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Further Comparison of Traffic Noise Predictions Using the CadnaA and SoundPLAN Noise Prediction Models

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ABSTRACT

This paper provides an update of information presented in a paper written for the AAS Acoustics 2008 conference in Geelong, Victoria. In particular this paper presents results of traffic noise modeling using CadnaA and SoundPLAN and compares both to noise measurements for three large recent road projects in NSW. CadnaA is a well known and internationally accepted noise modelling package, and its acceptance and use in Australia amongst acoustic professionals is growing fast. To assist the Australian acoustical profession, the appropriateness and accuracy of CadnaA under Australian conditions is currently being verified, and this paper presents actual project results for this purpose.

Unlike CadnaA, the SoundPLAN noise prediction model is extensively used in Australia, particularly for road traffic noise predictions, and has been recognised and accepted nationally by various regulatory authorities including the major road authorities and environmental agencies. The aim of this paper is to provide additional comparative data for predicted traffic noise levels using the Calculation of Road Traffic Noise (CoRTN) algorithms as implemented by SoundPLAN and the CadnaA noise models for three large recent road projects in NSW. These three projects offer features and characteristics that differ significantly from the projects reported in the 2008 paper. Results from this study re-confirm that the CadnaA noise modeling package is accurate and effective for modelling road traffic noise in Australia.

INTRODUCTION

CadnaA is a well known and internationally accepted noise modelling package, and its acceptance and use in Australia amongst acoustic professionals is growing fast. To assist the Australian acoustical profession, the appropriateness and accuracy of CadnaA under Australian conditions is currently being verified. This paper presents actual project results for this purpose.

This paper provides an update of information presented in the paper *'Comparison of Traffic Noise Predictions of Arterial Roads using CadnaA and SoundPLAN Noise Prediction Models'*, *AAS Acoustics 2008, Geelong, Victoria*. In particular this paper presents results of traffic noise modeling using CadnaA and SoundPLAN and compares both to noise measurements for three large recent road projects in NSW.

BACKGROUND

Road traffic noise is predicted using various noise prediction algorithms. In Australia, the noise prediction algorithms that have either been endorsed or are well accepted by regulatory or consent authorities, are the*'Calculation of Road Traffic Noise, 1988'* (CoRTN88) and the *'Federal Highway Administration'* (FHWA) algorithms. Of these noise prediction algorithms, the CoRTN88 algorithm is used most frequently for predicting road traffic noise and is recommended by the national body, Austroads (*Modelling, Measuring and Mitigating Road Traffic Noise* 2005).

Various noise modeling software packages are currently available, which incorporate an option to use CoRTN88 noise algorithms. The SoundPLAN (Braunstein + Berndt GmbH, Germany) noise modeling package includes a road noise module which has a CoRTN88 option, and this package is well accepted throughout Australia as a competent noise modeling package (eg *NSW Industrial Noise Policy* 2000).

For some years now, more and more noise modeling packages have been developed world-wide, and many of these are emerging with state-of-the-art features, improved graphics, improved flexibility and faster running speeds amongst other things. Many of these packages have emerged in the Australian market. One such package is CadnaA (DataKustik GmbH, Germany), which is widely used in Europe for the modeling and preparation of noise maps for cities in accordance with the European Directive on environmental noise (*Directive 2002/49/EC of the European Parliament* 2002). In Australia, CadnaA is relatively new and is currently being reviewed by some regulatory authorities on its ability to predict noise impacts accurately.

The accuracy of a noise model is an integral part of designing road noise mitigation measures, as there are often very strict and specific noise goals that must be met. Recent road project experience in NSW has shown that an accuracy of ±1dB(A) in some circumstances can result in the costs of implementing noise mitigation measures to vary dramatically.

This paper investigates the use of the CadnaA noise modeling software package in terms of its ability to accurately model road traffic noise. It provides comparative data for predicted traffic noise levels using the CoRTN88 algorithms as implemented by SoundPLAN and CadnaA, for three large recent road projects in NSW. These three projects offer physical features and traffic characteristics that differ significantly from the projects reported in the 2008 paper [1].

