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Comparison of Traffic Noise Predictions of Arterial Roads using Cadna-A and SoundPLAN Noise Prediction Models

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ABSTRACT

The use of Cadna-A is widely accepted in Europe as a tool for predicting noise from various types of sources, including traffic noise. However, traffic noise modeling using Cadna-A is still in the early stages of acceptance in Australia and as such the appropriateness and accuracy of Cadna-A for Australian conditions is currently being verified. Unlike Cadna-A, 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 compare predicted traffic noise levels using the Calculation of Road Traffic Noise (CoRTN) algorithms as implemented by SoundPLAN and the Cadna-A noise models for a proposed arterial road and an existing arterial road. A validation of both noise modeling packages is also conducted based on actual measurements of traffic noise from an existing arterial road and compared to one another.

Results from this study show that the Cadna-A noise modeling software package is as accurate and effective as the SoundPLAN model in modeling arterial road traffic noise.

INTRODUCTION

Road traffic noise along arterial roads is a major environmental noise problem in Australia. More so during recent years where the construction of new arterial roads through 'green-field' areas and the upgrade of existing arterial roads to increase their traffic carrying capacity, results in increased road traffic noise impacts on neighbouring noise-sensitive receivers.

As it is important to build new and upgrade existing arterial roads, it is also important to protect noise-sensitive receivers from adverse noise impacts. Predictions of future noise impacts from new or upgraded roads are therefore required to be as accurate as possible to allow for the design of noise mitigation measures to reduce road traffic noise to levels that meet the noise goals set by relevant policies and guidelines in a cost-effective manner. The accuracy of a noise model is therefore an integral part of designing roads to meet the relevant noise goals. Recent road project experienced in NSW has shown that an accuracy of $\pm$1dB(A) in some circumstances can result in the costs of implementing noise mitigation measures to vary dramatically.

Road traffic noise is predicted using various noise prediction algorithms. In most states and territories in Australia, the noise prediction algorithms that have either been endorsed or are well accepted by their relevant 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 utilise the CoRTN88 noise algorithms. The SounPLAN (Braunstein + Berndt GmbH, Germany) noise modeling software package uses the CoRTN88 noise algorithms to model road traffic noise, and this pacakage is well accepted throughout Australia as a competent noise modeling software package (eg *NSW Industrial Noise Policy* 2000).

In recent years, new noise modeling software packages have been made available to Australia. One such package is Cadna-A (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). However, in Australia, Cadna-A is fairly new and is currently being reviewed by some regulatory authorities on its ability to predict noise impacts accurately.

This paper investigates the use of the Cadna-A noise modeling software package in terms of its ability to accurately model road traffic noise. Noise models for a proposed arterial road and for an existing arterial road, both recent projects of Renzo Tonin & Associates, were developed in both the Cadna-A and SoundPlan software packages using the CoRTN88 algorithms. The results of both noise modeling packages were compared to one another and were also compared against actual noise measurements for the existing road scenario. This paper does not include an assessment of other traffic noise prediction algorithms (eg FHWA) and other software packages (eg TNM and ENM).

METHODOLOGY

Proposed arterial road

An intial investigation to compare Cadna-A with SoundPLAN was undertaken on a recent road traffic noise project undertaken by Renzo Tonin & Associates involving a proposed arterial road and a proposed adjacent residential subdivision with a set design for the road, buildings, land topography and noise barriers. The same road design, buildings design, land topography and noise barrier details were used in both the Cadna-A and SoundPLAN models. Figures 1 and 2 below present the three-dimensional image of the SoundPLAN and the Cadna-A models, respectively.

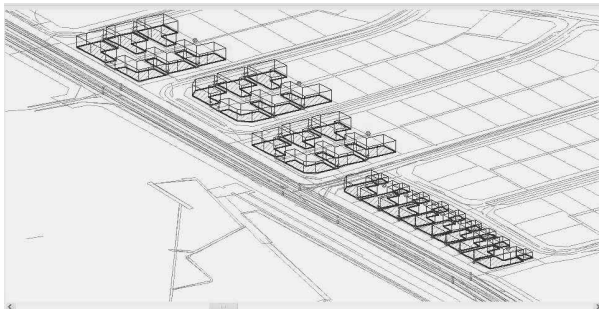

Figure 1. SoundPLAN noise model for proposed road

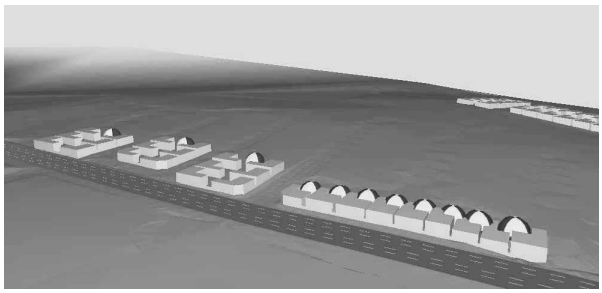

Figure 2. Cadna-A noise model for proposed road

Table 1 presents the traffic volumes, vehicle speeds and composition data entered into the noise models to predict road traffic noise levels.

