



Risks of optimising the Kilde 67/130 calculations in SoundPLAN

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ABSTRACT

The Kilde calculation algorithm is used in most of Australia for rail noise modelling. Large noise models are often required to be calculated which can take a long time. Changing the default settings in SoundPLAN is a possible method to get SoundPLAN to calculate results faster. Reducing the reflection order for the calculation of the $L_{\max}$ noise descriptor could be reasoned as an appropriate method as the direct line of sight or the noise path having only one reflection (rather than 2 or 3 reflections) is the noise path resulting in the highest noise level at a receptor point.

Noise modelling showed that both the predicted L_{eq} and $L_{\max}$ noise descriptor varied significantly depending on the number of reflections used in the calculations. SoundPLAN users should understand the risk of changing the default SoundPLAN settings.

1 INTRODUCTION

Noise modelling was undertaken for a project that included a section of rail. The reflection order in the SoundPLAN 8.2 Calculation Kernel was changed to reduce the calculation time as the model had to be run several times. Upon review of the results, it was noted that the noise level at the same receptor point varied by more than 5 dB, where the only change between model runs was a change in the reflection order.

Further investigations were undertaken to determine if these variations could be expected based on the Kilde documentation or if this variation was a result of the SoundPLAN implementation of Kilde Report 67/130.

2 REVIEW OF MODELLING METHODOLOGY

Kilde Report 67 and Kilde Report 130 were reviewed. Both documents provide information and formulas for calculating noise emission levels of train passbys. Both documents use a reference train travelling on a straight track and then provides information for how to handle screening, reflections, terrain, train types, ground absorption and so forth.

2.1 Kilde Report 67

Kilde Report 67 is a document that provides a method of predicting noise levels adjacent to a rail track. The document was prepared to help with noise planning in Scandinavian countries. The authors undertook noise measurements at various distances from rail tracks and of different types of trains, trains speeds and so forth. These measurements were plotted on figures and best fit curves were plotted allowing readers to predict noise levels at a location by graph readings. The location was sometimes referred to as location M. Several graphs or diagrams are used to determine noise corrections based on various properties. These properties are items such as train type, length, speed, track conditions, ground terrain, ground absorption and others. It should also be noted that the maximum noise level corresponds to noise meter time weighting set to slow.

In Section 5 "The Maximum Noise Level" of Kilde Report 67 there is an example where the maximum noise level at location M is calculated at two train positions of a train track where screening occurs between the shortest distance between track and location M and no screening is present where the distance between location M and the train is larger. The highest of the two calculated noise levels is used as the maximum noise level at location M. The document further states: "In more complicated geometries, it may be necessary to make calculations for more than two train positions".

2.2 Kilde Report 130

Kilde Report 130 conveys the same information as Kilde Report 67, however the graphs shown in Kilde Report 67 have been converted into formulas such that noise predictions can be undertaken using a computer or calculator. The Kilde Report 130 acknowledges that some of the equations do not correspond exactly to the figures

presented in Kilde Report 67 but that the differences are within a few tenths of a dB in most cases. Kilde Report 130 also states that the measure of the maximum noise level of a passing train is registered with a dBA “slow” meter setting.

The equations for L_{eq} and L_{max} rail noise predictions from an infinitely long, straight and level track as outlined in the Kilde Report 130 are presented below. Equation 1 presents the equation for determining the 24-hour energy equivalent noise level. Equations 2, 3 and 4 present the formulas for determining the maximum noise level.

$$L = 50 + 10 \log \left(\frac{l_{24}}{1000} \right) - 10 \log \left(\frac{a}{100} \right) \quad (1)$$

Where L = the reference noise level, being the 24 hour L_{eq} level in dBA (=50dBA at 100m with 1000m train/24hours travelling at 80 km/h).
 a = perpendicular distance from the track centre line to the prediction position in meters.
 l_{24} = total train length of all passing trains in a typical 24 hour period, in meters.

$$\hat{L} = 10 \log \left(10^{\Delta L_1/10} + 10^{\Delta L_2/10} \right) \quad (2)$$

$$\Delta L_1 = 92 - 10 \log \left(\frac{a}{10} \right) + 10 \log \left(\arctan (l_t/(2a))/1.37 \right) \quad (3)$$

$$\Delta L_2 = 50 - 20 \log \left(\frac{a}{10} \right) + (44 - 100/\sqrt{l_t})(3/\sqrt{a}) \quad (4)$$

Where $\hat{L}$ = the reference maximum noise level for a train travelling at 80 km/h.
 l_t = train length, including locomotive in meters.
 a = the perpendicular distance from the track, as described above. The distance should be set to b when appropriate (note that Kilde Report 67 provides an explanation of the distance b).

2.3 SoundPLAN Implementation

The SoundPLAN 8.2 user manual does not provide any information of how Kilde 67/130 has been implemented into the software; however, the SoundPLAN 6.3 user manual from 2005 provides a description of how the “Nordic Rail Prediction Method Kilde Report 130” has been implemented in SoundPLAN.

The manual states that there are small changes in some formulas, and that the SoundPLAN implementation is based on extra definitions of the developers of the standard, DELTA of Lyngby, Denmark.

The manual states that SoundPLAN calculates the noise levels for every degree of angle with angular increments fixed to 1 degree. The L_{eq} descriptor is determined as the summation of all the results from every angle. The determination of the L_{max} noise descriptor appears to be more complicated than just determining the maximum noise levels at the receiver position. The SoundPLAN documentation explains that the maximum noise level is determined by adding the values of maximum noise levels caused by the railroad car of each angle with the reflected components of the noise generated in this angle. The documentation also mentions that the length of the train is considered in the determination of the maximum noise level and that interpolation is used in the calculation.

The SoundPLAN documentation also advises that some deviations from the “Nordic Rail Prediction Method” has been incorporated into the implementation of the rail noise prediction method. However, these deviations are not related to reflections of buildings or barriers.

