Regulating the control of external sound for new residential development: a South Australian perspective

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ABSTRACT

Over recent years, a number of councils and State Governments have become aware of complaints in relation to external noise intruding into residential buildings (ABCB 2013). To be most effective however, mitigating external noise for new residential development requires a multifaceted approach that encompasses both the planning and building rules aspects of a development approval process.This paper presents a South Australian perspective of its recently adopted external noise regulation, and outlines the thinking behind the innovations that were developed to enable this multifaceted approach. It may assist other jurisdictions with their approach to managing similar issues. This paper covers aspects related to road and rail noise. It does not cover noise from mixed use development.

INTRODUCTION

While the requirement for considering sound exposure on new residential development is not a new concept, Council's have not been consistent in their approach for requiring an acoustic assessment. For example, there are situations where residential dwellings were allowed to be constructed adjacent major transport corridors without any consideration of noise exposure. This issue is considered both unstainable from a health perspective (WHO 1999) as well as being a future liability for Councils and State Governments.

In South Australia (until recently), this inconsistency across Councils was largely due to the lack of a clear state planning policy or guideline that triggered the requirement for an external noise assessment for new residential development. Additionally, given the often limited building design information available during the planning phase, and that planners are not able to be prescriptive on the construction aspects of a building, the decision to approve has generally been biased to achieving an external noise criterion (in those cases where external noise was considered).

This issue was particularly brought to light during a major green field road project, where the government provided noise mitigation to treat a large number of residential properties as part of the noise requirements of the project, however there was no Council requirement to ensure proposed new dwellings located in the same noise affected areas included adequate noise mitigation.

Development of The 30 Year Plan for Greater Adelaide, which provides for mixed use developments around major transport corridors (road and rail) that incorporates medium to high density housing, also highlighted the issue. It was therefore critical that appropriate policies were in place that also considered the internal amenity of building occupants, where other forms of noise mitigation, such as noise barriers, were not practical.

New complementary development plan policies ~~(~~*Noise and Air Emissions Overlay* (the Overlay)~~)~~ and building rules ~~(~~*Minister's Specification SA 78B – Construction Requirements for the Control of External Sound* (Minister's Specification)~~)~~ are now in place in South Australia (SA).

It is noted that similar provisions to the SA Minister's Specification for attenuating externally generated road and rail noise are potentially to be included in the National Construction Code (NCC) 2014 revision. However, adoption of the NCC provisions will require the various jurisdictions to develop a planning mechanism that relates to the new building rules.

This paper therefore presents an outline of the thinking behind the innovative noise assessment processes that has enabled SA to develop planning policies and building rules that function together to achieve a regulated approach to mitigating external noise.

It is intended that the insights outlined in this paper may assist other jurisdictions in developing their own approach to adopting the potential future NCC or similar regulations.

SA REGULATION OF EXTERNAL NOISE

As of 1 March 2013, the regulation of external noise for NCC Class 1, 2, 3, 4 and 9c aged care buildings came into effect in South Australia. The regulation and associated support documentation consist of:

- *Development (Control of External Sound) Variation Regulations 2013* (under the *Development Act 1993*)
- *Noise and Air Emissions Overlay* incorporated into council Development Plans
- Minister's Specification SA 78B – *Construction Requirements for the Control of External Sound*
- Reducing noise and air impacts from road, rail and mixed land use – *a guide for builders, designers and the community*
- South Australian Planning Policy Library, *Technical information sheet 8 - Noise and Air Emissions - Overlay 3*.
- Advisory Notice Building 02/13 Technical - *Reducing Noise and air impacts from road, rail and mixed land use*

Note that the new external noise regulation is specifically targeted at reducing internal noise for new residential development. It reflects an approach that noise needs to be managed by all parties and that mitigating noise to improve healthy living is a shared responsibility between noise generators and receivers.

The following sections provide a brief overview of the Overlay and the Minister's Specification and expands on the relevant acoustical aspects specific to road and rail in more detail.
Note that the people and entertainment sound aspects of the Minister's specification are not discussed in this paper.

