PROPOSED METHODOLOGY FOR THE ASSESSMENT OF NOISE IN A ROUTE SELECTION PROCESS

Matthew Harrison[1], Simon Kean[2] and Benjamin Hinze[3]

[1]SLR Consulting Australia Pty Ltd
2 Lincoln Street, Lane Cove NSW 2066, Australia
Email: mharrison@slrconsulting.com

[2]Roads and Maritime Services, NSW
101 Miller Street, North Sydney NSW 2060, Australia
Email: simon.kean@rms.nsw.gov.au

[3]SLR Consulting Australia Pty Ltd
Level 2, 15 Astor Terrace, Spring Hill, QLD, 4000 Australia
Email: bhinze@slrconsulting.com

Abstract

A methodology has been developed by the authors to address the issue of determining a transparent process whereby the selection of various routes for a new road can be ranked in terms of their noise impact on affected communities. A rating scale has been proposed to enable these rankings to be easily combined with the rankings of other environmental considerations in a multi-criteria assessment (MCA) framework associated with the project. The approach relies on the rating of “noise annoyance” to rank the proposed route options. The proposed procedure uses the annoyance response relationships for Day-Night levels (DNL) documented within the Environmental Health Perspectives magazine article *Annoyance from Transportation Noise: Relationships with Exposure Metrics DNL and DENL and their Confidence Intervals* [1]. These relationships are also cited in the European Commission’s “*Position Paper on Dose Response Relationships between Transportation Noise and Annoyance (2002)*”. The DNL level can be directly calculated using the current New South Wales (NSW) *Road Noise Policy* (RNP) [2] noise metrics for day and night noise levels (i.e. $L_{Aeq,15hr}$ and $L_{Aeq,9hr}$). The assessment methodology includes an additional consideration for the level of annoyance caused by an abrupt increase in noise level at route opening which mirrors the consideration of noise level increase provided in the RNP.

1. Introduction

The route selection methodology described here shares much with the procedures described in the UK’s *Design Manual for Roads and Bridges* (DMRB) 2011 (Volume 11, Section 3) [3] in that it is based on the Community Noise Burden (CNB) approaches pioneered in the UK [4]. These CNB approaches rely on ratings of annoyance to rank the proposed route options.

Unlike the annoyance weightings curve utilised in the UK, which is a function of L_{A10} noise levels, the annoyance response relationship used here is that provided by Miedema and Oudshoorn for Day-Night levels (DNL) [1]. This relationship was adopted because the DNL level can be directly calculated using the current NSW *Road Noise Policy* (RNP) noise metrics of a daytime $L_{Aeq,15hr}$ and night time $L_{Aeq,9hr}$. The DNL level also considers a 10 dB "penalty" to night time levels when compared to daytime noise levels for similar levels of annoyance. As the $L_{A10,18hr}$ noise level assesses only a portion of the night time noise level (i.e. halts at 12:00 midnight), use of the $L_{A10,18hr}$ annoyance curve cannot practically be used to generate an annoyance relationship for the nine-hour night time period. The assessment methodology includes an additional consideration for the level of annoyance caused by an abrupt increase in noise level at route opening. The assessment procedure of the short term noise level increase is similar to that described in the DMRB where the short term (i.e. on opening) increase / decrease of 1 dB defines the trigger threshold for the subject road and surrounding road network.

The assessment of noise level increase also mirrors the consideration of noise level increase provided in the RNP. Introduction of a noise level increase criteria within the RNP is aimed to address instances where, for example, a new road is constructed in a relatively quiet area. A maximum noise level criterion may not be breached; however the change in noise level throughout the local area may still be significant. This effect is taken to be additional to the annoyance level expected from the long term exposure to the noise level expected for the project design year rather than as an alternative weighting function. The purpose of this approach is to provide an additional level of protection to existing areas of relative quiet. No adjustment has been proposed to the long term level of annoyance expected where there is an abrupt reduction in noise level at project opening since this will have the effect of helping to further protect existing areas of relative quiet. Additionally, anecdotal evidence suggests that the positive effect of a sudden noise reduction may have a much shorter life span than a sudden increase in noise level, the effect of which has been shown to persist for many years.