2.4 ISO 9613-2

ISO 9613-2 attenuation of sound during propagation outdoors Part 2, was also reviewed. This standard describes noise prediction methods for complex geometries. The formulas for noise predictions due to screening or obstacles are considerably more detailed compared to the formulas presented in the Kilde Report 130. This noise prediction method has been updated in 2024 and is expected to provide more accurate noise predictions in complex geometry situations compared to the Kilde 67/130 prediction method.

3 MODELLING SCENARIOS

The difference in predicted noise levels with different reflection orders was initially observed in a complex noise model. Both simple and complex noise models were created to determine if the cause of these differences could be determined.

The following noise models were created:

1. Flat earth with point receivers
2. Flat earth with point receivers and barriers

3. Flat earth with buildings and façade attached receivers
4. Model with complex ground contours with buildings and façade attached receivers
5. Complex ground contours with barriers, buildings and façade attached receivers

Table 1 presents the settings used in the noise models.

Parameter	Value
Ground absorption, α	0
Number of trains	10
Train length, L (m)	100
Train speed, v (km/h)	80
L_{eq} correction, C_{Leq} (dB)	0
Engine correction, C_{Eng} (dB)	-99
Wagons correction, C_{Wag} (dB)	0
Track length, L_t (m)	13160
Search radius, S_r (m)	5000
Assessment duration, t (hours)	24
Number of buildings	433

The duration of the various calculations was noted to investigate the reduction in calculation time when reducing the reflection order.

4 RESULTS

4.1 Simple Noise Model

The predicted noise levels for a 13km long straight track with a calculation search radius of 5000 m predicted expected noise levels at free field receptors situated at the halfway point of the rail track. Table 2 shows the predicted noise levels for the flat earth situation with free field receptors situated at a height of 2 m above the ground for various reflection orders.

Table 2: Predicted noise levels for a flat earth model without structures

Reflection order	0	1	2	3	4	0	1	2	3	4
Distance between receptor point and rail track	Predicted L_{eq} noise level, dBA					Predicted L_{max} noise level, dBA				
10 m	59.9	59.9	59.9	59.9	59.9	91.9	91.9	91.9	91.9	91.9
15 m	58.2	58.2	58.2	58.2	58.2	89.9	89.9	89.9	89.9	89.9
20 m	57.0	57.0	57.0	57.0	57.0	88.3	88.3	88.3	88.3	88.3
25 m	56.0	56.0	56.0	56.0	56.0	87.1	87.1	87.1	87.1	87.1
50 m	53.0	53.0	53.0	53.0	53.0	82.6	82.6	82.6	82.6	82.6
100 m	49.9	49.9	49.9	49.9	49.9	77.4	77.4	77.4	77.4	77.4
200 m	46.9	46.9	46.9	46.9	46.9	71.6	71.6	71.6	71.6	71.6
400 m	43.7	43.7	43.7	43.7	43.7	65.7	65.7	65.7	65.7	65.7

Table 2 shows that the noise levels do not change as a result of varying reflection orders. This is expected as the model used for the calculations does not have any structures that the noise can reflect off.

The model further shows that the predicted L_{eq} noise level 100 m from the track is 49.9 dBA and that the predicted L_{max} noise level is 91.9 dBA 10 m from the rail track. Both predicted noise levels are 0.1 dB less than the expected noise level outlined in the Kilde Report 130. However, this minor discrepancy is considered insignificant and may be attributed to the receptor height.

Eight noise reflective barriers were included in the model, everything else remained the same. Figure 1 shows the schematic of the noise model. Note that another three receptors were situated above the 50 m receptor point, although these are not shown in Figure 1. These three receptors were situated 100m, 200 m and 400 m from the rail track.

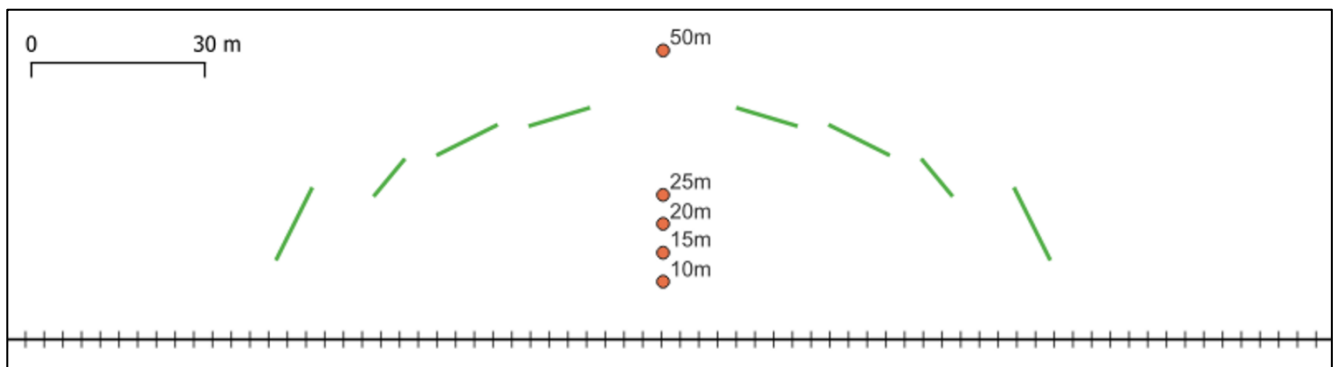


Figure 1: Predicted L_{max} noise levels along the rail track with reflection order 3

Table 3 shows the predicted noise levels for the free field receptors for the flat earth model but with eight reflective barriers situated between 10 m and 40 m from the rail track.