NOISE AND AIR EMISSION OVERLAY

The Overlay contains planning policies to protect new noise and air quality sensitive development from noise and air emissions generated from major transport corridors as well as mixed land use. Noise and air emissions are linked together in the Overlay given that design decisions often have mutual benefit e.g. the location of private and communal open space at the rear of buildings, away from the emission source (DPTI, 2013).

There are three different situations where the Overlay can be applied:

- a mixed use zone located adjacent to a designated sound source (road, train or tram)
- a residential type zone located adjacent to a designated sound source; or
- a mixed use zone not located adjacent to a designated sound source. In this instance, other noise sources may occur, such as entertainment venues and/or people related noise – which are also covered by the Minister's Specification.

The Overlay, when integrated into a Council Development Plan, activates the Minister's Specification. Therefore, the Overlay plays a key role in linking the planning and building construction aspects early in the design process.

Considering both the planning and building construction aspects early has significant benefits for proposed development, such as:

- Optimising the development footprint considering both the external and internal noise amenity and associated noise mitigation cost. Furthermore, the *deemed-to-satisfy* constructions contained within the Minister's Specification allow preliminary additional building costs to be calculated. For example, this could assist with pre-purchase due diligence to easily enable an assessment of the likely costs prior to land purchase.
- Councils (and other government authorities such as the EPA) now have an assessment mechanism to grant planning approval based on the requirement that the proposed development must comply with external and/or internal noise criteria (i.e. rather than external noise only).

- Please refer to The Department of Planning, Transport and Infrastructure (DPTI, 2013) *Reducing noise and air impacts from road, rail and mixed land use– a guide for builders, designers and the community*, for further design guidance and case studies to assist with understanding noise mitigation possibilities.

Figure 1 provides an Overlay example, as depicted in the City of Charles Sturt Development Plan. Importantly, note that the Overlay designates the sound sources and the assessment area.

Designated sound sources can either be a train line, tram line or a specific road type (type A, B, or R). Each of these noise sources relate to a *designated sound source level* and a *designated sound source spectral adjustment level* in the Ministers Specification (explained further in this paper below). Should a proposed development be located within a designated area, the Minister's Specification applies to the development.

Designated sound sources

The types of roads which may be designated as sound sources in the Minister's Specification are presented in Table 1.

Figure 1. Noise and Air Emissions Overlay over Bowden Development, Bowden, South Australia (DPTI, 2013).

Table 1. Types of roads

Types of roads	Definition
Type A	• 50,000 vehicles per day (vpd) and over; or • a freight route (not rural).
Type B	• 25,000 – 49,999 vpd; or • a freight route; or • a DPTI major traffic route; or • the basis for a growth corridor.
Type R	• a rural road which is a freight route.

Note that the types of roads are not simply based on traffic volume, but also freight traffic and growth. This is in recognition of the increased noise and annoyance associated with freight routes, as well as future urban growth.

Therefore, there is a strategic aspect of where the types of roads apply and what level of noise mitigation is triggered.

To understand which road type applies where, DPTI have produced network maps that cover Greater Adelaide and the state. These maps also outline the railway and tramway corridors. Figure 2 shows the Greater Adelaide map.