This paper does not include an assessment of other traffic noise prediction algorithms (eg FHWA) and other software packages (eg LimA, TNM, ENM etc).

DESCRIPTION OF PROJECTS

Project A

Physical Features

Project A is a high-speed, major arterial road running to the north of a suburban residential area. The nearest residential receivers are 200 to 400 m from the main carriageway. The road alignment varies within the study area, running atop two small embankments and through two cuttings approximately 8m deep.

Moderate to high noise barriers, ranging from 4 to 6.5m in height have been incorporated into the project's design along either side of the main carriageway. The noise barriers are 1km to 1.5 km in length.

Traffic Characteristsics

Table 1 presents the traffic volumes, vehicle speeds and composition data entered into the noise models to predict road traffic noise levels. Note the moderate percentage of heavy vehicles during the night period.

Table 1. Hourly traffic data used for Road Project A

	Day	*Night*
Light vehicle volumes	3142	557
Heavy vehicle volumes	376	132
Heavy vehicle %	11	19
Vehicle speed, km/h	115	120

Project B

Physical Features

Project B is a high-speed major arterial road running adjacent to a residential area, but separated from the residential area by a rail corridor. The nearest residential receivers are approximately 100 to 150m from the road. The road alignment runs through a significant cutting approximately 11m deep.

There are two sections of noise wall that run along the edge of the road and partway along the top of the cutting. There is a long gap in the noise wall where the road passes through the deepest part of the cutting. The total length of noise wall within the study area is approximately 4.5km and the wall ranges from 2m to 6m in height.

Traffic Characteristsics

Traffic volumes, speeds and composition data obtained concurrently with the noise monitoring data and used for the validation process are presented in Table 2. Note the moderate-to-high percentage of heavy vehicles during the night period.

Table 2. Hourly traffic data used for Road Project B

	Day	*Night*
Light vehicle volumes	1649	305
Heavy vehicle volumes	338	116
Heavy vehicle %	17	28
Vehicle speed, km/h	115	120

Project C

Physical Features

Project C is a high-speed major arterial road running through several residential areas that are separated by rural land. The residential receivers modelled for validation purposes are within 20m of the alignment at the closest receiver point and just over 300m at the furthest receiver point. The road alignment runs through varied terrain, from relatively flat floodplain to small ranges.

There were no noise walls within the study area for this project.

Traffic Characteristsics

Table 3 presents the night-time (10pm-7am) traffic volumes, vehicle speeds and composition data entered into the noise models to predict road traffic noise levels. Note the high percentage of heavy vehicles.

Table 3. Hourly traffic data used for Road Project C

	Northbound	*Southbound*
Light vehicle volumes	382	463
Heavy vehicle volumes	347	228
Heavy vehicle %	48	33
Vehicle speed, km/h	100	100

Differences between the 2008 Study and this 2010 Study

As with all studies, there are always limits that apply to the studies and their findings. In the case of the 2008 study, there were a number of limitations which were identified in that paper [1]. Those constraints have been addressed with this study in the following manner:

- this study predominantly still applies to arterial roads, however all the three projects contain ramps and adjoining collector and local roads which were mostly included in the modelling
- this study focuses on high vehicle speeds, rather than moderate vehicle speeds as previously assessed
- this study applies to moderate to high percentage levels of heavy vehicles, instead of only low-percentages of heavy vehicles
- this study includes concrete and low-noise (open graded and stone mastic asphalts) road wearing pavements, rather than only dense-graded asphalt pavement as with previous study
- this study includes receiver locations ranging from 10m to 300m from the road, instead of only close to the road
- this study includes areas ranging from flat terrain with no shielding to areas with large cuttings (eg 11m deep) and very tall noise barriers (up to 6.5m high) that pro-

vide large levels of noise shielding, instead of only applying to low to moderate height noise barriers as previously studied

- this study considers areas with both at-road noise barriers and at-property noise barriers, rather than near receivers locations only
- this study includes modeling and monitoring undertaken in the free-field and at 1m from noise receiver building facades, rather than at 1m from receiver facades alone
- this study was conducted at over 160 modelling locations plus an additional 21 locations where both modelling and monitoring was conducted, whereas the previous study was conducted only at 15 locations.

