HAUL ROUTE MODELLING

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Abstract

Development of an open cut mine requires a noise impact assessment to determine the likelihood of affectation. Open cut mines typically comprise one or more pits and associated dumps. Transport of waste from pit to dump involves large trucks (haul trucks) travelling on earthen roads (haul routes). Haul trucks are inherently noisy, and, their emissions vary, as does the speed of travel. These variations need to be factored into any predictive noise model where a time based result is required, for example $L_{Aeq,15\text{-}minute}$. Past practice was to model haul truck emissions simply by placing truck sources in the model, the number of which corresponded to the number of trucks at the mine. Current best practice is to model haul routes as strings of relatively short segments; each having a specific period L_{Aeq} sound power determined by a set of relevant variables. The accuracy of this method has been evaluated by comparison of a validated model using 15-minute haul route source locations for trucks as logged in a mine GPS database, and a theoretically developed model using current best practice.

1. Introduction

To satisfy the requirements of the *Environmental Planning and Assessment Act (1979)*, development of open cut mines require a noise impact assessment (NIA) be undertaken to determine the likelihood of affectation due to noise annoyance. This assessment should include a computer model which takes into account geometric spreading, atmospheric absorption, and, barrier and ground attenuation, however the guidance given in policy documents such as the *NSW Industrial Noise Policy* [1] is fairly limited.

Open cut mines, once established, typically comprise one or more pits (big holes in the ground) and dumps (big piles of waste material). Transport of waste from pit to dump involves large dump trucks (haul trucks) travelling on earthen roads known as haul routes.

Modelling noise emissions from open cut mine haul routes requires more than just placing sources along the route, the number of which equates to the number of trucks on that route. This concept also extends to other mobile equipment travelling on haul routes such as graders, service trucks and water carts (light vehicles are not included as they are insignificant sources in this context). This paper evaluates current best practise for modelling noise from open cut mine haul routes.

2. Noise Emission from Haul Routes

Haul trucks are inherently noisy. There are now attenuated models of most truck makes, however, these, while far superior to an un-attenuated machine, are still not overly quiet.

These trucks tend to make noise during most parts of the haul route travel cycle, although, the mechanism of generation does vary, the dominant sources typically being:

- Engine and exhaust for uphill travel;
- Engine and transmission for travel on flatter sections; and
- The retard mechanism (which includes the engine on mechanical drive trucks) on downhill sections.

Also, truck speed is not constant. Uphill travel, where the truck is slowest (and considerably so), results in a longer duration of that noise emission than for flat or down-grade haul route sections. Additionally, the movement of trucks along a haul route is varied by the need to slow for corners, intersections and interactions with other traffic. Incorporation of these factors is important to allow for in developing a model where a time based result is required, for example $L_{Aeq,15\text{-minute}}$.

3. Modelling Methods

Reliable sound power data is obtained from tests conducted consistent with ISO methods and draft NSW guidelines [2]. These results are a constant noise emission for the various modes of operation. The required model output is usually an $L_{Aeq,15minute}$ value, therefore it is necessary to convert the available constant noise emission data (base sound power) to a period equivalent. The following sections describe past, and current best practice.

3.1 Past Practice

To account for equipment 'down time' such as idling, waiting to be loaded etc., the truck sound power is usually adjusted down (de-rated) to estimate an $L_{Aeq,15minute}$ emission. A perusal of documentation from various mine projects will show that this time (duration of operation per period) adjustment is not consistent between predictive noise models commonly used, or by the various noise consultants engaged to prepare the NIAs.

It was also customary to model haul truck emissions simply by placing truck sources in the model, the number of which corresponds to the number of trucks at the mine. So, if there are proposed to be 40 trucks at a mine, then 40 truck sources would generally be arbitrarily distributed in the model.