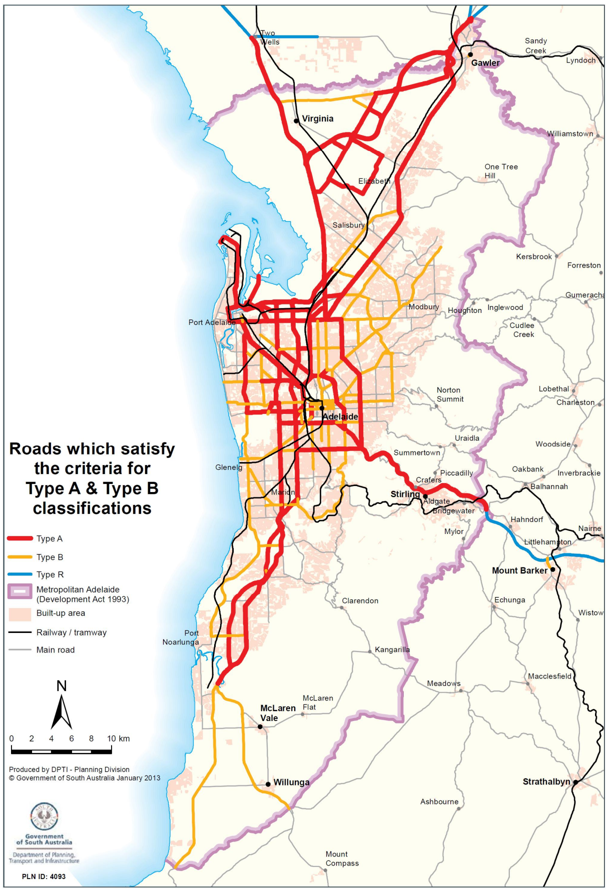

Figure 2. Roads in the Greater Adelaide area classified Type A, B, or R (DPTI, 2013).

Councils are able to refer to the SA Planning Policy Library – Technical Note 8, to assist with developing their own Overlays specific to their jurisdiction (note, via a Development Plan Amendment (DPA) process).

MINISTER'S SPECIFICATION SA 78B

The Minister's Specification contains different construction requirements depending on the distance from the designated sound source(s) and the type of development expected in a council zone.

The Minister's Specification comprises:

- **Performance criteria**—the acceptable internal noise standard—for National Construction Code Class 1, 2, 3, 4 and 9c aged care buildings (including additions)
- **Deemed-to-satisfy requirements**—such as window glazing, solid doors and seals, wall and ceiling insulation, alternative ventilation if necessary—based on the noise exposure at the building façade
- **Alternative solution—**an acoustic consultant report can be prepared to demonstrate compliance with the performance requirement—allowing flexible design solutions to be adopted

Performance criteria

Performance criteria are expressed as an equivalent continuous noise level (L_{Aeq}) for all designated sound sources. The use of a maximum sound level (L_{AFmax}) metric for rail sources was explored, however not favoured (explained in detail later in this paper).

Furthermore, the *Night Noise Guidelines for Europe* (WHO, 2009) report recommends a long term night noise guideline (NNG) of 40 dB(A) $L_{night,outside}$ for the protection of public health. It also recognises that it may not be feasible to achieve this NNG, and suggests a feasibility-based interim target (IT) of 55 dB(A) $L_{night,outside}$ where the NNG cannot be reasonably achieved. The report emphasises that the IT is not a health based guideline by itself, and therefore recommends that it only be temporarily considered by policy-makers for exceptional local situations.

Given that our South Australian urban environment around major road and rail corridors consists of sound levels significantly above the IT (more than 15 dB(A) above the IT in some areas), the adopted internal design sound level criteria therefore needs to strike a practical balance between building development cost and health amenity.

The performance criteria are comprised of an average internal sound level to be achieved across all such rooms in a building (Building Design Target) and a maximum allowable level for individual rooms in the building.

The Building Design Target for bedrooms of 30 dB(A) (during the night time) is consistent with the satisfactory internal design sound level from AS/NZS 2107. The maximum allowable sound level for individual bedrooms lies midway between the AS/NZS 2107 satisfactory and maximum design sound levels. The maximum allowable internal sound level for bedrooms of 35 dB(A) $L_{Aeq,9hr}$ is also approximately equivalent to the WHO IT (i.e. 55 dB(A) $L_{night,outside}$), assuming a transmission loss of 20 dB(A) through a typical facade with the windows closed.

Note that the *Deemed-to-Satisfy Provisions* in the Minister's Specification were designed to achieve the maximum allowable internal sound levels, rather than the Building Design Target, which is 5 dB(A) lower. However, as the treatments outlined in the Minister's Specification are based on the shortest distance from a transport corridor to the nearest point of the building envelope bounding a habitable room, there will be a number of habitable rooms in most buildings that will be exposed to considerably lower sound levels, although subject to the same construction requirements.