Table 3: Predicted noise levels for a flat earth model with eight reflective noise barriers

Reflection order	0	1	2	3	4	0	1	2	3	4
Distance between receptor point and rail track	Predicted L_{eq} noise level, dBA					Predicted L_{max} noise level, dBA				
10 m	59.9	60.2	60.2	60.2	60.2	91.9	92.1	92.1	92.1	92.1
15 m	58.2	58.6	58.6	58.6	58.6	89.9	90.4	90.4	90.4	90.4
20 m	56.8	57.4	57.4	57.4	57.4	88.3	89.0	89.0	89.0	89.0
25 m	55.7	56.6	56.6	56.6	56.6	87.1	88.0	88.0	88.0	88.0
50 m	52.3	52.6	52.7	52.7	52.7	82.6	82.7	82.8	82.8	82.8
100 m	49.2	49.3	49.3	49.3	49.3	75.9	76.0	76.0	76.0	76.0
200 m	46.5	46.5	46.6	46.6	46.6	70.6	70.6	70.8	70.8	70.8
400 m	43.6	43.6	43.6	43.6	43.6	65.4	65.4	65.4	65.4	65.4

Table 3 shows that the predicted noise level increases with the number of reflections for some of the receptor points. The largest increase is at the receptor point situated 25 m from the track. This receptor point has a predicted noise increase of 0.9 dB when comparing a reflection order of 0 to a reflection order of 1.

It is also noted that the L_{max} noise level for the receptor point located 50 m from the track is predicted to increase by 0.1 dB when comparing a reflection order of 0 to a reflection order of 1 and then increase another 0.1 dB when comparing a reflection order of 1 to a reflection order of 2. This is despite this receptor point having an unobscured view of the rail track where the distance between this point and the track is the shortest. This shows that the number of reflections used in the calculations of the L_{max} noise descriptor influences the predicted noise levels in situations where there are structures noise can reflect of.

Modelling results shows that reflective structures result in different predicted noise levels where different reflection orders are used in the calculation of noise levels.

4.2 Complex Noise Model

A cluster of 433 buildings with a 1 dB façade reflection loss (the default SoundPLAN façade reflection loss building setting) were included in the noise model. Approximately the same number of buildings were placed on either side of the rail track. The model was a flat earth noise model without any noise barriers. Noise levels were calculated 1 m from all the facades using reflection orders between 0 and 4. Noise levels were calculated at 3657 facades.

A histogram showing the difference between 3 and 1 reflections for the L_{max} noise descriptor is shown in Figure 2.

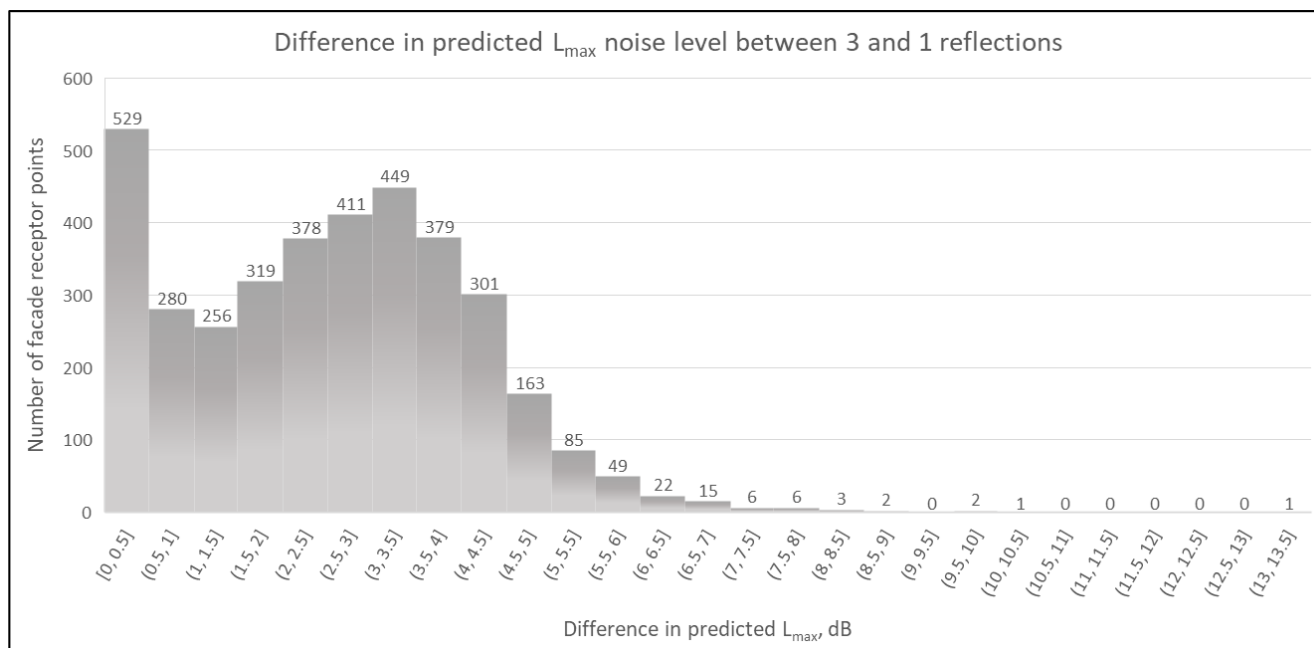


Figure 2: Difference in predicted L_{max} noise levels for a reflection order of either 3 or 1

The difference of the L_{eq} noise descriptor between 3 and 1 reflections is shown in Figure 3.

