Noise loggers are placed at a range of distances and locations to evaluate propagation loss throughout the range of project impact. These locations may include representative points on multi- storey residential receivers.
- Some loggers are not influenced by residential fences as they increase modelling uncertainty due to uncertain shielding effects.

Under most circumstances this will result in:

- Median error within +-1dBA for the sample locations where noise logging was completed. Note that this may vary a small amount depending on the number of noise loggers in the sample.
- Random scatter within +-2.0dBA and values that are of similar magnitude but opposite sign. Any random discrepancies outside of +-2.0dBA should be accounted for at each logging location. Free field loggers within 30m of the road (no closer than 10m) and with unobstructed view to the road/tyre interface with an angle of view of around 150 degrees are regularly within +-1.5dBA.

However, in some instances calibration may be required where it can be strongly justified based on the median error and a physical explanation of the cause of the error.

Consideration should be given as to whether calibration is relevant to both the 'no-build' and 'build' scenarios or just the 'no-build' scenario. Aspects for consideration are whether the traffic conditions, old and new pavement surfaces and propagation losses are expected to be similar in both the 'no-build' and 'build' scenarios.

Typical examples of where additional calibration may be required are:

- Worn and degraded pavements with noise emission different from standard factors.
- High heavy vehicle percentages, high proportion of medium trucks, and/or areas affected by the frequent use of engine compression brake (Australian vehicle fleet at present is different to that in 1970's UK when CoRTN was derived).
- Where the unusual traffic flows or temporarily reduced speeds are a feature of the road. These effects need to be quantified and included where significant in the context of the time period set by the noise criteria. Examples may include school zones, intersections, smart motorways and congested flow.
- Significant differences in temperature.

5. Management of error and risk along different project stages

5.1 Route options

Validation may not be possible during a route options assessment. This will depend on the level of information available and also whether a desktop analysis or noise model is to be prepared. During a route options assessment it is common that:

- Future or existing traffic volumes are not known.
- Detailed ground topography surveys have not been completed.
- 2-D or 3-D road design information is unavailable.

Where sufficient information is available validation should be completed. Standard modelling parameters should be used where available information does not allow reliable validation.

5.2 Environmental assessment

The environmental assessment may be the first opportunity where validation and potential calibration may be completed.

In some instances, detailed ground topography may not be readily available. This should be sought as much as possible and if not obtainable the assessment should be suitably qualified about the modelling limitations.

Some small environmental assessments (e.g., a Review of Environmental Factors) approved internally by Transport may not have a further detail design stage. In this situation the level of accuracy and certainty in modelling and predictions may need to be suitable for construction. The Transport project manager can provide guidance on whether the project will have additional design stages and opportunity for refinement.

An environmental assessment approved by the Department of Planning and reviewed by the NSW EPA needs to have sufficient detail and certainty to identify minimum mitigation requirements. During detail design refinement additional noise mitigation may be identified.

Where there is a degree of uncertainty (e.g., traffic volume, speed, topography) a project specific risk allowance may be applied where approved by the Transport project manager.

In some instances, the existing road surface may be degraded resulting in higher noise levels or have temporary resurfacing with chip seal. This needs to be considered when validating the existing noise model.

However, where this road surface is to be replaced or no longer trafficked following the upgrade then standard design pavement corrections should be used in the 'no-build' scenarios for these pavement sections. This ensures that nearby residents are assessed against the noise increase mitigation trigger that would have occurred if the pavement had not significantly degraded or been treated with a temporary chip seal resurface. Surface degradation and temporary resurfacing are cost effective approaches to extend an asset life until the road is upgraded.

5.3 Reference design

In most instances the reference design and associated noise levels and mitigation provided in the Tender Documents comes from the environmental approval.

Where there has been further design refinement the reference design is an update of the environmental assessment and should be prepared using the same approaches.

5.4 Tender design

The design and associated noise levels and mitigation produced by the contractor is used to inform Transport of the benefits, impacts and costs of the tender design during a competitive bid.

Models need to be validated and in some instances calibrated to provide Transport with confidence in the tenderers design and mitigation. It also needs to sufficiently inform the tenderer so that they can manage refinement through detail design and meet compliance upon project opening.

Where the environmental assessment or reference design has been completed prior to the competitive tender process the previously validated modelling parameters may be included in the scope of works to ensure consistency between competing tenderers.