For example, a detached dwelling (NCC Class 1) adjacent to a transport corridor may have one bedroom facing the sound source, one bedroom with an opening (e.g. window) in the facade perpendicular to the sound source and one bedroom with an opening in the facade facing directly away from the sound source.

The internal sound level in the bedroom facing the transport corridor would be expected to be 35 dB(A), once the *Deemed-to-Satisfy Provisions* have been incorporated. The internal sound levels in the other bedrooms though, would be expected to be considerably lower, with a level of 31 dB(A) possible in the bedroom facing perpendicular to the facade and a level of 24 dB(A) possible in the bedroom facing directly away from the sound source. The Building Design

Target of 30 dB(A) for bedrooms would therefore be achieved in this example.

The purpose of the Building Design Target is therefore to encourage designers to locate the majority of rooms to minimise noise intrusion where practical.

Note that the Building Design Target may be more difficult to achieve for other habitable rooms in an *Alternative Solution*, such as in the case of a dwelling with an open plan living area incorporating a kitchen, lounge and dining area i.e. no other rooms available to arithmetically average the internal sound level. However, the application of this provision will be monitored by Government to see how effective it is in practice.

Deemed-to-Satisfy

To ascertain the level of *Deemed-to-Satisfy* (DTS) construction applicable to new development, five *sound exposure categories* were developed. These *sound exposure categories* are based on 4 dB increments increasing from a base façade reduction of 20 dB(A) for standard construction. It was considered that the 4 dB increment generally provides sufficient construction 'resolution' in the context of human perception of sound level difference.

The DTS constructions were designed to meet the Minister's Specification performance criteria at the highest exposure level for a given category, e.g. *Sound exposure category 1* construction was designed to achieve a façade reduction of 24 dB(A) with windows and doors closed.

To ascertain the separation distances for each sound exposure category, general calculations of sound emissions were made on the basis of conservative estimates. All calculations assumed no intervening structures between source and receiver (i.e. no shielding between source and receiver). The following sections describe how the calculations were carried out for both road and rail sources.

Calculation of road sound source levels

Sound levels from road traffic were calculated using the UK's Calculation of Road Traffic Noise (CoRTN) algorithm. The calculations were based on conservative inputs for traffic conditions and ground topography, which were selected as typical for the majority of the Adelaide metropolitan area.

Specifically, the following assumptions were made in the calculations:

- all calculations assumed 90% of the AADT traffic occurs during the day time period with 10% occurring during the night time
- %CVs (defined as Austroads Class 3 – 12) are assumed to make 10% of AADT volumes during both the day and night times. Note that for the majority of Adelaide metropolitan roads, %CV's ranged between 2% and 8% of AADT, but could be as high as 40% on rural heavy vehicle routes.
- Dense Graded Asphalt was assumed to be the wearing surface on all roads, and the surface was assumed to be in reasonable condition, which is typical for the Adelaide metropolitan area.
- a 160 degree view of the road was assumed for all receiver locations
- a gradient of 0% was assumed for all roads
- no screening or shielding was assumed from intervening ground topography or built form
- a sound level correction of -1.8 dB(A) was applied to the CoRTN calculated output during the daytime and +0.8 dB(A) during the night time to account for local conditions based on measurements conducted within and around metropolitan Adelaide.

Figure 3 presents an example of the analysis (i.e. night time period, speed limit of 110 km/h) that was used to determine the applicable separation distances for each sound exposure category, for each of the road types.

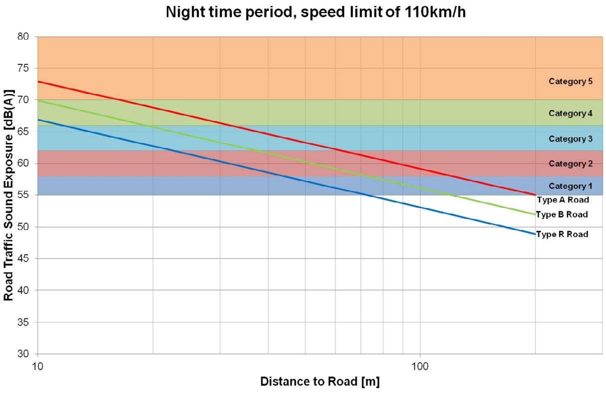

Figure 3. Night time road traffic *sound exposure categories*, for 110km/h roads, with respect to separation distance

For each of the three road types, three speed categories were also modelled based upon the posted speed limits found in SA, namely 50 – 60, 70 – 90, 100 – 110.