2. Assessment Consideration

The following considerations are regarded as important elements in the assessment methodology for ranking the noise impacts of alternative traffic routes.

2.1 Assessment of annoyance due to both the future road traffic noise levels and any abrupt increase in noise level

The annoyance weighting for different noise levels and increase in noise levels allows the number of houses exposed to a lower noise level (and levels of increase) to be meaningfully compared to the number of houses exposed to a higher noise levels (and higher levels of increase). These weighting factors are derived from the relationship between the percentage of people highly annoyed and the DNL levels, where the DNL is determined by the indices used for the day and night criteria given in the RNP (i.e. daytime $L_{Aeq15hr}$ and night time L_{Aeq9hr}). The DNL level is calculated from the $L_{Aeq15hr}$ and L_{Aeq9hr} noise levels where a 10 dB penalty is applied to noise during the night as follows:

$$\mathrm{DNL} = 10 \log \left[(15/24) \times 10^{(\mathrm{LAeq15hr}/10)} + (9/24) \times 10^{(\mathrm{LAeq9hr}+10)/10}\right] \quad (1)$$

A four point scale, which includes 'not much' and 'not at all' to help quantify the number of people bothered by long term annoyance of the road traffic noise levels was determined by Miedema and Oudshoorn. The relationship between the percentage of people highly annoyed by traffic noise and the DNL is presented in Figure 1.

2.2 There is a need to account for the importance of a change in noise level and to protect areas of quiet

This has been achieved in this assessment methodology through weighting the increase in noise level by the percentage of people "bothered very much" by the predicted change in traffic noise level increase and by adding this to the long term annoyance of the road traffic noise levels. This approach to protecting areas of quiet is relatively arbitrary. An alternative approach may be to either use the greater of the annoyance resulting from either the long term noise level or an abrupt increase in noise level, so that all routes are treated equally.

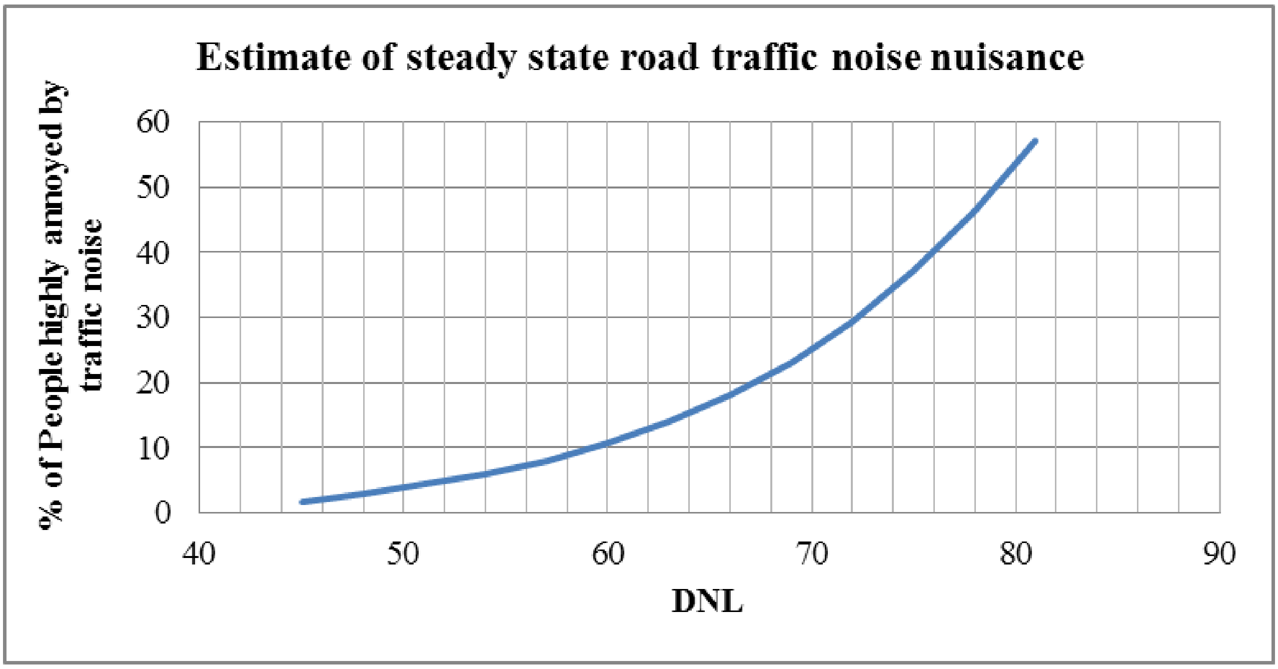

Figure 1. Nuisance of steady state traffic noise

2.3 The philosophy behind the assessment methodology should be relatively easily understood

This should be a primary aim of all environmental policy, even if the actual calculations required to determine the acoustically preferred route requires a level of specialist understanding.

