Overview of the noise model (TRANEX) used in the TRAFFIC study

Noise metrics (all A-weighted in dB)

Primary metrics:

$L_{Aeq,16hr}$: average sound level over the 16 hour period of 0700 - 2300 hours.

L_{night}: average sound level over the 8 hour night period of 2300 - 0700 hours.

Other metrics:

$L_{Aeq,1hr}$: average sound level over a specific hour of the day.

L_{day}: average sound level over the 12 hour day period of 0700 - 1900 hours.

L_{eve}: average sound level over the 4 hour evening period of 1900 - 2300 hours.

L_{den}: a logarithmic composite of the Lday, Levening, and Lnight levels but with 5 dB(A) being added to the Levening value and 10 dB(A) being added to the Lnight value.

Summary

Instead of using proprietary software a new model was developed for two main reasons: 1) so that the treatment of source geometry, traffic information (flows/speeds/spatially varying diurnal traffic profiles) and receptors matched as closely as possible to that of the air pollution modelling being undertaken in the TRAFFIC project, and 2) to optimize model performance for practical reasons of needing to implement a noise model with detailed source geometry, over a large geographical area, to produce noise estimates at up to several million address locations, with limited computing resources. To evaluate TRANEX, noise estimates were compared with noise measurements made in the British cities of Leicester and Norwich. High correlation was seen between modelled and measured $L_{Aeq,1hr}$ (Norwich: $r = 0.85$, $p = .000$; Leicester: $r = 0.95$, $p = .000$) with average model errors of 3.1 dB. TRANEX was used to estimate noise exposures ($L_{Aeq,1hr}$, $L_{Aeq,16hr}$, L_{night}) for the resident population of London (2003 - 2010). Results suggest that 1.03 million (12%) people are exposed to daytime road traffic noise levels ≥ 65 dB(A) and 1.63 million (19%) people are exposed to night-time road traffic noise levels ≥ 55 dB(A). Differences in noise levels between 2010 and 2003 were on average relatively small: 0.25 dB (standard deviation: 0.89) and 0.26 dB (standard deviation: 0.87) for $L_{Aeq,16hr}$ and L_{night}.

Choice of model

The Calculation of Road Traffic Noise method (CoRTN) (Department of Transport, 1988) was adopted. The CoRTN method is used in the UK for strategic noise mapping (DEFRA, 2008; HMSO, 2006) and has been implemented as an optional noise calculation method in leading proprietary software such as SoundPLAN (http://www.soundplan-uk.com) and CadnaA (http://www.datakustik.com/en/products/cadnaa). The CoRTN method is also used as the UK primary noise calculation methodology for new road schemes (http://www.dft.gov.uk/ha/standards/dmrb/vol11/section3/hd21311.pdf).

Model terms

Traffic noise estimates are calculated in CoRTN as one-hour, A-weighted L_{10} (dB) (i.e. the noise level that is exceeded 10% of the time), denoted as $L_{A10,1hr}$, and $L_{10,18hr}$ for the period 06:00 until 0:00.

The CoRTN method includes the following terms:

$$L_{A10,1hr} = L_0 + \Delta_f + \Delta_g + \Delta_p + \Delta_d + \Delta_s + \Delta_c + \Delta_a + \Delta_r$$

where L_0 is the basic noise level calculated at 3.5 m from the kerbside, at 0.5 m above ground level; Δ_f is the correction for traffic speed and the percentage of heavy vehicles; Δ_g is the adjustment for the gradient of a road section; Δ_p is the road surface correction; Δ_d is the slant distance between the road (source) and receptor; Δ_s is the correction for shielding (i.e. barriers) between a road (source) and receptor; Δ_c is ground cover attenuation; Δ_a is the correction for the angle of view of the road; Δ_r is the correction for reflections from buildings on the opposite side of the façade.

Data used to run TRANEX

For implementation of the noise model in London the most detailed data sets available for traffic information (i.e. composition, speed, diurnal varying traffic profiles for different parts of London), land cover, road geography, building heights, and receptors (i.e. postcodes and addresses) were used.

Information on buildings and land cover (Topographic Layer) and the Integrated Transport Network (ITN) form part of Ordnance Survey's 2009 version of MasterMap™ (MM).

The ITN provides detailed road network information including road type and information on one-way streets. Traffic source data (i.e. 10 m points along roads) are from the London Atmospheric Emissions Inventory (LAEI) (LAEI, 2010). Information on one-way streets and road tunnels in the ITN were linked to traffic source points. Information from the ITN was used to exclude road tunnels from TRANEX.

Road traffic flows in the LAEI are represented using annual averaged daily traffic (AADT) data. The AADT data for each link has been calculated in accordance with that used in the LAEI 2008, and is described in Beevers et al. (2009). The same 10m points along roads and traffic information matched those used in the air pollution model in the TRAFFIC study.

Building heights were assigned to the nearest MM building within a 20 m radius of each building height location. MM buildings that could not be assigned a building height (e.g., no MM building within 20 m of building height data, missing building heights in Landmap) were assigned a default building height of 10 m if the footprint of a MM building was ≥ 15 m^2. Small buildings such as bus shelters, porches, garages etc. potentially cause problems in the definition of building facades and noise calculations (see Figure 2). All buildings < 15 m^2 were therefore deleted (see Figure 2). Building heights were converted into a 0.5 m x 0.5 m grid of buildings attributed with heights for viewshed analysis (i.e. for the reflections calculation).

