NOISE MAPPING OF WESTMINSTER - PRACTICALITIES AND POTENTIALS

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1 INTRODUCTION

Westminster City Council is recognised as having the busiest 24 hour/365 day noise service in the country with 17,000 calls last year. In recognising the need to develop proactive measures and techniques to deal with noise issues, and with reference to the direction which the EU and UK Governments are taking, the City Council have worked in partnership with Hepworth Acoustics this year to produce detailed noise maps of Westminster. The project has brought together information from across the Council's departments including the noise team, transportation and GIS sections; and promises benefits to all as well as reporting of information into the planning department and helping to shape future policy decisions. This paper describes the process of integrating the source data into a noise mapping model, the checking and validation processing which are being carried out, and some of the future possibilities for utilising the results of the work.

2 BACKGROUND

The utilisation of calculated noise levels to meet the requirements of legislation and public policy in England may be traced back as far as 1973 with the introduction of the Noise Insulation Regulations (NIR)[i]. The necessity to use the calculation method set out in the Calculation of Road Traffic (CRTN)[ii] led to the development of computer based methods for carrying out the required calculations and assessment at the hundreds of properties in the vicinity of new roads. During the 1980s and 1990s these requirements increased with the revisions to CRTN in 1988 and the introduction of Volume 11 Part 4 of the Design Manual for Roads and Bridges (DMRB)[iii] in 1993. The planning framework and scale of the road alterations being carried out during this period often led to areas of over 30km^2 being modelled and the change in noise levels assessed at many thousands of properties.

Although the publication of the work on the Birmingham Noise Maps in 2000[iv] appeared to some as a step into a new unknown area of work, the calculation of road traffic noise levels really represented an enhancement and improvement on the type of work which had been carried out for over 20 years. The level of detail, and the area of over 300km^2, represented a new state of the art in UK noise calculations, whilst the most radical innovation was the integrated assessment of road, rail, aircraft and industrial sources together, rather than the more usual single source assessments carried out in the UK.

Westminster City Council has the busiest 24 hour / 365 day noise team in the country with almost 17,000 calls last year. The public awareness, population density and record of the Council in dealing with these complaints have led to the high profile of noise within Westminster. In this context it was decided that Westminster City Council would take steps towards meeting the proposals within the new EU Environmental Noise Directive[v], the UK Government Rural White Paper[vi] and the Ambient Noise Strategy[vii] in a concise time frame.

The EU Environmental Noise Directive sets out three clear steps:

1. monitor the environmental noise problem by drawing up "strategic noise maps" for major roads, railways and airports.
2. inform and consult with the public about noise exposure, its effects, and the measures considered to address noise
3. draw up action plans to reduce noise where necessary and maintain environmental noise quality where it is good.

These three steps can be seen as being complimentary to the desire within the UK Rural White Paper to identify and protect areas of tranquillity. Whilst areas of tranquillity within cities are unlikely to reach the very low noise levels found in the countryside, their importance as areas of relative peace is well understood.

The desire within Westminster is to reach a point where the noise maps required in Step 1 under the EU directive are completed as early as possible to enable their use in informing future policy, assessing proposed developments and reporting on the effects of proposed London wide policies within the Westminster area. Hepworth Acoustics have been working to develop a detailed noise model of Westminster to assess the city wide noise environment. This model will then be passed through to Westminster where in-house trained staff will be used to carry out project specific assessments using the baseline model.

3 DEVELOPING THE NOISE MODEL

The scope and objectives of the project are as follows:

- Creation of 3D computer model of the City of Westminster, including all major Buildings, Roads, Railways and Industrial sites

- Calculation of noise levels for each of the above noise sources on a 10m grid spacing across the whole city
- Combination of the above calculations to assess the total noise level across the City
- Integration of data from inside and outside the City Council, such as GIS, road traffic flow data, railway traffic flow data, noise measurement information

The desire was to produce a detailed noise model which contains all of the Ordnance Survey described buildings as closed 3D polygon objects within the model. This is to ensure that the model will be suitable for future developments in noise mapping, such as more sophisticated calculation algorithms likely to result from projects such as Harmonoise[viii], and to enable the model data to be passed back into GIS to be used as the basis for other assessments, such as visual impact, air quality and 3D rendering.

3.1 Source Model

3.1.1 Road traffic noise

Within the Westminster City boundary the GIS “Streets” data layer holds information about the geometric location, street name and other data describing every street in Westminster. This is thought to have been based upon the OS OSCAR data and was supplied in ArcView Shapefile format. The Greater London Authority (GLA) emissions inventory (LEI)[ix] contains road traffic flow data for major roads and motorway links within Westminster, and beyond into neighbouring boroughs. The Emissions inventory is geometrically simplified with most node points located with reasonable accuracy, but using straight line links, as opposed to the real road alignments which curve between buildings. This was supplied in ArcView Shapefile format.