Table 1. Hourly traffic data used for proposed road

	Westbound	Eastbound
Light vehicle volumes	839	837
Heavy vehicle volumes	26	27
Heavy vehicle %	3%	3.1%
Vehicle speed, km/h	70	70

With the Cadna-A and SoundPLAN models prepared and the traffic information entered, road traffic noise predictions using both noise models were undertaken at eleven (11) noise sensitive receiver locations.

Predicted road traffic noise levels at each receiver location for the Cadna-A and SoundPLAN models were compared and the difference in noise levels between the two provided an indication of the accuracy of the Cadna-A model against the well-accepted SoundPLAN noise model.

Existing arterial road

A further analysis was undertaken on an existing arterial road based on a previous road traffic noise project undertaken by Renzo Tonin & Associates. Cadna-A and SoundPLAN noise models were developed using identical road design details, location of existing noise sensitive receivers and the existing land topography. Three-dimensional images of the SoundPLAN and Cadna-A models are presented in Figures 3 and 4, respectively.

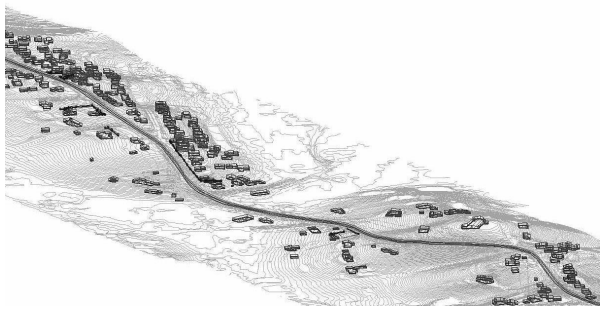

Figure 3. SoundPLAN noise model for existing road

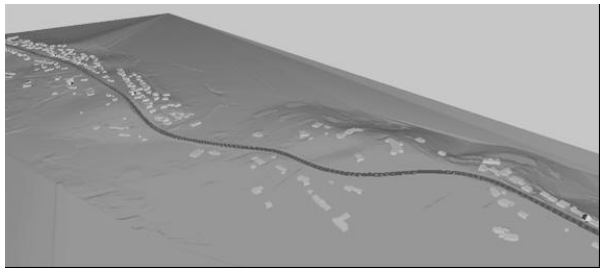

Figure 4. Cadna-A noise model for existing road

Road traffic noise monitoring was conducted at four (4) noise-sensitive receiver locations. Based on the monitored results, the Cadna-A and SoundPLAN models were compared and validated to determine their accuracy against actual measured noise levels. Traffic volumes, speeds and composition data obtained concurrently with the noise monitoring data and used for the validation process are presented in Table 2.

Table 2. Hourly traffic data for validation process

	Westbound	Eastbound
Light vehicle volumes	590	593
Heavy vehicle volumes	21	26
Heavy vehicle %	3.4%	4.2%
Vehicle speed, km/h	65	65

A further comparison of the validation results between the Cadna-A and SoundPLAN noise models was undertaken to quantify the difference between the noise models and to determine how accurate Cadna-A is in predicting road traffic noise in comparison to SoundPLAN.

RESULTS

Proposed arterial road

The Cadna-A and SoundPLAN road traffic noise modeling results at eleven (11) locations for the proposed road are presented in Table 3 below. These locations are spread out over distances of 33 to 75m from the nearest kerb and are shielded by noise barriers of 1.8 to 2.1m in height positioned at the sub-division's boundary.

The difference in road traffic noise levels are also shown in Table 3 to allow for a direct comparison between the two noise modeling software packages.

Table 3. SoundPLAN and Cadna-A outputs, Leq, dB(A)

Receiver	SoundPLAN output	Cadna-A output	Difference (SP - Cadna)
R1	52.7	52.1	0.6
R2	52.3	51.5	0.8
R3	52.4	51.9	0.5
R4	51.4	51.2	0.2
R5	51.1	50.9	0.2
R6	51.3	51.1	0.2
R7	50.9	50.7	0.2
R8	50.9	50.8	0.1
R9	50.5	50.3	0.2
R10	50.5	50.4	0.1
R11	51.8	51.8	0

The results presented in Table 3 were modeled 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 Table 3 were all modeled at 1m from the facades of receiver buildings using the CoRTN88 $L_{A10,1hr}$ algorithm with a +2.5dB(A) facade correction. These noise levels were then converted to $L_{Aeq,1hr}$ values by applying a -3dB(A) correction.

Existing arterial road

For the existing arterial road situation, modeled road traffic noise levels used for the validation process at the four (4) noise monitoring locations, are presented in Tables 4 and 5 for the SoundPLAN and Cadna-A models, respectively. These locations were over distances of 19 to 66m from the nearest kerb of the road. The difference between the modeled road traffic noise level and the monitored road traffic noise level for each location were calculated to determine the accuracy of the noise models to actual measured noise levels.