Therefore, this is a much more comprehensive study than the study presented in the 2008 paper. Notwithstanding this point, Renzo Tonin & Associates continue to compare and verify noise models as part of their regular acoustic consulting work on large transport infrastructure projects and other major projects.

NOISE MODELLING METHODOLOGY

Noise levels for these three projects were modelled using a modified three-source-height method that was developed to enable noise from heavy vehicles to be better accounted for. This method appropriately distributes the acoustic energy from three source heights, being at 0.5m (for light vehicle exhausts and tyre/road interface for light and heavy vehicles), 1.5m (for light and heavy vehicle engines) and 3.6m (for heavy vehicle exhausts).

The results presented in this paper are either modelled in the free-field or at 1m from the facades of receiver buildings (ie +2.5dB(A) facade correction applied). The CoRTN88 $L_{A10,1hr}$ algorithm was used and the modelled noise levels were converted to $L_{Aeq,1hr}$ values by applying a -3dB(A) correction. Day $L_{Aeq,15hr}$ and Night $L_{Aeq,9hr}$ noise levels were then derived from these.

COMPARISON OF MODELLED NOISE CONTOUR RESULTS

One way of comparing two noise models is to compare their noise contour outputs. To do this, the same inputs and model settings are critical. In this study the same road design, buildings, land topography and noise barrier details were used in both the CadnaA and SoundPLAN models. Both noise models were run using the following calculation parameters:

- maximum search radius = 1,000m
- grid spacings = 50m
- grid interpolation = 9 x 9
- ground absorption = 0.5
- maximum order of reflection = 1
- receiver height = 1.5m above ground level

To compare the two sets of noise contour maps, Figures 1, 2, 3 and 4 were generated. This was done by taking the output noise contour maps from CadnaA and SoundPLAN, converting the SoundPLAN noise contour files into a format that can be imported into CadnaA, and then opening both within the CadnaA platform to generate contours that show differences between the two sets of noise contour results. These figures show differences between CadnaA and SoundPLAN as follows:

$$\Delta \text{ (Noise Contours)} = \text{CadnaA} - \text{SoundPLAN}$$

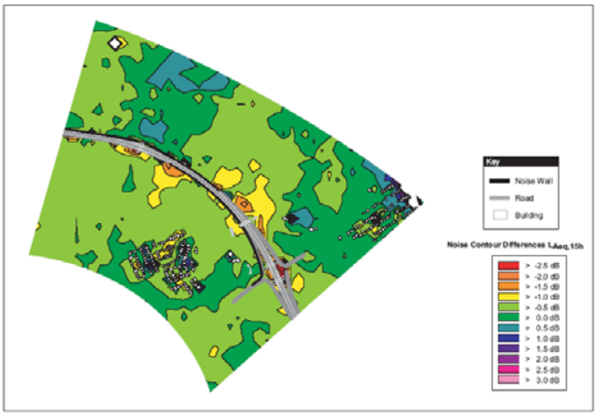

Figure 1. Project A, Day $L_{Aeq15hr}$ Differences

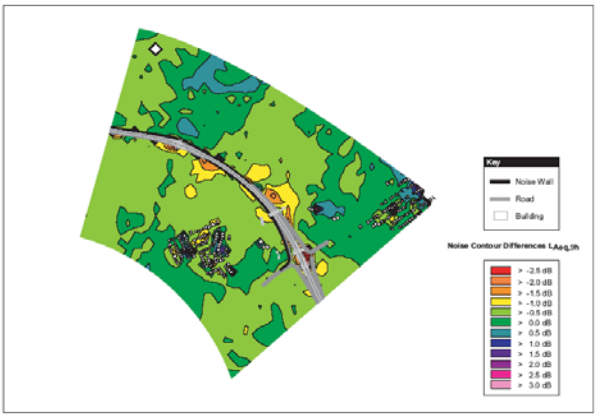

Figure 2. Project A, Night L_{Aeq9hr} Differences

Figures 1 and 2 above, generally show noise level differences between the two noise models to mostly be within 0.5dB(A). Differences in only a few areas nearest to the road reach 1-1.5dB(A).

