Some considerations of network traffic noise and a decision support system
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Abstract

In recent years the traditional operation of transport systems in urban areas has come under increasing scrutiny. Physical characteristics of urban networks have been altered to induce traffic calming and hence modify the functionality of the network. The ability to plan and access such alterations has been limited to the first order effects of traffic flow and speeds. Few tools are currently in existence which can quantify second order effects including environmental impacts and safety at the network scale. The authors are developing a planning tool capable of assessing changes to the operation of urban road networks in terms of environmental effects and safety. This paper considers the development of such a tool with regards to traffic noise. A set of Decision Support Rules are integrated with a network noise prediction model, NetNoise, and a Geographic Information System (GIS), MapInfo. Using a case study area, a system has been developed using a comprehensive database built up with extensive field measurements including noise loggers and Global Positioning System (GPS) technology.

Introduction

The issue of traffic noise in urban areas has now been around for many years. The Organisation for Economic Cooperation and Development (OECD) has estimated that in the early eighties 130 million people in its member countries were exposed to noise levels of 65 dB(A) and above and 300 million living in acoustic discomfort being exposed to levels of 55 to 65 dB(A)\(^1\). Recent studies have indicated that noise is still a major environmental issue in the urban environment and only slight improvement has been made over the last 10 to 15 years\(^2\). In Australia, Brown\(^3\) has estimated that 19 percent of the population is
exposed to noise levels of 63 dB(A) $L_{A10}$ (18 hour) and above. This is somewhat lower than other OECD countries due to the low density urban form that is prevalent in Australia. Nevertheless, noise black spots near major freeways and arterial roads do pose problems to the exposed population. Noise management in Australia has tended to be reactive rather than pro-active but this trend is slowly changing with new planning approaches and the introduction of Environmental Impact Statements (EIS). Timing of the noise assessment is also crucial as noise tended to be considered after draft transport plans had been fixed. At present there are very few tools available to practicing engineers and planners which quantify the effects of noise on a community over an area based coverage. The development of network based noise prediction model and its integration with Decision Support Rules forms the basis of this paper.

The NetNoise model

The NetNoise model was developed by the authors to provide an area wide estimation of noise levels from a road traffic network. NetNoise forms a module in the IMPAECT supermodel as outlined in Taylor et al. IMPAECT consists of a suite of traffic, pollution and land use models combined through a common database structure (TNRDB) which allows the user to assess the impacts of transportation systems on the urban environment.

The basic algorithm in the NetNoise model adheres closely to the Calculation of Road Traffic Noise (CoRTN) procedure developed by the United Kingdom’s Department of Environment in 1977 and consequently revised in 1988. CoRTN has been adopted as the standard noise prediction procedure by road authorities in Australia. The performance of CoRTN under Australian conditions was investigated by Saunders et al and was found to be suitable for Australian conditions. The procedure was found to have a standard deviation of ±2.5 dB(A) and correction factors of -0.7 dB(A) and -1.7 dB(A) recommended for receivers located in the free field and 1 m in front of a facade respectively. Research into road surfaces prevalent in Australia has also led to another set of corrections. This data may be used in preference to the CoRTN corrections and incorporates chip seal, densely and open graded asphaltic concrete surfaces (non-rigid pavements) and Portland Cement concrete surfaces (rigid pavements).

Several programs have been developed in Australia using the CoRTN procedure. The most prominent of these include NOISE 3 and T-NOISE. Both of these programs require detailed site and traffic information and are therefore labour intensive and only intended for site specific investigations.

The NetNoise program was designed to be simple to use and run on a personal computer (PC) and is described in detail in Woolley. The program was
written in the MS Windows environment with a user friendly graphical user interface as shown in Figure 1. Once NetNoise is running the user is provided guidance for data input and stepped through sequentially to set up a calculation run. The user has been given as much control as possible over the input variables without compromising the integrity of a calculation run. NetNoise allows for several sources of input and output. At present input is in the form of delimited text files or ACCESS database files (TNRDB format). Output can be made to text files, spreadsheets, ACCESS databases and the MapInfo and ARC/INFO GIS. Both input and output may be viewed in NetNoise and summary information such as corrections applied and contour plots are available.