It can be seen from the above that the noise modelling adopted was not unnecessarily detailed. It was considered that embarking on a significant modelling exercise to account for local shielding features (etc.) across the Adelaide network was not required for a DTS; this aspect would be picked up in an alternative solution as needed.

Calculation of rail sound source levels

Sound source levels from rail traffic were determined on the basis of measured pass-by Sound Exposure Levels (SEL), the type of rail using the corridor and separation distance.

Measurements were taken at various rail lines and for various types of trains (i.e. trams, passenger and freight trains). The median and standard deviation (SD) of the measured SELs for each train type was then calculated.

In order to reduce the risk of under predicting sound levels associated with individual train pass-bys, the reference SEL was based on the average of the median SEL for each train line plus the average of one standard deviation across each of the lines for which measurements were available. This considerably reduced the chance that an individual train pass-by would result in an SEL above the reference value, although this will still occur for some pass-bys. Table 2 presents the reference SEL for each train type.

Table 2. Reference SEL's in dB(A) at 20m

Source	Median SEL	Standard Deviation	Reference SEL
Passenger	83.5	2.5	86.0
Freight	94.8	3.4	98.2
Tram	80.0	5.0	85.0

Under South Australian legislation, freight trains can potentially operate on any rail line. Because of this, government preferred that a combined reference SEL was calculated (i.e. passenger and freight trains).

The ratio of freight trains to passenger trains varies with location and time of day, so a worst case scenario of 15% freight trains as part of the movements on any line was assumed for the calculation of combined sound emissions. A combined "single train" pass-by reference SEL of 91.2 dB(A) at a distance of 20 metres was therefore used for all rail lines, regardless of time of day or whether the line is used by freight trains or not.

Similarly, in order to determine the typical worst case number of train movements for the train lines, the median value from all of the Adelaide metropolitan train lines (plus one standard deviation) was assumed for the number of movements. All predictions of sound emissions from train lines therefore assumed 97 train movements during the day time period and 24 during the night time period, with all pass-bys having a reference SEL of 91.2 dB(A) at a distance of 20 metres.

Figure 4 presents an example of the analysis that was used to determine the applicable distance band for each sound exposure category, for train lines.

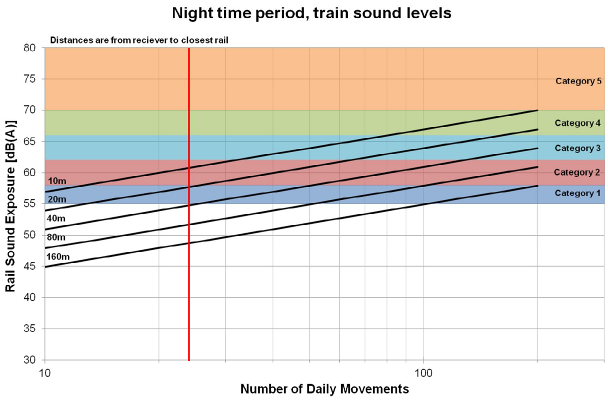

Figure 4. Night time train traffic *sound exposure categories* with respect to separation distance and daily movements

Note that the separation distances presented in the Minister's Specification were based on achieving the internal L_{Aeq} performance criteria and do not directly relate to L_{AFmax} events generated by typical train or tram pass-bys or to wheel squeal levels in those locations where wheel squeal may occur.

To assist decision making regarding the preferred metric for the Minister's Specification in relation to rail noise, a sensitivity analysis regarding the sound exposure category separation distance was carried out. This is explained in the following sections.