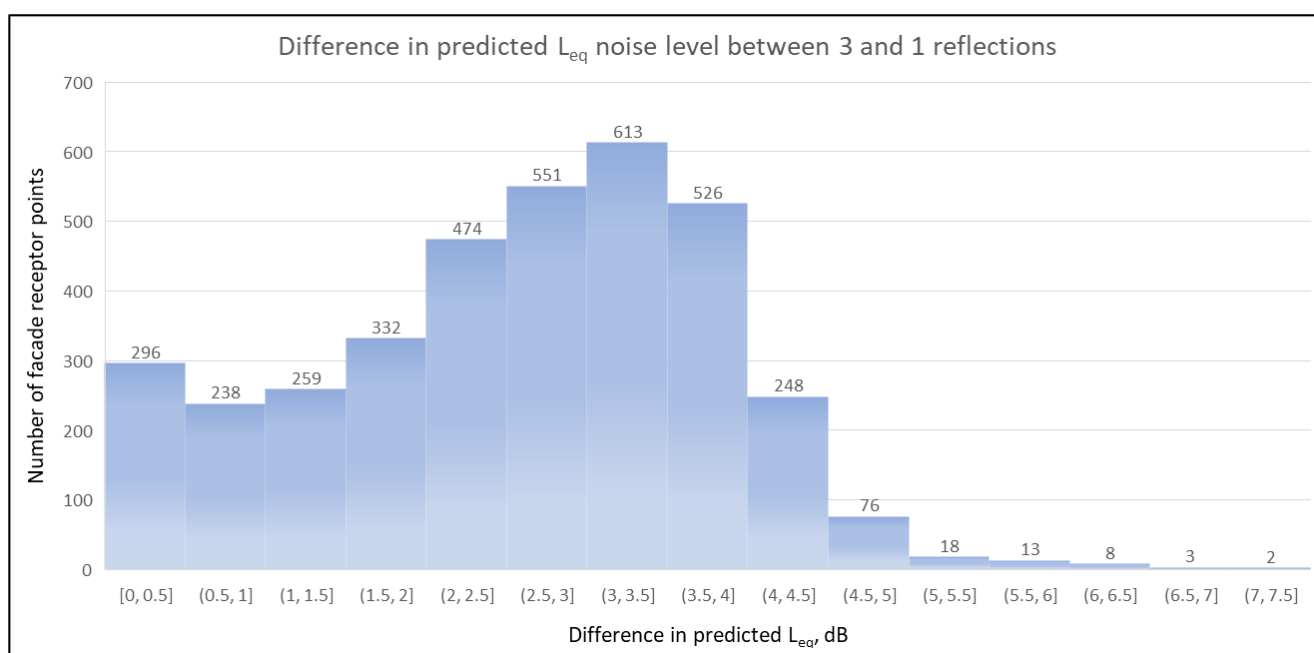


Figure 3: Difference in predicted L_{eq} noise levels for a reflection order of either 3 or 1

Figures 2 and 3 show that the predicted difference is positive, that is noise levels predicted using a reflection order of 3 are greater or equal to a predicted noise level using a reflection order of 1. The figures also show that more than half of the receptor points have a predicted difference greater than 2.5 dB as a result of the number of reflections used in the noise calculations.

Noise models for prediction of rail noise are typically created to determine existing noise levels along a rail track or to determine required mitigation measures to achieve a noise limit. In most cases the noise limit is independent of the distance to the rail track, and where if compliance can be achieved on the façades facing the rail track for the buildings nearest to the rail track, then compliance is generally achieved at buildings situated further from the track. The predicted noise levels were therefore presented on a map to investigate the location of noise level differences as a result of the reflection order.

The difference in predicted noise levels between 3 and 1 reflections was divided into five equal sized bins and plotted. Figure 4 shows the difference in predicted L_{max} noise levels at all assessed façades. The figure shows

that the 20% or the calculated differences are less than 1 dB and that 20% of the calculated differences between 3 and 1 reflections are greater than 3.9 dB. The largest difference was 13.4 dB.

Figure 4 shows that the difference in predicted $L_{\max}$ noise levels between the 3 and 1 reflections is less than 1 dB on the facades facing the rail track. Further analysis showed that the difference on the facades facing the rail track ranged from 0.2 and 0.5 dB for 95% of the receptors between the 3 and 1 reflection order calculations.

The differences between the 3 and 1 reflections of the L_{eq} noise descriptor were also assessed. The largest difference was found to be 7.4 dB. The lowest fifth of the differences were determined to be between 0 dB and 1.4 dB. The 20% largest differences ranged from 3.7 dB to 7.4 dB. The map showing the location of the differences is not presented in this paper, but the distribution of differences is very similar to the distribution shown in Figure 4.

Figure 4 shows that the difference in predicted noise levels on building facades facing the rail track on the first row (the row of buildings adjacent to the rail track) do not differ significantly as a result of varying reflection orders. This would generally expect to be the receptor points that would be assessed for compliance.