Figures 3 and 4 below, generally show noise level differences between the two noise models to mostly be within 1.0dB(A). Differences in only a few areas, nearest to the road and amongst buildings in the built up area, reach 1.5-2dB(A). Also seen in the figures, is that CadnaA appears to predict slightly higher noise levels behind the noise barrier on the left hand side of Figures 3 and 4, and at locations nestled in amongst buildings within the built-up area.

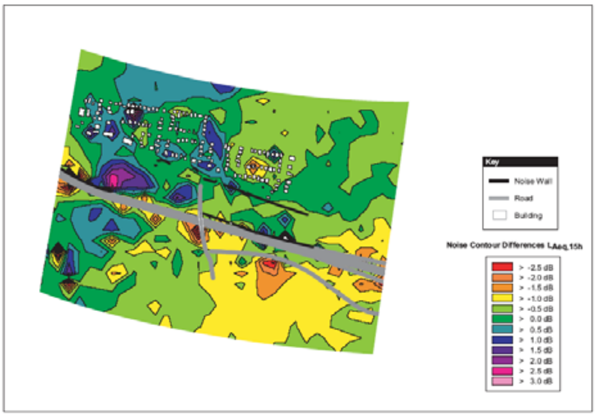

Figure 3. Project B, Day L_{Aeq1hr} Differences

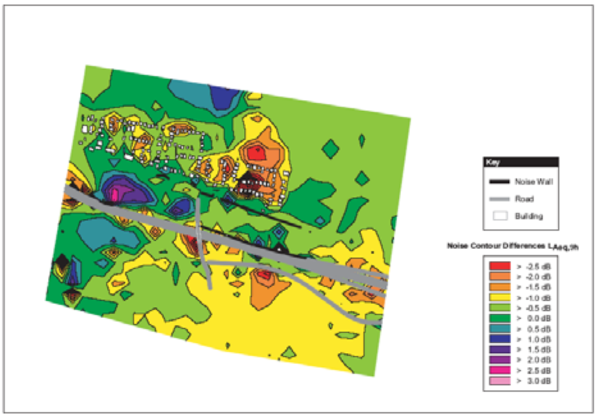

Figure 4. Project B, Night L_{Aeq1hr} Differences

Noise contour difference presented in Figures 1 – 4 above, may be a result of how each model interpolates noise levels and how they generate noise contours graphically. Therefore, to provide a better evaluation by comparison of noise model outputs, single point receiver noise levels between models should be compared, and modelled versus measured noise levels should also be compared.

COMPARISON OF MODELLED RECEIVER NOISE LEVEL RESULTS

To compare single point receiver noise levels between models, the same road design, buildings design, land topography and noise barrier details were used in both the CadnaA and SoundPLAN models.

Over 160 single point receiver locations, all at 1.5m from ground and at distances ranging from approximately 10m to 300m from the road, were modelled in both CadnaA and SoundPLAN, for Project A. Most of these points were modelled as free-field locations in a mix of different positions in relation to shielding from cuttings, barriers and buildings.

Figures 5, 6 and 7 below, graphically present each location's Day $L_{Aeq15hr}$, Night $L_{Aeq15hr}$ and peak hourly L_{Aeq1hr} (day and night) traffic noise level results modelled in both CadnaA and SoundPLAN. These graphs allow a simple comparison to be made between the two models.

Figures 5, 6 and 7 below, show good agreement in the data. As is releveant for most noise receivers along a major road, the bulk of the data fall within the 45-60dB(A) noise level range where there is generally very good alignment of the two noise models, with a few outlying points.