In modelling at the network scale several assumptions and features are added to the basic CoRTN procedure:

- corrections such as facade effect and ground absorbency are applied globally (ie to all links in the network)
- the study area was assumed to be relatively flat with ideal meteorological conditions
- a road hierarchy and scenario planning feature was included into the program to allow the comparison of what if scenarios
A radius of influence feature allows the user to place a limit on how far noise propagates in the urban environment. A background noise level applies for areas of the network distant from roads. Area wide coverage is achieved by placing a grid of receivers over the study area in question. The user has total control over the coarseness of the grid and its size and location. Traffic volumes can be in any units provided a conversion factor is approved by the user. Vehicle composition on the network roads can be fine tuned according to AUSTRoads classification data or Australian Bureau of Statistics data. The user has the option of choosing which corrections to apply and information regarding the derivation of the final noise level can be obtained on a link by link basis. Uncomplicated noise barrier configurations can also be incorporated into the network.

The scenario manager allows the user to investigate *what if* scenarios and compare alternative traffic schemes. For example, the scenario manager could be used to determine the effect of banning heavy vehicles on local roads or reducing speeds by certain amounts. Another advantage of the hierarchy system is its ability to incorporate tunnels, elevated roadways and other link based modes of transport (such as trains and trams) into the network.

Whilst the NetNoise model can predict noise levels for individual points in the network its use is not intended to provide absolute values of noise. Noise can be a very localised phenomena and accurate prediction requires detailed representation of the urban fabric, which may be viewed as unnecessary for planning purposes and not feasible for use on a PC. A further point to note is the source and accuracy of the input variables. Most traffic network coordinates can now be obtained easily from GIS databases and are generally speaking more than adequate for noise modelling. Traffic variables such as flows, speeds and composition of heavy vehicles will always have certain degrees of accuracy.

The NetNoise model must also be used with caution in environments where traffic flow is heavily congested or where interrupted flow conditions exist. The development of interrupted flow prediction models in Australia has been slow and only the ITFNS model exists for simple signalised intersections. ITFNS is a simulation model and its incorporation into a PC based network model is not considered feasible at this point in time.

**The noise decision rules**

The NetNoise model provides the user with the capability to investigate the area wide distribution of noise from a road network. What is also needed is the ability to provide guidance as to where problem areas may be and what remedial
action can be used. An Expert System is being developed by the authors to provide such a capability. A modelling approach was adopted to extract the domain knowledge at the knowledge acquisition stage. The Decision Rules are intended to be used to assess the traffic noise impacts on pedestrians and residents in land uses immediately adjacent to the road in question. The main roads in urban areas serving both traffic mobility and frontage related activity functions (access, shopping, etc.) were the primary subject of this study.

The NetNoise program was used to estimate traffic noise levels for differing traffic scenarios. These scenarios were set up corresponding to the guidance derived from various research papers and other publications including Brown and Patterson\textsuperscript{12} and the Department of Planning\textsuperscript{13}. The following assumptions were made when estimating traffic noise:

i. noise levels ($L_{10}$ (18 hour)) at different distances perpendicularly from the centre line of a 400 m road length are assumed to be representative of critical noise levels for any road section;

ii. noise source height is 0.5 m above the road surface and receivers 1.2 m high and 1.0 m in front of a building facade;

iii. road surface type is a dense grade asphaltic concrete (DGAC);

iv. the effects of road gradient, absorbent ground coverage, presence of screening and the existence of an opposite facade were not taken into account. In addition, it is also assumed that all road sections are physically homogeneous along their lengths and symmetrical about their centre line. Traffic was assumed to be free flowing in typical off-peak conditions. The corrections for Australian conditions were applied in this study.

Based on important research findings concerning the general noise effects in several OECD member countries\textsuperscript{1}, the following noise impact ratings were adopted:

1. Very Low (VL): 58 dB(A) $L_{10}$ (18 hour) and below;
2. Low (L): between 58 and 63 dB(A) $L_{10}$ (18 hour);
3. Medium (M): between 63 and 68 dB(A) $L_{10}$ (18 hour);
4. High (H): between 68 and 73 dB(A) $L_{10}$ (18 hour);
5. Very High (VH): 73 dB(A) $L_{10}$ (18 hour) and above.