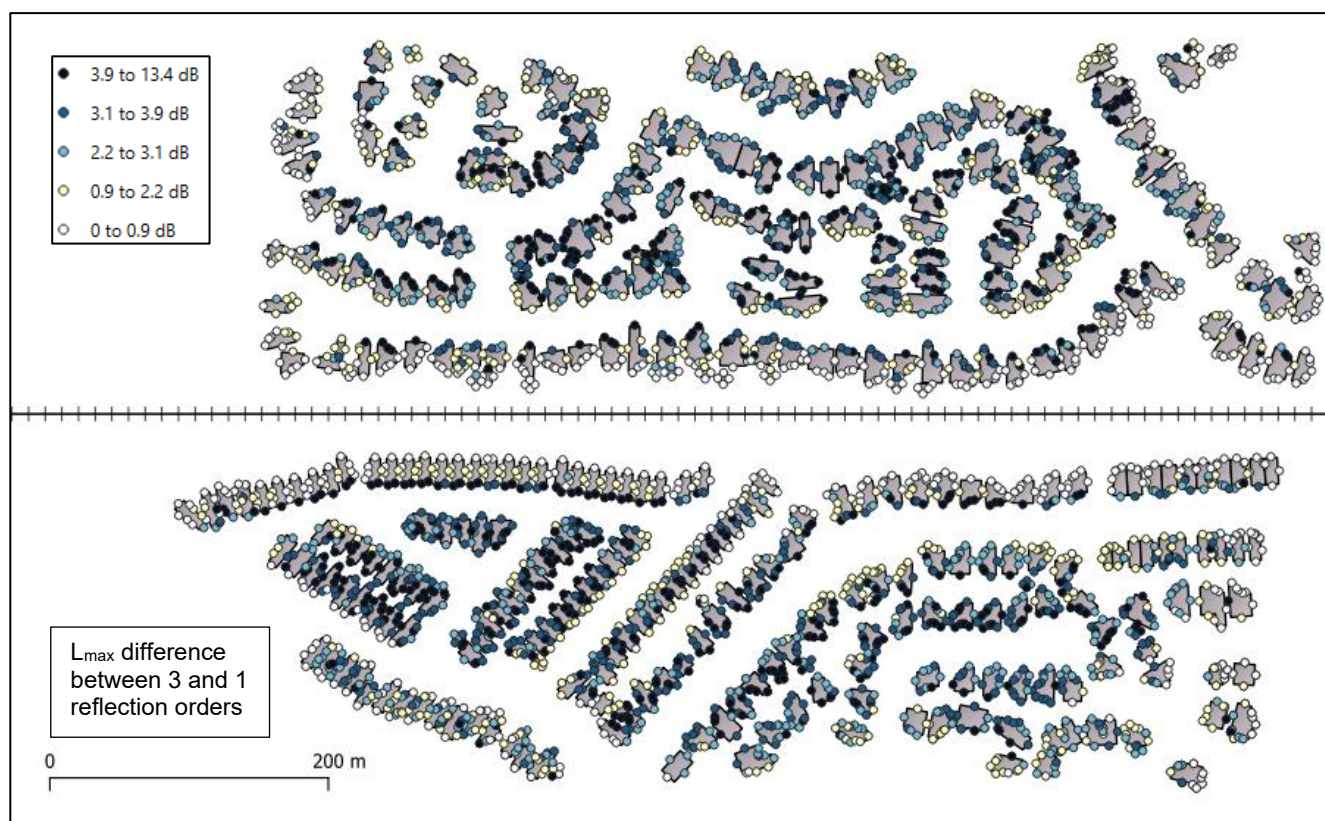


Figure 4: Predicted difference in $L_{\max}$ noise levels due to a reflection order of either 3 or 1

The overall predicted noise levels were assessed to investigate if the predicted noise levels appeared reasonable. Figure 5 shows the predicted $L_{\max}$ noise levels for the flat earth noise model for a reflection order of 3. Figure 6 shows the same noise prediction but calculated with a reflection order of 1.

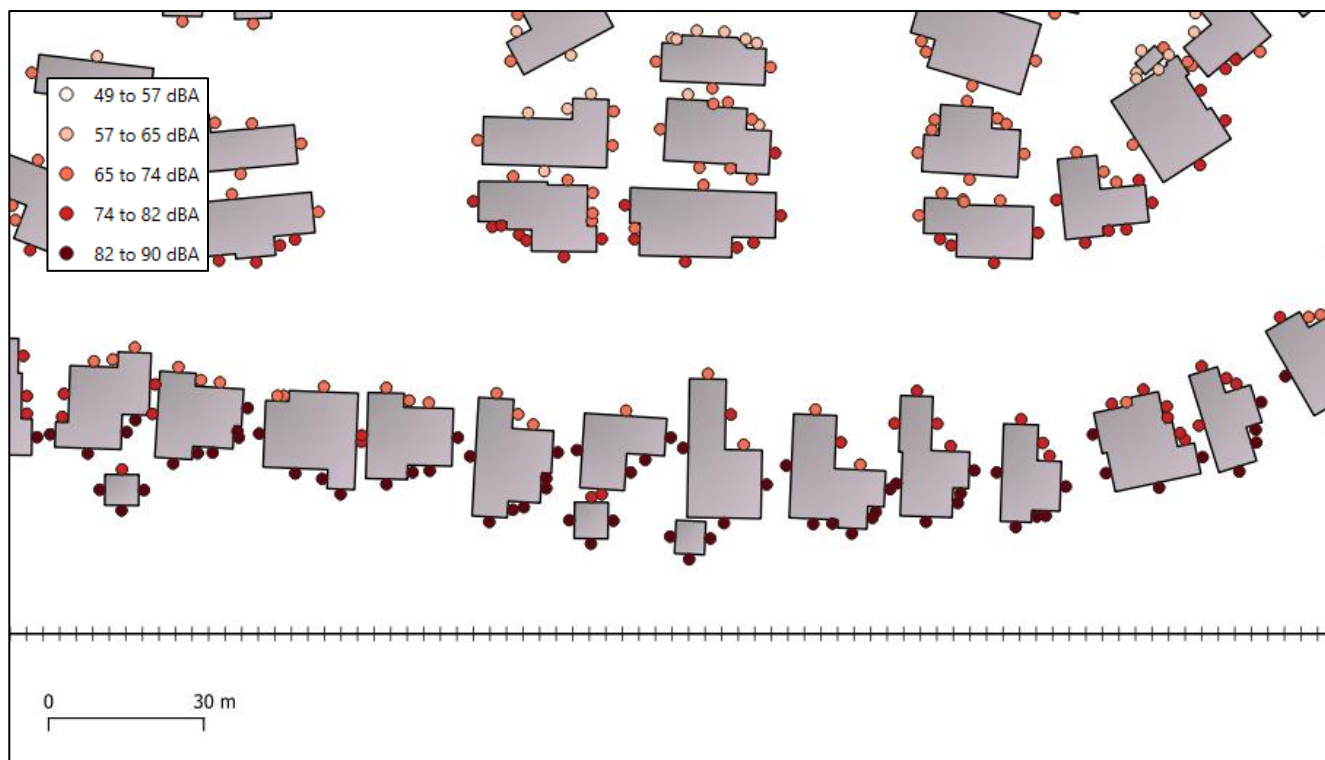


Figure 5: Predicted L_{max} noise levels along the rail track with reflection order 3