On some projects the competitive tender process may be undertaken before an environmental assessment has been completed. In this situation Transport will request that all contractors complete a noise assessment using standard parameters and then complete their own risk assessment against these standard parameters. This ensures that Transport can compare like for like comparison between competing tenders since the same modelling approach was taken while the risk assessment means the contractor is responsible for identifying if the standard parameters are incorrect and can assess any resulting cost and design impact.

The reference design and scope of works may require that quieter pavements are used in certain locations. Note that this does not form part of the acoustic base design in the 'build' year unless the quieter pavement has been selected for reasons other than noise. Please see Transport's *Road Noise Mitigation Guideline* for the assessment of quieter pavement surfaces.

Note and apply approaches used for environmental assessment for degraded pavement.

5.5 Detailed design

The approaches used for environmental assessment should be used during detail design.

In addition, the detail design presents the opportunity for design refinement to ensure the requirements of Transport's Road Noise Criteria Guideline, Road Noise Mitigation Guideline, requirements of the scope of work and the environmental approval are being addressed.

6. Post-construction operational compliance

There are two approaches to confirming post construction operational compliance. The first is by measurement only and the second is by measurement and validated post construction operational noise model.

The first approach is best suited for projects with small number of affected receivers where noise logging can be completed at most receivers and the worst affected receiver before and after the project.

The second approach is required where there is large number of receivers and logging at most locations before and after the project is not practicable.

Noise measurements should be sufficient to verify the noise emission performance of the pavement, vehicle traffic and noise levels at an appropriate number of receivers.

6.1 Post-construction traffic flows

Simultaneous hourly classified traffic (light and heavy vehicle speed and volumes) and noise logging should be completed. The measured traffic volumes should be compared with the predicted traffic volumes.

Where the traffic volumes, traffic mix or speed is significantly different to the predicted traffic volumes the traffic flows should be re-evaluated and the project noise levels and mitigation reassessed. The Transport project manager can provide guidance on whether the traffic volumes are significantly different from the predicted flows.

If the measured traffic is similar, but lower than predicted, the measured noise levels should be increased by adjusting them for the change in traffic volume, mix and speed. This allows them to be compared with the predicted noise levels for the design.

6.2 Compliance by noise measurement

If compliance is to be based on measurement then noise logging should be completed in the same locations as prior to construction. Noise logging prior to construction should have covered most receivers and the worst affected receivers.

Where noise levels, including any adjustment, have increased by more than the noise mitigation increase trigger in the *Road Noise Mitigation Guideline* (Section 5.2), then noise mitigation should be reviewed at that receiver.

6.3 Compliance by measurement and modelling

In many instances, it may not be practicable to measure noise at all receivers. In this situation the post construction measured noise levels should be supplemented with a post construction compliance noise model.

The detail design model should be updated to produce the post construction compliance noise model. As a first step updates should include any differences between the 'for construction' drawings and the 'as built' road and also the traffic parameters such as volume, speed and heavy vehicle mix encountered during the post construction noise logging.

This updated noise model should be validated against the post construction noise logging results using the same software as the detail design. Where it can be strongly justified the application of noise calibration may be required.

The next step is to review the post construction traffic and confirm that it is not significantly different from that predicted at detail design. If the detail design traffic parameters are not significantly different from the opening traffic parameters then the detail design traffic parameters for the design year should be inputted into the validated post construction compliance noise model.

Where the validated noise model predicts a noise level at a receiver that is more than 2dBA higher than the detail design predicted noise level, mitigation should be re-evaluated for that receiver.

Where traffic parameters are significantly different from those used in detail design and result in higher noise levels, then all RNMG mitigation triggers and noise mitigation identified in detail design should be re- evaluated.

7. Standard parameters and approach

The following lists standard parameters and an overall approach suggested by Transport as a starting point in operational traffic noise assessment. These may be used to form the basis of modelling parameters to be included in a technical scope of work.

The approach requires a review and risk assessment of the standard parameters to be completed as part of the noise assessment as Transport does not warrant or guarantee that the standard parameters will be correct in all situations.