If all sources were placed on the top of dumps then this would obviously over-state impact. Similarly, if all sources were placed at the bottom of pits then the impact would be under-stated (a lot). No-one should set up a model either of those ways, but clearly the overall result (the haul route/s contribution to total mine noise emissions as represented by contours) can be biased, inadvertently, by choice of truck source locations.

Additionally, even if a model has been set-up with a relatively even distribution of trucks at high and low elevations (on dumps, in pit and, in-between), the result for individual receptors can be vastly different due to actual truck source location. For example, moving the nearest truck source could be the difference between exposure or significant shielding by topography.

3.1.1 Past practice pros

- This is a simple method. Model set-up is quick and easy.

3.1.2 Past practice cons

- Many different and wide ranging adjustments to base sound power have been seen in various NIAs, indicating a high degree of subjective interpretation which increases the scope for error; and

- The overall model outcome (the mine is generally noisy or quiet as represented by contour plots) can be biased by choice of source locations, particularly with regard to elevation and topographical exposure.

3.2 Current Best Practice

Current best practice (CBP) is that haul routes are represented by strings of relatively short segments. Each segment has a $L_{Aeq,\ 15minute}$ sound power that is determined by:

- Truck type emission data (which varies for modes of operation);
- Truck speed;
- Number of trucks on route; and
- Truck cycle time.

The outcome is that segments get a period L_{Aeq} sound power determined for them that is related to what really happens at that point of the route (note: some models use a haul string with the same sound power for each segment, clearly this is wrong as the truck speed changes with gradient).

This is very similar to road traffic modelling except that point sources are used instead of line sources. This is possible as the nearest receptors to an open cut mine are nearly always some kilometres away (usually no less than three).

3.2.1 Current best practice pros

- Provides a relatively accurate estimate of noise emissions from a haul route;
- The process is repeatable, which is unlikely for the past practice method; and
- All parts of the haul route are included in the model. This is very important in ensuring that the exposure of all receptors is correctly evaluated.

3.2.2 Current best practice cons

- This is a relatively complex method that requires more information about the site; it adds more time to setting up and processing a model.

4. Best Practice Method Evaluation

To evaluate the accuracy of the CBP haul route modelling method, as described above, a comparison of model results for an open cut mine has been undertaken. Two methods were employed to model haul routes at the mine, which are:

- 15-minute haul route source locations for trucks as logged in the mine GPS database, sound power per location is $L_{Aeq,30second}$ in accordance with the logging interval; and
- A theoretically developed model being CBP as described above.

Care was taken in establishing the GPS model to exclude source location clusters where trucks were obviously queuing to be loaded (sound power at idle is insignificant in this context). A string of sources is then modelled (a comparable method to CBP) as well as dumping noise emissions.

Results were predicted for neutral atmospheric conditions. It should be noted that the haul routes modelled are part of an entire GPS mine model that was validated using attended monitoring results, actual pit topography and prevailing meteorological conditions for the monitoring period. That is, the only variable was the modelling software itself. This model validated very accurately (within +/- 1 dB) and so it is fair to assume the subset of haul route GPS models represent actual levels. It is not possible to provide GPS model validation results for this present paper as the project is currently commercial in confidence.

Results for nine haul routes modelled to nine receptor locations around the mine show the CBP model levels to be 0.8 dB less on average than those for the GPS model. However, one of the haul route results appeared unusual. On closer inspection it was found to only have three trucks, which is an unusual configuration. Excluding this haul route from the results set gives a correlation of 0.5 dB less on average relative to the GPS model. This is considered to be within acceptable tolerances.

5. Conclusion

As can be seen from the results the CBP for modelling haul route noise emissions provides results within 1 dB of a validated model based on GPS plant locations. The difference was that in this exercise the CBP model slightly under-predicts, but was found to be within acceptable tolerance limits.

References

[1] *Industrial Noise Policy*, NSW Environment Protection Authority, 2000.

[2] *Draft Planning Guideline: Mining. Assessment of Sound Power Levels of Mining Equipment and their use in Noise Models*. NSW Department of Planning and Environment, 2015.