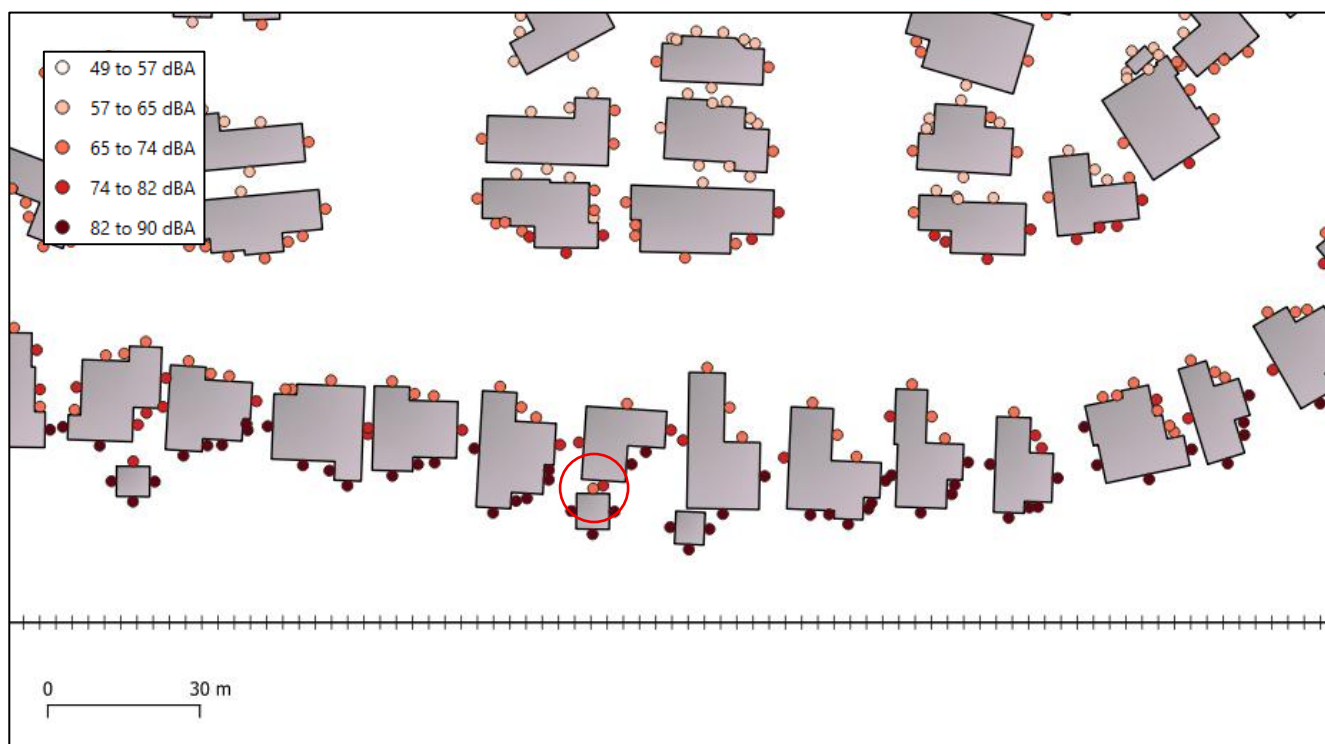


Figure 6: Predicted L_{max} noise levels along the rail track with reflection order 1

Figures 5 and 6 show that the predicted noise levels on facades with a relative unobscured view of the rail track are between 82 and 90 dBA for both reflection orders. The point circled in Figure 6 shows that the backside of the shed is predicted to have a noise level lower than 74 dBA with one reflection but higher than 74 dBA with 3 reflections. This receptor point was investigated further, and it was determined that limited energy arrived at this point with one reflection whereas more reflected acoustic energy arrived at this point where 3 reflections were used for the calculations.

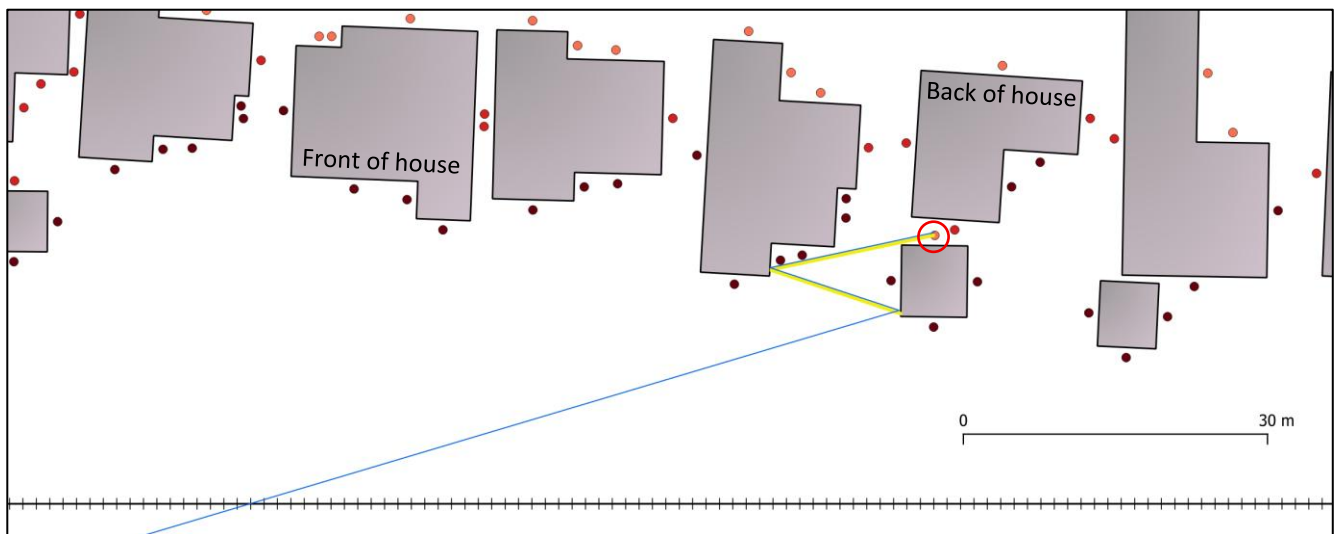


Figure 7: An example of reflection paths for 1 and 2 reflections

Figure 7 shows an example of how one reflection does not result in reflected energy arriving at this receptor point (yellow line), whereas the blue line shows an example of how two reflections result in acoustic energy arriving at the receptor point.