2.4 The procedure must be implementable using the information that is generally available to a project team during the early stages of a route options analysis

For a route option assessment methodology, often only a concept design is made available for each route alignment. This information, combined with ground and feature survey data can be used to quickly build noise models to provide an indication of potential noise impacts, prior to detailed modelling during the Environmental Impact Statement (EIS) and detailed design phases.

3. Assessment Methodology

This procedure applies to the preparation of a Route Options noise assessment report to allow a preferred option to be determined where the proposal is likely to result in a new road and/or increased traffic carrying capacity of the existing road infrastructure and/or there are substantial realignments to existing freeways/highways, local roads and/or arterial roads. This procedure should also be read in conjunction with the New South Wales (NSW) Government's RNP.

3.1 Methodology

Step 1 – Project Definition

- Identify the proposed route options to be evaluated between the project start and end points.

- Define an assessment boundary that encompasses the area within 600 metres of all route options centrelines between the project start and end points. If there is a conflict between this requirement, and the project brief, the defined boundary given in the project brief should take precedence. The assessment boundary will also consider all roads throughout the study area where, based on changes in traffic volumes, suggest a change in excess of 1 dB, as discussed in Section 1.

Identify all potentially affected noise sensitive receiver locations within the assessment boundary.

- Obtain topographical information of the area within the assessment boundary.

Step 2 – Determine Traffic Composition

- Obtain the 15 hour and 9 hour traffic volumes, road pavement surfaces, anticipated speed and percentage heavy vehicles composition for the route options for the assessment year (generally 10 years after opening).

- In most cases the existing traffic volumes and the future traffic volumes will be known for both the day and night time periods. If future traffic volumes and composition are unknown, the existing can be used with an appropriate level of assumed growth.

Step 3 - Noise Predictions

- Noise level predictions of the following scenarios are required:

  a) Calculate the future noise levels for the existing no-build route alignment in terms of $L_{Aeq15hr}$ and L_{Aeq9hr} noise levels and use these levels to determine the DNL level. This is called the "future no-build" (or "do minimum") noise level.

  b) Calculate the future noise level for each of the proposed route options in terms of $L_{Aeq15hr}$ and L_{Aeq9hr} noise levels and determine the DNL for each route.

  c) Calculate the difference in noise level between each proposed route alignment and the future no-build route alignment in terms of the DNL levels. This represents the expected change in noise level that would occur after the alternate route is opened to traffic.

- The Calculation of Road Traffic Noise (CoRTN) algorithms or other methodology approved by the regulatory authority should be used to determine the $L_{Aeq15hr}$ and L_{Aeq9hr} noise levels.

- In built-up areas, the width of the study may be reduced to where the noise levels from the project contribute slightly less than half of the total noise level. This is where the project adds no more than 2.0 dB to the total noise level. Confirmation of the existing noise environment can be made following initial modelling and noise measurements.

Step 4 – Determine Number of Dwellings that are Highly Annoyed within the Assessment Area for each Proposed Route Option

- Calculate the DNL for each noise sensitive receiver in the project area for the design year.

- Determine the corresponding "percentage highly annoyed" (%HA) for each receiver using the Miedema and Oudshoorn relationship [4] for road traffic noise below (shown graphically in Figure 1.

$$\%HA = 9.994 \times 10^{-4} (DNL - 42)^3 - 1.523 \times 10^{-2} (DNL - 42)^2 + 0.538 (DNL - 42) \qquad (2)$$

- Sum the %HA for each route option. This total is the number of dwellings predicted to be highly annoyed due to the noise level predicted for the project year (10 years after opening).