For generation of receptors (i.e. address or postcode locations) a geometric centroid was created for each MM building. Each receptor was then moved to 1 m from the facade on the side of the building closest to the nearest road section with traffic information. Figure 2 shows how this was achieved and also shows situations where this automated method of moving receptors to facades does not work.

Postcodes and address points were intersected with buildings and subsequently linked to receptors using a unique building identifier. Typically there are ~15 addresses associated with each postcode. Point locations for postcodes are the geometric centroids of the address locations associated with each postcode. Each postcode is attributed with a headcount using data from the 2011 census. There are 189531 postcodes, ~3 million address locations, and a population of 8613526 in the study area.

A fixed value of 600 vehicles day^{-1} was applied to minor roads based on the magnitude of manual counts undertaken during noise measurements, and MCC data made available by Norwich City Council and available in the LAEI. Counts were proportionally assigned to minor roads for each hour of the day using the diurnal traffic profile associated with the nearest main road in the LAEI.

In this study all receptors were given a height of 4 m above ground. For each receptor, the noise level is the combination (equation 13) of noise levels predicted for each pair of source-receptor points with the basic noise level adjusted for the propagation terms listed in section 2.1.

The CoRTN method also includes a correction based on the proximity of sound reflective surfaces (building façades). This is achieved via viewshed analysis of buildings within a 50 m radius of a receptor point.

Model Evaluation

To evaluate the performance of TRANEX, noise measurements were utilised that were collected as part of previous studies undertaken by the authors in the EU funded 5th Framework Program HEAVEN (Healthier Environment through the Abatement of Vehicle Emissions and Noise, in 2002) and HEARTS (Health Effects and Risks to Transport Systems, in 2005) projects in Leicester, UK, and data collected in 2014 to coincide with on-going air pollution monitoring being undertaken by the authors in Norwich, UK. In Leicester a total of 38, 30-minute noise measurements were taken and in Norwich a total of 35, 30-minute noise measurements were taken.

Information from local traffic models and land use data sets were obtained to evaluate TRANEX in Leicester and Norwich.

A high level of correlation was seen between measured and modelled noise levels (Leicester: r = 0.85; Norwich: r = 0.95). The average error in predicted noise levels was 2.6 dB(A) for Leicester and 3.5 dB(A) for Norwich. In Leicester and Norwich 63% and 34% of sites, respectively, have predicted noise levels within +/- 2 dB(A) of measured noise levels. In both cities, modelled noise levels tend to over-predict measured noise levels, but the model under-predicts the variability in measured noise levels as indicated by the values of variance of measured (Var_O) and modelled (Var_P) noise levels. Pooling sites from Leicester and Norwich yields an r = 0.90 and an average model error of 3.1 dB(A).

Exposure Assessment

For each noise metric (e.g. $L_{Aeq,1hr}$), exposures were assumed to be equal to modelled noise levels. Road traffic noise exposures were calculated for all 189531 postcodes in London for each year between 2003 and 2010. Exposure assessment of the population of London was undertaken by assigning population headcounts to noise exposures calculated for each postcode location.

For $L_{Aeq,16hr}$ there is < 1 dB (i.e. median – min) variability across 50% of postcode locations (Table 3); 10% of the population have $L_{Aeq,16hr}$ and L_{night} noise levels > 68.3 dB and > 63.5 dB, respectively. For $L_{Aeq,16hr}$ and L_{night}, 74% and 70%, respectively, of the population have modelled road traffic noise exposures in the lowest 4 dB category of noise exposures. Approximately 19% and 12% of the population are exposed to road traffic $L_{Aeq,16hr}$ noise levels ≥ 60 dB and ≥ 65 dB, respectively. Approximately 19% and 12% of the population are exposed to road traffic L_{night} noise levels ≥ 55 dB and ≥ 60 dB, respectively.

Differences over the study period (2003 - 2010) in noise exposures were calculated by subtracting values of $L_{Aeq,16hr}$ and L_{night} predicted at postcode locations (n = 189531) for 2003 from values predicted for 2010. Relatively large negative and positive changes were seen at a small number of postcodes. This may be due to traffic interventions (road closures, road building, traffic diversions etc.) between 2003 and 2010 (N.B. the comparison is for the same postcode locations). The average change for $L_{Aeq,16hr}$ and L_{night} is < 0.3 dB. Traffic flows over this period have generally increased but lower speeds due to traffic congestion may counteract the ability of traffic flows to raise noise levels. Approximately 54% of postcodes for both $L_{Aeq,16hr}$ and L_{night} have an increase in modelled noise exposures between 2003 and 2010. The majority of postcode locations (96%) have changes in predicted $L_{Aeq,16hr}$ and L_{night} noise exposures of < +/- 2 dB between 2003 and 2010.

References

Beevers S, Carslaw, D, Westmoreland E, Mittal H. Air pollution and emissions trends in London, 2009: http://uk-air.defra.gov.uk/assets/documents/reports/cat05/1004010934_MeasurementvsEmissionsTrends.pdf (accessed on 28th July, 2014).

DEFRA (2008). Noise Mapping England. Online Resource: http://services.defra.gov.uk/wps/portal/noise [Accessed: 31/07/2014].

Department of Transport. Calculation of Road Traffic Noise. HMSO, 1988.

HMSO (2006). Environmental Noise (England) Regulations 2006. SI 2006 No. 2238.

London Atmospheric Emissions Inventory (LAEI):
http://data.london.gov.uk/datastore/package/london-atmospheric-emissions-inventory-2010 (accessed on 28th July, 2014).