Noise levels were predicted at seven locations situated between 24m and 30 m from the rail track with the aim of determining predicted differences in noise levels for receptor points near to the rail track but with some degree of noise shielding due to intervening structures. The noise predictions were undertaken with 1, 3 and 10 reflections. Table 4 presents the predicted L_{eq} noise levels. Note that the receptor point circled in red on Figure 7 is listed on the first line in the table and that the receptor point immediately adjacent to red circled point is listed on the second line in the table.

Table 4: Predicted L_{eq} noise levels for a flat earth model at receptor points near a rail track

No.	Location	Predicted L_{eq} noise level for various reflection orders, dBA			Difference in L_{eq} noise level between reflection orders, dB	
		1	3	10	1 to 3	3 to 10
1	Backside of shed (point in the red circle), 26 m from the track	44.0	47.9	49.2	3.9	1.3
2	Front of house, but shielded by shed (next to red circle), 27 m from track	49.1	50.8	51.5	1.7	0.7
3	Backside of shed, 28 m from track	49.7	52.0	53.1	2.3	1.1
4	Backside of shed, 25 m from track	50.1	50.8	51.2	0.7	0.4
5	Backside of shed, 30 m from track	51.0	52.8	53.2	1.8	0.4
6	Front of house with unobscured view of the track, 28 m from track	55.9	56.1	56.1	0.2	0.0
7	On the side of a shed with direct view of the track, 24 m from track	55.0	55.6	55.9	0.6	0.3

Table 4 shows that the highest noise level is predicted at receptor point 6 which is the receptor point with unobscured view of the rail track. The table shows that the predicted noise level at this receptor does not change significantly with a change in the number of reflections.

The table also shows that the predicted noise reduction where a receptor point is shielded by a shed compared to having an unobscured view of the rail track is around 5 to 7 dB for one reflection where receptor point 1 is excluded. The predicted noise level at receptor point 1 is 12 dB lower than the noise level at the unobscured point where only 1 reflection is included in the noise calculations. The difference in noise levels between these two points is 8 dB where 3 reflections are included in the noise calculations.

With one noise reflection included in the calculations the difference between receptor points 1 and 2 is 5.1 dB. It is noted that the distance between these two points is 2.0 m and that both points are shielded by the shed. It is considered unlikely that a noise level difference of over 5 dB will be measured at these two locations and that this difference most likely is a modelling irregularity.

The predicted difference at these two receptor points is reduced to 2.9 dB for three reflections and again reduced to 2.3 dB for 10 reflections. These differences are still quite large but are considered more reasonable predicted noise levels.

Table 5 presents the predicted L_{max} noise levels at the same seven locations.

Table 5: Predicted L_{max} noise levels for a flat earth model at receptor points near a rail track

No.	Location	Predicted L_{max} noise level for various reflection orders, dBA			Difference in L_{max} noise level between reflection orders, dB	
		1	3	10	1 to 3	3 to 10
1	Backside of shed (point in the red circle), 26 m from the track	72.4	76.2	77.2	3.8	1.0
2	Front of house, but shielded by shed (next to red circle), 27 m from track	80.4	80.7	80.7	0.3	0.0
3	Backside of shed, 28 m from track	79.0	81.3	82.3	2.3	1.0
4	Backside of shed, 25 m from track	77.9	78.4	78.6	0.5	0.2
5	Backside of shed, 30 m from track	81.1	81.8	82.1	0.7	0.3
6	Front of house with unobscured view of the track, 28 m from track	86.6	86.7	86.8	0.1	0.1
7	On the side of a shed with direct view of the track, 24 m from track	86.7	87.1	87.2	0.4	0.1

Table 5 shows that the predicted L_{max} noise level generally follows the same pattern that was observed for the L_{eq} noise predictions.

The difference between receptor points 1 and 6 is 14.2 dB where one reflection was included in the calculations, this difference reduced to 10.5 dB with three reflections.

Table 5 shows that the predicted L_{max} noise level generally is higher the more reflections are included in the calculations. This indicates that the predicted L_{max} noise descriptor is a summation of many reflection paths and not just a prediction of the highest noise level from one point of the rail track. This is particular evident for location number 6 which is the place that has an unobscured view of the rail track.

4.3 ISO 9613-2

The rail track was converted to an industrial line source with an arbitrary noise emission level of 50 dBA SWL per meter and an L_{max} sound power of 70 dBA.

The same seven locations were calculated using the ISO 9613-2 calculation method. Table 6 presents the predicted L_{eq} levels with different reflection orders.