Table 4. SoundPLAN model validation, Leq, dB(A)

Receiver	Monitored noise level	SoundPLAN output	Difference (SP - Monitored)
R1	52.2	52.4	0.2
R2	60.8	63.3	2.5
R3	57.3	58.7	1.4
R4	65.2	63.9	-1.3

Table 5. Cadna-A model validation, Leq, dB(A)

Receiver	Monitored noise level	Cadna-A output	Difference (Cadna - Monitored)
R1	52.2	52.0	-0.2
R2	60.8	62.4	1.6
R3	57.3	59.4	2.1
R4	65.2	62.7	-2.5

A further comparison (Table 6) of the road traffic noise levels modeled in the above validation process was undertaken to determine the differences of the Cadna-A model when compared to the SoundPLAN model.

Table 6. Comparison of SoundPLAN and Cadna-A, Leq, dB(A)

Receiver	SoundPLAN output	Cadna-A output	Difference (SP - Cadna)
R1	52.4	52.0	0.4
R2	63.3	62.4	0.9
R3	58.7	59.4	-0.7
R4	63.9	62.7	1.2

The results presented in Tables 4, 5 and 6 were also modeled using the 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 Tables 4, 5 and 6 were also all modeled at 1m from the facades of receiver buildings using the CoRTN88 $L_{A10,1hr}$ algorithm with a +2.5dB(A) facade correction. These noise levels were then converted to $L_{Aeq,1hr}$ values by applying a -3dB(A) correction.

DISCUSSION

Results presented for the comparison of the modeled road traffic noise levels between SoundPLAN and Cadna-A for a proposed arterial road, indicate that road traffic noise levels modeled by Cadna-A are in good agreement with the noise levels modeled in SoundPLAN at all receiver locations. Differences of nil to 0.8dB(A) were calculated, which are considered insignifcant when comparing modeled noise levels. Interestingly for this proposed situation, SoundPLAN generally modeled slightly higher noise levels than Cadna-A.

For the existing road situation, the SoundPLAN noise model modeled road traffic noise levels that were within 2.5dB(A) of the actual road traffic noise levels measured at the noise monitoring receiver locations. For the Cadna-A noise model, predictions were also within 2.5dB(A) of the actual road traffic noise levels measured at the noise monitoring locations. As for the proposed road, in general SoundPLAN also modeled slightly higher noise levels than Cadna-A in this existing road study.

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 $\pm$2.7dB(A) and $\pm$5.0dB(A) of the true noise level with an 85% and 95% confidence interval, respectively. With this in mind, the differences between the modeled and measured noise levels, as presented in Tables 5 and 6, all fall well within the accuracy of the CoRTN88 noise algorithms for both the SoundPLAN and Cadna-A road traffic noise models.

Furthermore, from Table 6, road traffic noise levels predicted using the Cadna-A model were shown to be within 1.2dB(A) of the predicted SoundPLAN model results for the existing main arterial road investigation. That is, Cadna-A modeled road traffic noise levels are generally in good agreement with the levels predicted using SoundPLAN.

Therefore, based on the arterial road noise studies reported here, the accuracy of the Cadna-A noise modeling software package is shown to be in line with the accuracy of the

SoundPLAN noise modeling software package. Also the modeled road traffic noise levels using Cadna-A when compared to the measured noise levels are shown to fall well within the documented 85% confidence interval of the CoRTN88 algorothm, and so Cadna-A is considered to have an acceptable level of accuracy.

LIMITATIONS & FUTURE WORK

As with all studies, there are always limits that apply to the studies and their findings. In this case, the study and its findings may be limited by the following for both situations:

- applicable to arterial roads,
- applicable to moderate vehicle speeds,
- applicable to low-percentages of heavy vehicles,
- applicable to dense-graded asphalt road pavement type,
- applicable for receiver locations reasonably close to the road,
- applicable to dry, relatively calm and isothermal atmospheric conditions that existed at the time of noise monitoring,
- nil to moderate height noise barriers,
- noise barriers only at receiver locations,
- modeling and monitoring undertaken at 1m from noise receiver building facades, and
- study was conducted at only a total of 15 receiver locations.

Further work is being undertaken by Renzo Tonin & Associates to provide aditional verification and validation data for the Cadna-A noise modeling software package under Australian conditions. This further work includes additional comparisons of modeling and measured results at more distant receiver locations, modeling of roads with high percentages of heavy vehicle traffic and modeling of roads with high roadside noise barriers.

CONCLUSION

Noise modeling using the Cadna-A and the SoundPLAN noise modeling software packages were undertaken for a proposed arterial road and an existing arterial road.

Results for the proposed road situation showed good agreement between the noise prediction results of the Cadna-A model and the SoundPLAN model.

For the existing road situation, the validations conducted for Cadna-A and SoundPLAN modeled noise levels against measured noise levels, indicated that the differences between the modeled and the measured noise levels fall within an acceptable level of accuracy of what is expected from the CoRTN88 noise algorithm. Furthermore, modeled noise levels between the Cadna-A and SoundPLAN models were generally in good agreement with each other.

Therefore, the overall findings of this noise study show that the Cadna-A noise modeling software package is as accurate and effective as the SoundPLAN model in modeling arterial road traffic noise.

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