This scoring system can be used to assess not only desirable or acceptable noise levels but also annoyance. An example of the resultant rules is given below:

**IF** Average Daily Traffic is between 12500 and 17500 vehicles per day **AND**
Mean Speed is between 55 and 65 kilometres per hour **AND**
Percentage of Heavy Vehicle Composition is between 7.5 and 12.5% **AND**
Distance from Centre Line of the Road is between 12 and 28 metres **THEN** Traffic Noise Rating is High (H).
The Decision Rules can be used to qualitatively assess the traffic noise impacts at the local level, identify traffic noise problem locations and suggest the main contributing factors for those locations. Their accuracy lies between subjective approaches such as the Amenity Sensitivity (AS) method and rigorous approaches like the Environmental Capacity (EC) method. Decision Rules can be applied to road hierarchy classification and traffic management planning. A further refinement can be achieved by including the influences of land use types. However, this task is very difficult due to the lack of universally acceptable traffic noise standards based on individual land use types.

The case study

The City of Unley in Adelaide, South Australia is a well established inner suburban area immediately abutting the southern part of the Adelaide central business district (CBD). The road network is based on a traditional grid system common in Adelaide. The central part of the Unley area as shown in Figure 2 was used as the case study area due to its relative flatness, mix of land uses and availability of traffic data. The area has formed part of a trial 40 km/h urban speed zone and is surrounded by Greenhill Road (link 11), Unley Road (links 7-10), Cross Road (link 12), Victoria Avenue (link 6) and King William Road (links 1-5).
These roads, which formed the basis of the study, were divided into twelve homogeneous road sections corresponding to the uniformity of physical conditions, consistency of abutting land uses, configurations of road junctions, and derived road sectional lengths as illustrated in Figure 2.

A database of the area was built up using available data, manual site surveys and equipment including noise loggers, vehicle classifier/counters, radar guns and Global Positioning Systems. The database consisted of:

i. physical road characteristics (eg surface types, width, number of lanes, etc.);
ii. adjacent land use types;
iii. building setbacks;
iv. building facade orientation;
v. traffic volumes (daily, annual and peak flows);
vi. composition of heavy vehicles;
vii. instantaneous spot speeds;
viii. measured noise levels;
ix. in vehicle GPS data.

Data was refined and verified by using on-road video recordings, aerial photographs and other relevant documents. Databases were constructed for the MapInfo and TNRDB environments.

Assessment of the case study area

Output from the NetNoise model for the study area is shown in the form of a thematic map in Figure 3. Receivers were placed across the network at 5 by 50 metre intervals. The backdrop to this figure is a low resolution aerial photograph which provides a useful indication of land use types. The bands of noise emanating from the traffic network can be used to calculate regions of exposure based on land use. This can lead to estimations of the number of households exposed to certain noise levels when combined with a demographic land use layer.
When applying the Decision Rules each link was classified with a noise rating score as shown in Figure 4. This immediately identifies the links which require treatment or special attention. Links 7 to 9, 11 and 1 are classified as very high and attention must be paid to the land uses adjacent to these links. In the case of the study area, the high rating is brought about by a combination of high traffic flow and the close proximity of buildings to the roadway.

**Conclusion**

Noise still forms a major concern in OECD countries and conditions have not improved significantly over the last 10 to 15 years. While there are many noise prediction models in use, these tend to be labour intensive and intended for site specific investigations. The authors have proposed an area based tool using a network noise prediction model (NetNoise) and a set of Decision Rules which, when combined with a GIS, is capable of identifying problem roads and the exposure of land uses to noise levels. The tool is made easy to use through intelligent guidance to the user when setting up calculation scenarios and its graphical user interface. The initial application of the tool to the Unley case study area has already indicated its utility for transport and land use planning.
Figure 4: Link based noise ratings for the Unley study area

References


96  Urban Transport and the Environment