Table 6: Predicted L_{eq} noise levels for a flat earth model using an industrial line source

No.	Location	Predicted L_{eq} noise level for various reflection orders, dBA			Difference in L_{eq} noise level between reflection orders, dB	
		1	3	10	1 to 3	3 to 10
1	Backside of shed (point in the red circle), 26 m from the track	21.7	21.7	21.7	0.0	0.0
2	Front of house, but shielded by shed (next to red circle), 27 m from track	24.3	24.3	24.3	0.0	0.0
3	Backside of shed, 28 m from track	24.0	24.0	24.2	0.0	0.2
4	Backside of shed, 25 m from track	24.3	24.3	24.3	0.0	0.0
5	Backside of shed, 30 m from track	25.1	25.1	25.3	0.0	0.2
6	Front of house with unobscured view of the track, 28 m from track	28.9	28.9	28.9	0.0	0.0
7	On the side of a shed with direct view of the track, 24 m from track	28.6	28.6	28.6	0.0	0.0

Table 6 shows that the predicted noise levels do not vary a great deal when the number of reflections used in the noise calculations are changed.

Table 7 presents the predicted L_{max} levels with different reflection orders for the industrial line source.

Table 7: Predicted $L_{\max}$ noise levels for a flat earth model using an industrial line source

No.	Location	Predicted $L_{\max}$ noise level for various reflection orders, dBA			Difference in $L_{\max}$ noise level between reflection orders, dB	
		1	3	10	1 to 3	3 to 10
1	Backside of shed (point in the red circle), 26 m from the track	41.7	41.7	41.7	0.0	0.0
2	Front of house, but shielded by shed (next to red circle), 27 m from track	44.3	44.3	44.3	0.0	0.0
3	Backside of shed, 28 m from track	44.0	44.2	44.2	0.2	0.0
4	Backside of shed, 25 m from track	44.3	44.3	44.3	0.0	0.0
5	Backside of shed, 30 m from track	45.1	45.3	45.3	0.2	0.0
6	Front of house with unobscured view of the track, 28 m from track	48.9	48.9	48.9	0.0	0.0
7	On the side of a shed with direct view of the track, 24 m from track	48.6	48.6	48.6	0.0	0.0

Table 7 also shows that the predicted noise levels do not vary a great deal when the number of reflections used in the noise calculations are changed.

Tables 6 and 7 also show that the noise levels behind the sheds, except for location 1, generally are 4-5 dB lower than at the locations having a direct line of sight to the rail track. The predicted noise level at location 1 is 7.2 dB lower than location 6.

The average of the predicted noise levels at receptor locations 2 to 5 was subtracted from the receptor location 6, to compare how the different prediction methods calculated the noise level at a point shielded by a building compared to an unshielded point. Table 8 presents these results.

Table 8: Average difference between shielded and unshielded receptor point

Prediction method and noise descriptor	Difference between receptor 6 and the average of receptors 2 to 5 for various reflection orders, dB		
	1	3	10
Kilde rail L_{eq}	5.9	4.5	3.9
ISO 9613-2 Industrial line source L_{eq}	4.5	4.5	4.4
Kilde rail $L_{\max}$	7.0	6.2	5.9
ISO 9613-2 Industrial line source $L_{\max}$	4.5	4.4	4.4

Table 8 shows that the Kilde L_{eq} predictions with a reflection order of 3 correspond well to the ISO 9613-2, whereas the Kilde $L_{\max}$ predictions does not correspond well with the ISO 9613-2 prediction method. This outcome indicates that the reflection order should be set to 3 when calculating L_{eq} noise levels using the Kilde prediction method. Based on the predicted results shown in Table 5 it is not recommended to use 1 reflection order when calculating the $L_{\max}$ noise descriptor using the Kilde prediction method; rather, 3 reflection orders appear to provide more reasonable results.

Note that the calculations were also undertaken with a noise model that included complex ground contours as well as noise barriers placed along the rail track. The outcome of this model was comparable to the outcome of the flat earth model.

4.4 Calculation Time

The time for the various model runs were noted. No rigorous assessment was undertaken; however, the calculation time approximately doubles each time the reflection order is increased by 1. It should be noted that the duration of the ISO 9613-2 calculations was almost identical to the Kilde 67/130 calculations for all investigated reflection orders.

5 CONCLUSIONS

This paper has identified that significant deviations can occur depending on the number of reflections used in the calculation of noise levels when using the Kilde prediction method in SoundPLAN. The largest difference between predicted noise levels at the same receptor point was 14.3 dBA of the $L_{\max}$ noise descriptor, where the only difference was a reflection order of either 1 or 3 used for the calculation of the noise level. It should be noted that this was found in a model that included 433 buildings. The largest difference in predicted L_{eq} noise level in the same model was 7.4 dB.

It was noted that the difference in predicted noise levels when changing the reflection order generally was less than 1 dB for receptor points with a relatively unobscured view of the rail track. As noise mitigation generally is designed for receptors situated immediately adjacent to a rail track the predicted noise levels for these receptors are not expected to be hugely incorrect where a reflection order of 0 or 1 is used in the calculations. Nonetheless it is recommended that the reflection order is set to 3 for the calculation of both L_{eq} and L_{max} noise descriptor to minimize the risk of significantly underpredict rail noise levels

This paper also identified that the predicted L_{max} noise descriptor is a summation of many reflection paths and not just the highest noise level. This further demonstrates that the number of reflections should not be reduced in the calculations. However, it is noted that the Kilde Report 67 states that the highest of all possible L_{max} levels that are calculated at one receptor point should be used as the L_{max} result. The outcome of the modelling undertaken for this paper shows that this is not the way SoundPLAN has implemented the L_{max} calculation.

In conclusion, it is not recommended that a SoundPLAN user reduces the default set number of reflections when calculating noise levels using the Kilde noise prediction method.

ADDITIONAL WORK

The default setting for search radius in SoundPLAN is 5000 m. Additional runs with various search radius could be undertaken to determine the impact of reducing the search radius on the predicted noise levels and the reduction in calculation time.

Additional effects and limitations may be noted by undertaking noise modelling of:

- a noise barrier on just one side of a rail track to further determine the impacts of reducing the predicted noise levels when using reflection orders less than three.
- different building façade reflection losses.
- absorptive noise barriers.
- the differences between ISO 9613-2 and the Kilde 67/130 prediction method.

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