Rail maximum sound levels

Typical measured maximum sound levels produced by trains operating on freight, passenger and tram lines at a distance of 20 metres from the rail line are outlined in Table 3.

Table 3. Maximum sound levels in dB(A) at 20m

Source	L_{AFmax}
Passenger train	90.4
Freight train	78.8
Tram	75.2

These values were calculated based on the median values of measurements conducted adjacent a number of rail lines in the metropolitan Adelaide area.

Note that the measurements used to determine the maximum sound levels from freight rail movements have excluded locations where wheel squeal was present. Wheel squeal is discussed in the following section below.

Figure 5 presents the typical maximum sound levels (L_{AFmax}) with distance for freight, passenger and tram lines. The figure also shows the sound levels at which specific construction categories are triggered in order to meet an adopted internal design sound level criterion of 60 dB(A) L_{AFmax} (derived from the SA EPA *Guidelines for the assessment of noise from rail infrastructure*).

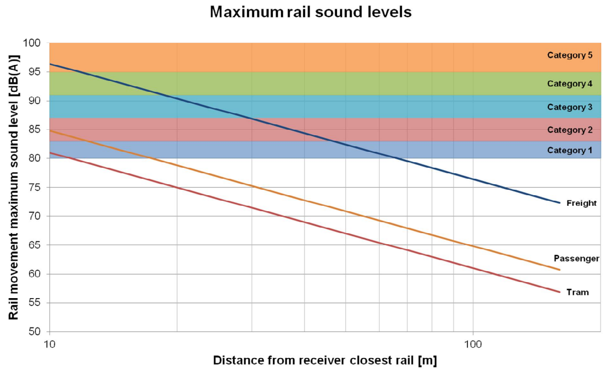

Figure 5. Maximum rail sound levels (without wheel squeal) with respect to separation distance. The sound exposure categories relate to a 60 dB(A) L_{AFmax} indoor criterion

Table 4 presents the sound exposure category separation distances for freight, passenger and tram lines based on Figure 5.

Table 4. Rail sound exposure category separation distances, based on L_{AFmax}

Sound exposure category	Tram line	Passenger train line	Freight train line
Category 1	< 10 m	10 < 15 m	45 < 65 m
Category 2	-	< 10 m	30 < 45 m
Category 3	-	-	20 < 30 m
Category 4	-	-	10 < 20 m
Category 5	-	-	< 10 m

Table 5. Sound exposure category – rail, based on L_{Aeq} (Minister's Specification Table 8)

Sound exposure category	Separation from Tram line (metres)	Separation from Train line (metres)
Category 1	10 < 20 m	25 < 50 m
Category 2	< 10 m	10 < 25 m
Category 3	-	< 10 m
Category 4	-	-
Category 5	-	-

With reference to Table 5 (Minister's Specification Table 8) and comparing to Table 4, it can be seen that the separation distances for tram lines are controlled by the L_{Aeq} rather than the L_{AFmax} sound level. The L_{Aeq} separation distances for train lines (which combine both passenger and freight trains) represent a good compromise between the L_{AFmax} separation distances for passenger and freight.

Overall, the separation distances adopted in the Minister's Specification are expected to result in L_{AFmax} levels less than the adopted maximum internal sound level criterion of 60 dB(A) for tram and passenger trains, and result in a marginal exceedance of the criterion for freight trains.

Rail wheel squeal

Wheel squeal from freight rail movements can be a significant contributor to sound emissions from rail lines in certain locations around metropolitan Adelaide. Although wheel squeal may occur infrequently on any rail line, it most commonly occurs on the freight rail line that travels through the Adelaide hills.

Table 6 presents median wheel squeal sound emission levels based on measurements of over 100 freight train pass-bys at various locations in the Adelaide hills where wheel squeal is known to regularly occur.