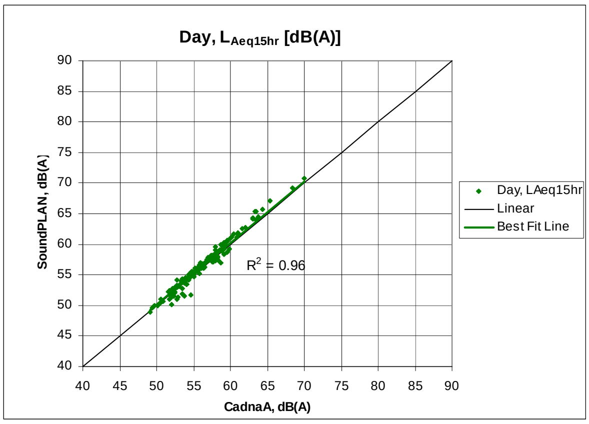

Figure 5. Day, $L_{Aeq15hr}$

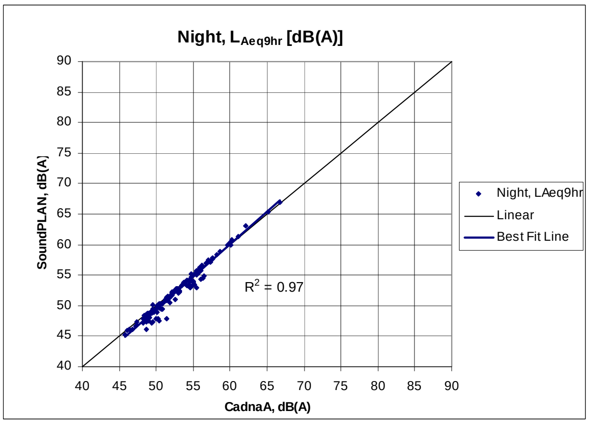

Figure 6. Night, L_{Aeq9hr}

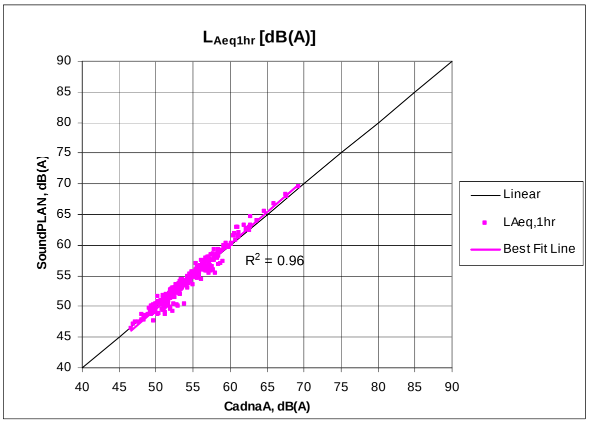

Figure 7. Peak Hourly, L_{Aeq1hr}

In terms of simple regression analysis, the squared correlation coefficient (R^2) is 0.96-0.97 for the day and night levels, and 0.96 for the peak hourly data.

The R^2 values appear to be influenced by data points modelled very far from the road, ie 250-300m which approach the limits where CoRTN88 algorithms cease to reliably predict noise levels. Normally for major road projects the bulk of critical noise receivers that require assessment and noise mitigation are well inside these extreme distances. By removing data points that are close to the working limits of the noise modelling algorithms and leaving only data points at distances from the road where noise affected receivers are typically found, the R^2 was found to improve slightly.

Notwithstanding this, the R^2 values presented above still show that there is an excellent level of fit in the data sets, although an even better fit is achievable for typical receiver distances from the road.

COMPARISON OF MODELLED -V- MEASURED NOISE LEVELS

For Projects A, B and C, noise measurements were conducted whilst concurrently monitoring traffic volumes, vehicle classifications and vehicle speeds. These values were used to verify and calibrate the noise models against actual measurements.

A total of 21 data points, 8 at locations 1m from building facades and 13 at free-field locations are used in this study to carry out a comparison of modelled versus measured noise levels.

Figures 8 and 9 below graphically present the modelled versus measured validation results in terms of L_{Aeq1hr} traffic noise levels as modelled in CadnaA and SoundPLAN, respectively, and prior to calibrating the noise models.