Step 5 – Determine Number of Dwellings Affected by Changes in Noise Level

- From the calculated difference in DNL level between each proposed route alignment and the future no-build route alignment determine the number of dwellings affected by an increase in noise level. Note that only the receivers that are affected by an increase in noise level are considered in this Step. This provides both a relative increase assessment consideration, similar to the relative increase assessment limit of the RNP, and a methodology to help protect areas of relative quiet.

- Calculate the total number of dwellings for each option affected by this increase in noise level. The weighting factors represent the percentage of people found to be bothered quite a lot by the increased noise levels [2] and have been derived by from the following relationship, which is also shown graphically in Figure 2.

  Change in % bothered = 21(Change in DNL dB)$^{0.33}$ (3)

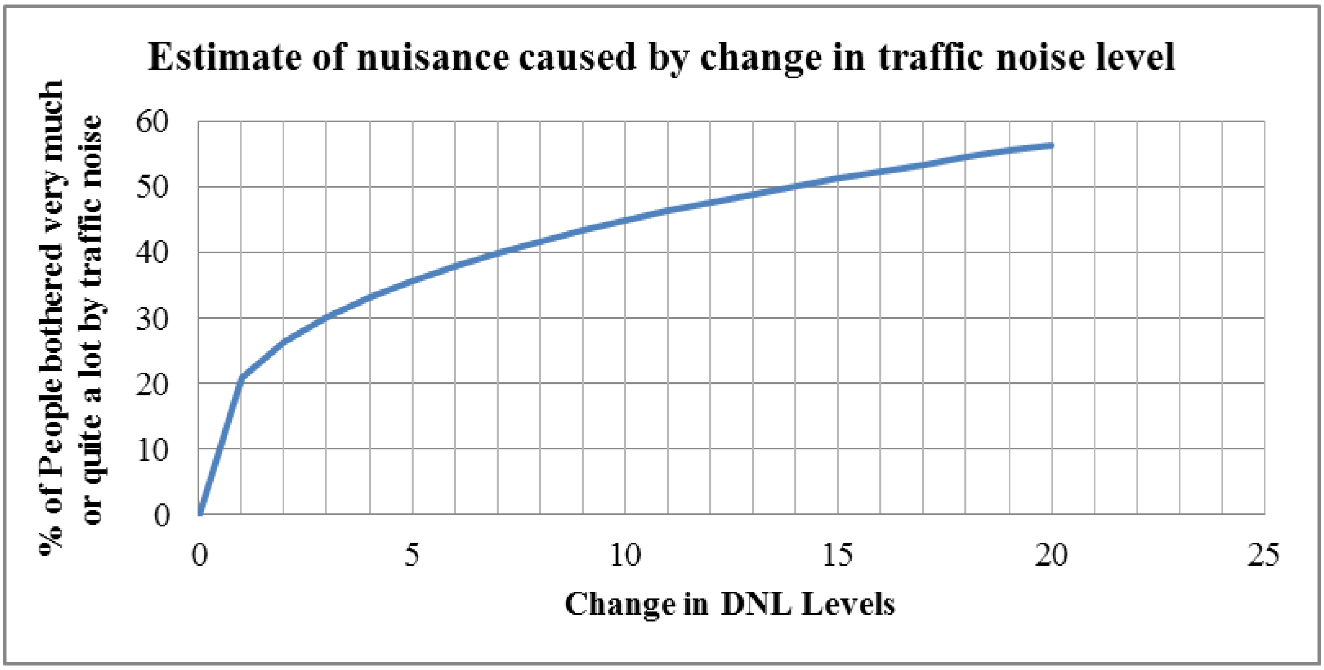

Figure 2. Nuisance caused by change in traffic noise level

Table 1. Calculation of noise nuisance due to steady state road traffic noise and increase in traffic noise levels

Receiver Location	Future No-Build Scenario				Route Option A						Route Option B					
					Nuisance of Steady State Traffic Noise				Nuisance Caused By Increase in Traffic Noise Level		Nuisance of Steady State Traffic Noise				Nuisance Caused By Change in Traffic Noise Level	
	$L_{Aeq,15hr}$	$L_{Aeq,9hr}$	DNL[1]	%HA[2]	$L_{Aeq,15hr}$	$L_{Aeq,9hr}$	DNL	%HA	ΔDNL_3	%HA	$L_{Aeq,15hr}$	$L_{Aeq,9hr}$	DNL	%HA	ΔDNL	%HA
1																
2																
3																
4																
5																
6																
7																
8																
9																
10																
TOTAL				FNB				A1	A2					B1	B2	
OVERALL TOTAL					A (= A1 + A2)						B (= B1 + B2)					