Table 6. Reference SEL's and L_{AFmax} in dB(A) at 20m

SEL		**L_{AFmax}**	
Median	SD	Median	SD
103.4	4.3	101.4	6.0
Reference 107.7		Reference 107.4	

Table 7 presents the sound exposure category setback distances for freight lines based on the reference SEL and L_{AFmax} level for wheel squeal. Note that these have been calculated on the basis that the estimated transmission loss provided by the facade will be 10 dB higher than for general transport sound as wheel squeal is controlled at much higher frequencies (2 kHz to 8 kHz). They have also been calculated assuming a typical scenario of five freight train movements during the night time period.

Table 7. Rail wheel squeal sound exposure category separation distances, based on L_{Aeq} and L_{AFmax}

Sound exposure category	**To meet internal 35 dB(A) L_{Aeq} criteria**	**To meet internal 60 dB(A) L_{AFmax} criteria**
Category 1	30 < 55 m	105 < 150 m
Category 2	10 < 30 m	65 < 105 m
Category 3	< 10 m	40 < 65 m
Category 4	-	25 < 40 m
Category 5	-	< 25 m

Comparing the Table 7 distances at which the different sound exposure categories are triggered to those adopted in the Table 5 (Minister's Specification Table 8), it can be seen that the DTS constructions are expected to result in sound levels generally achieving the internal L_{Aeq} design sound levels for freight lines with wheel squeal.

In order to achieve the internal 60 dB(A) L_{AFmax} design sound level however, it would be necessary to significantly extend the sound exposure category distances.

Due to the limited number of locations at which wheel squeal regularly occurs in and around Adelaide, it was not considered reasonable to require new developments adjacent to any train line to implement treatments to achieve an internal sound level of 60 dB(A) L_{AFmax} under the Minister's Specification. Despite this, the Minister's Specification still affords a greater level of protection for freight lines than previously existed in South Australia.

Measurement of Separation distance

For both road and rail sound sources, it is important to note that the reference point for measurement of the separation distance is 3 meters inside the transport corridor when measured from corridor cadastral boundary. There are two primary reasons for this, that is:

- from a Geographic Information System (GIS) mapping perspective, it is easier to reference from the corridor cadastral boundary rather than the road pavement surface or rail line. Often the georeferenced road pavement or rail line polyline strings are not available as a GIS layer; and
- in the case of a wide transport corridor, noise mitigation allowances for future growth (e.g. duplicated road or rail track) has already been accommodated. Note that this does not necessarily mean that external noise will not need to be mitigated. Mitigation of external noise is also important consideration from an outdoor amenity perspective where practical.

Alternative solution

In some situations, developers of new Class 1, 2, 3 and 4 buildings and 9c aged care buildings may opt to have an acoustical consultant provide an alternative solution to the DTS.

An alternative solution will allow an optimum solution to be developed with consideration of both the external and internal noise mitigation and associated cost.

To improve the consistency between developments exposed to transport sound however, the Minister's Specification specifies both the *designated sound source level* and the *designated sound source spectral adjustment levels* that an acoustical consultant is to use in developing an alternative solution.

This aspect enables the Minister's Specification to provide future protection from *designated sound sources* as well as to ensure adequate consideration of the frequency characteristics for each sound source in the façade design.

Note that the future protection of dwellings is an important aspect of the Minister's Specification. For example, a road corridor may be designated as a Type A corridor, although it may not be constructed, or a minor road may become a Type B road in future.

For cases such as this, it was considered important by government that new developments incorporate protection from these corridors. Furthermore, because of this reasoning, measurement of the existing traffic noise exposure may not be possible or valid without correcting for the future use of the corridor.

Note that the SA government have already strategically considered the applicable road types for the state (as previously discussed above in relation to Figure 2).

The Minister's Specification therefore allows a simpler 'desktop approach' to be taken, without the need for site based measurements or corrections for future changes in traffic volume and mix to be considered. It also allows government to trigger a level of noise mitigation treatment strategically across the transport network.

CONCLUSION

This paper has provided a brief overview of the thinking behind the development of a multifaceted approach to enable the regulation of external noise in South Australia.

It is hoped that insights contained within this paper may benefit other jurisdictions in developing their own approach to adopting the potential future NCC or similar external noise regulations.

ACKNOWLEDGEMENTS

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