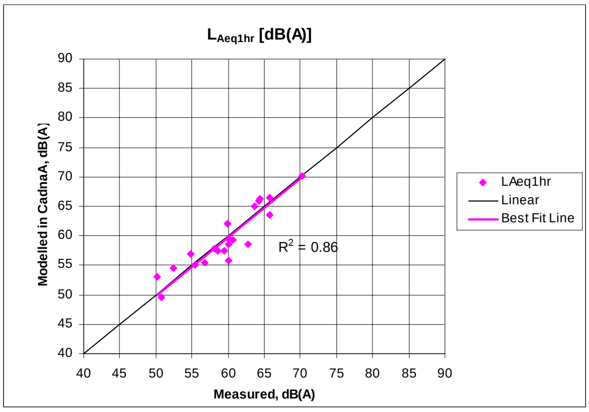

Figure 8. CadnaA Modelled -V- Measured, L_{Aeq1hr}

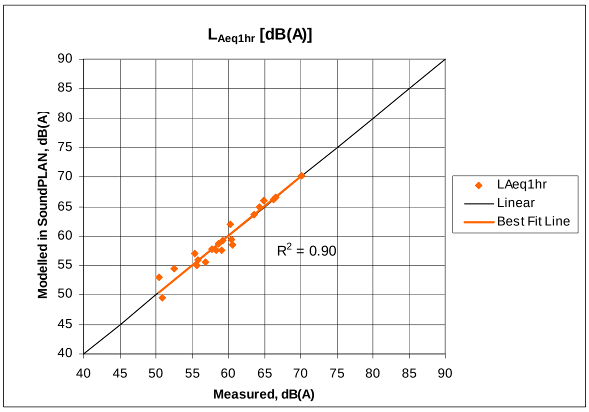

Figure 9. SoundPLAN Modelled -V- Measured, L_{Aeq1hr}

By analysing these graphs a comparison can be made between the two models in terms of their overall accuracy against measured noise levels.

Both Figures above show good agreement between modelled and measured data. In terms of simple regression analysis, the squared correlation coefficient (R^2) is 0.86-0.90 for both models when compared to measured data. This implies that there is a very good level of fit in both data sets and therefore both models are considered to be competent and reliable in modelling traffic noise.

DISCUSSION

Models Compared to Each Other

The findings of this study are that there is generally very good correlation of output results between the CadnaA and SoundPLAN noise models.

For example in the comparison of noise contours, the results generally show that noise level differences between the two noise models tend to mostly fall within 0.5-1dB(A), with only a few isolated areas where differences reach 1.0-2.0dB(A).

Also, in the comparison of receiver noise levels, the results show good agreement between models, with an R^2 of 0.96 to 0.97, which shows an excellent level of fit in the data. By removing data points that are close to the limits of the noise modelling algorithms and leaving only data points at distances from the road where noise affected receivers are typically located, the R^2 was found to improve slightly.

Models Compared to Measurements

In accordance with previous studies and literature (*Interim Traffic Noise Policy* 1992) the accuracy of the CoRTN88 noise algorithms when used to model road traffic noise at facades under Australian conditions is ±2.7dB(A) and ±5.0dB(A) of the true noise level with an 85% and 95% confidence interval, respectively.

With this in mind, the differences presented here between the modelled and measured noise levels for both models, all fall well within the accuracy of the CoRTN88 noise algorithms.

The findings of this comparison show good agreement between modelled and measured data, with an R^2 of 0.86-0.90 for both models when compared to measured data. This implies that there is a very good level of fit in both data sets and therefore both models are considered to be competent and reliable in modelling traffic noise.

CONCLUSION

The overall findings of this reasonably comprehensive noise study show that the CadnaA noise modeling package is as accurate and effective as the SoundPLAN model in modelling road traffic noise.

It also shows that CadnaA is as accurate and reliable as the SoundPLAN model when compared to actual measured noise levels.

Therefore both models are considered competent, reliable and generally accurate in modelling traffic noise in Australia.

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