[1] $DNL = 10 \log [(15/24)\times 10^{(LAeq15hr/10)} + (9/24)\times 10^{(LAeq9hr+10)/10}]$
[2] $\%HA = 9.994 \times 10^{-4} (DNL - 42)^3 - 1.523 \times 10^{-2} (DNL - 42)^2 + 0.538 (DNL - 42)$
[3] ΔDNL = DNL of Route Option – DNL of Future "No-Build" scenario

Step 6 – Evaluation of Preferred Route Option

- For each route option, including the future no-build (FNB) scenario, the overall total number of residences highly annoyed is calculated to determine the total annoyance. For example, in Table 1 for route A, the total annoyance is labelled A, and is equal to A1 + A2.

- Rank all the route options, including the future no-build option, in order of the largest weighted number of residences to determine the one with the lowest nuisance value. This will be the preferred route option since it results in the lowest level of annoyance.

- To determine the benefit of each route option relative to the future no-build option, subtract the total weighted level for the future no-build alignment from each route options and multiply each result by -1 and display graphically. The future no-build route will have a value of 0. This last step is required to make the more desirable options positive and the options that have less desirable outcome than the future no-build route, negative. The output will resemble the comparison chart presented in Figure 3.

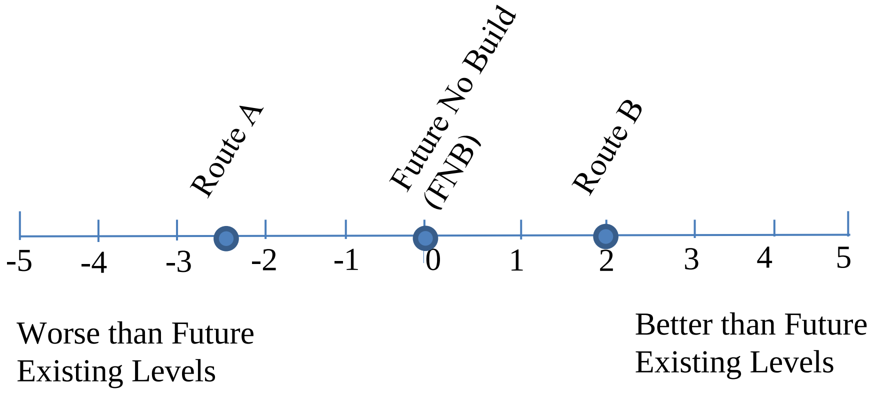

Figure 3. Route comparison results

3. Discussion

The proposed route selection methodology is aimed to provide a transparent process whereby the selection of various routes for a new road can be ranked in terms of their noise impact on affected communities, with a view for the ranking system to be combined with the rankings of other environmental considerations in a multi-criteria assessment framework. The approach relies on the rating of "noise annoyance" to provide a ranking system for the proposed route options. If required, the above rating system can be made compatible with that used for other environmental considerations – for example a common scale is a percentage score. If a percentage score is adopted, the score for the future no-build route should be made to equal 50 and, in the example presented in Figure 3, Route A would score 25, Route B (preferred) would score 70.

References

[1] H.M.E. Miedema and C.G.M. Oudshoorn, "Annoyance from transportation noise: Relationships with exposure metrics DNL and DENL and their confidence intervals", *Environmental Health Perspectives*, **109**(4), 409-416, (2001).

[2] NSW Road Noise Policy, *NSW Department of Environment Climate Change and Water* (DECCW), March 2011.

[3] Design Manual for Roads and Bridges, Volume 11, Environmental Assessment, Section 3, Environmental Assessment Techniques, Part 7 Noise and Vibration, *The Highways Agency*, UK.

[4] Guidance on the Methodology for Multi-Modal Studies (GoMMS), *UK Department of the Environment, Transport and the Regions*, http://www.detr.gov.uk/itwp/mms.