Note contractual scope of works may include additional or alternative parameters based on the findings of an environmental assessment.

a) Complete noise modelling using the following standard parameters:
   - apply single source height of 0.5m for cars and three source heights for trucks corresponding to 0.5m for truck tyres, 1.5m for truck engines and 3.6m for truck exhausts.
   - the noise source should be located in the centre of each lane of traffic.
   - for design purposes use pavement corrections of:
     - +3.0dBA for concrete
     - 0.0dBA for dense graded asphalt or equivalent
     - -2.0dBA for OGA or equivalent
     - +4.0dBA for 14mm chip seal or +2.0dBA for 7mm chip seal.
   - for validation of existing scenarios pavement corrections may vary from those used for design purposes. Table 3 below shows a range of values encountered on Transport roads. The choice of surface corrections used in the model should be justified. Where possible the existing road surface correction applicable at road side receivers should be verified by measurement.
   - adopt a minimum receiver height of 1.5m above ground level and 4.5m above ground level for single and double story premise respectively. Note where buildings are located on a sloping block, receiver heights may need to be increased
   - within CoRTN adopt a ground factor of 50% over residential areas, 75% over open grass areas and 0% over water. Note that factors of 100% may improve correlation in highly vegetated areas. However vegetation may not be permanent and Transport does not currently support its use to assist in reducing noise levels to meet criteria until issues of permanence are resolved. During design areas of vegetation should be set to 75%
   - for the generation of noise contours adopt a maximal search radius = 3000m
   - for the generation of noise contours adopt a grid space = 20, and height above ground = 1.5m
   - include a +2.5dBA facade reflection at 1m from façade conditions
   - where appropriate, account for L_{A10} low volume corrections and assume a L_{A10} to L_{Aeq} difference of 3dBA in CoRTN. Site specific empirical L_{A10} to L_{Aeq} corrections must not be used
   - evaluate the noise model in accordance with this guideline Sections 2 to 6
   - with CoRTN, consider use of additional or alternative vehicle source adjustments for different traffic mix (for example, in circumstances where the proportion of trucks is high, or increases significantly), including pavement temperature.

b) Complete a risk assessment of standard parameters against the evaluation in item (xi) to determine how noise levels and mitigation outcomes may vary if additional ground factor and source level calibration is required during design refinement or post construction.

Table 3: Typical range of road surfaces corrections

Surface name	Relative noise level dBA (freeway speeds)
14 mm chip seal	+4.0
14/7mm chip seal	+4.0
7mm chip seal	+2.0
Portland cement concrete (PCC) (free of tonal characteristics)	+3.0
Next generation diamond ground concrete (note other concrete ground surfaces may have negligible noise reduction compared to standard PCC)	0.0
Cold overlay	+2.0
Stone mastic asphalt 7	-1.0
Open graded asphaltic concrete	-2.5 to -4.5
Worn open graded asphalt	0.0 to +2.5
Dense graded asphalt (AC10, AC14)	0.0
Stone mastic asphalt 10 (generally used in NSW)	0.0
Stone mastic asphalt 14	+1.0

8. Definitions

Term	Definition
A–frequency weighting	A frequency-based adjustment made to sound level measurement, by means of an electronic filter, in line with international standards. This approximates the frequency response of the human ear and accounts for reduced sensitivity at low frequency.
Decibel (dB)	A measure of sound level. The decibel is a logarithmic way of describing a ratio. The ratio may be power, sound pressure, voltage, intensity or other parameters. In the case of sound pressure, it is equivalent to 10 times the logarithm (to base 10) of the ratio of a given sound pressure squared to a reference sound pressure squared.
Decibel (A-weighted; dBA)	Unit used to measure 'A-weighted' sound pressure levels. A-weighting is a frequency-based adjustment made to sound-level measurement to approximate the response of the human ear.
'Build' year / 'no-build' year	Build years – assumes the project proceeds No-build years – assumes the project does not proceed
CoRTN	UK Department of Transport's Calculation of Road Traffic Noise (CoRTN) algorithm
EPA	NSW Environment Protection Authority
Frequency	The number of times that a vibration or periodic function occurs or repeats itself in one second, measured in Hertz (Hz).
L_{A10}	The A-weighted sound pressure level measured using fast time weighting that is exceeded for 10% of the time over the relevant time period.
L_{Aeq}	Energy average A-weighted sound level – the steady sound level that, over a specified period of time, would produce the same energy equivalence as the fluctuating sound level actually occurring.
$L_{Aeq(15hour)}$	The L_{Aeq} noise level between the period of 7am–10pm.
rms	root-mean-square
Classified traffic counting	Raw traffic counting conducted in accordance with the Austroads vehicle classifications
RNP	NSW EPA's Road Noise Policy

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