This leads to a question over how to bring together the two data sets. The accurate geometry of the “Streets” data is required for placement, and other attributes such as Street Name are useful, whilst the minor roads are to be retained within the model, even if traffic flows are not currently known, to allow for future enhancement to the model as data becomes available. On the other hand, the traffic data within the LEI does not have sufficient geometric accuracy to be used for the calculations.

Using geometry commands within the LIMA package used, the geometrically accurate “Streets” were matched to the geometrically less accurate Emissions, and the road traffic flow attributes copied across onto the Streets objects. This lead to geometrically accurate emissions lines with full traffic flow data as attributes. This matching process was checked in detail by hand, and all errors or omissions which were discovered were corrected.

As the Emissions inventory only covers the major roads within Westminster, whilst the Streets data contains information on all the roads, there are some roads within the Westminster boundary for which no traffic flow data is currently assigned. There are just over 400 km of road objects within the Westminster boundary in the model, with 290 km of them modelled as emitters with traffic flows defined.

Outside the Westminster boundary the Emissions data has been used as the basis for the road layout. The geometrical layout has been adjusted by hand to ensure that the emissions lines follow the actual road paths as accurately as possible, and pass between the building objects within the model as would be expected.

The basic noise level of the road objects is calculated according to CRTN, and the propagation may be calculated as an L10 according to CRTN, or L_{eq} in accordance with the new correction factors TRL has proposed for noise mapping purposes. Calculation of L_{day}, $L_{evening}$, L_{night} and L_{DEN} can be carried out in one calculation run if the relative factors or flows are known for the 3 time periods.

3.1.2 Rail traffic noise

The rail line geometric layout has been derived from the OS data layers within the supplied Land Line files. Unfortunately great difficulties have been encountered in sourcing rail traffic flow data for the routes approaching the mainline stations within Westminster. Due to the incomplete data it has not been possible to carry out rail noise calculations at this point.

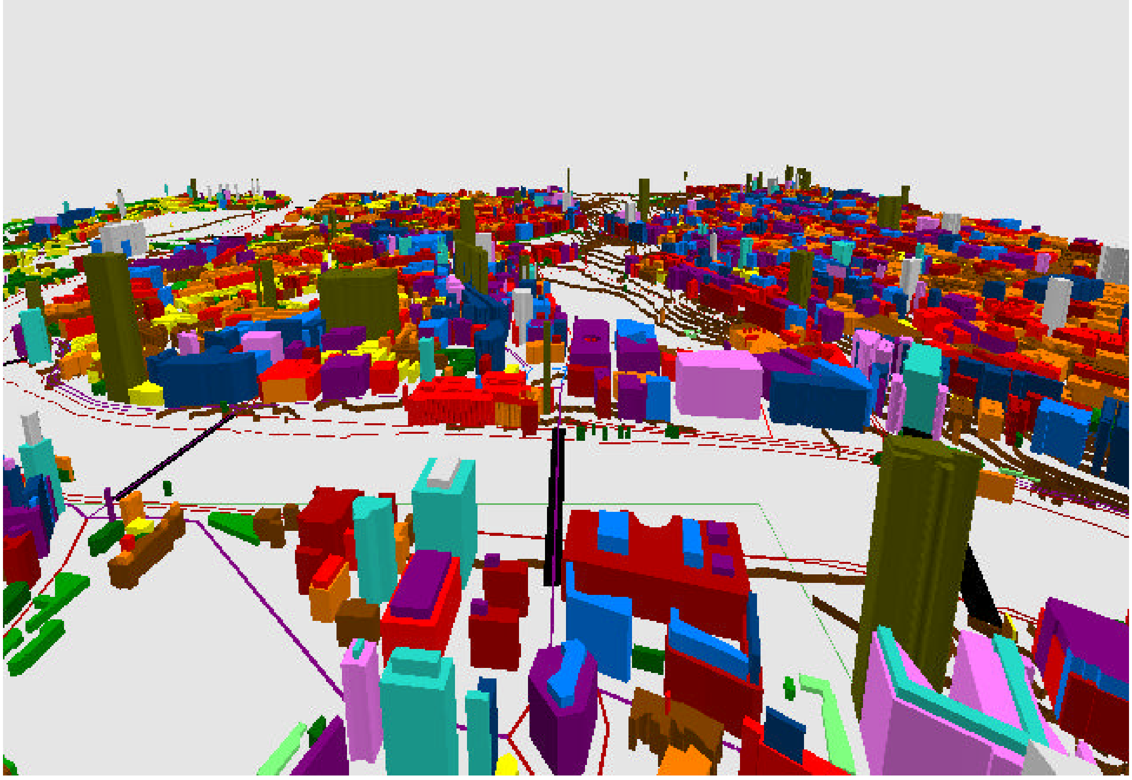
3.2 Propagation Model

3.2.1 Buildings

The geometric layout information for buildings within Westminster City Council's area came from 118 Ordnance Survey (OS) Land Line Plus 500m x 500m tiles that were supplied by the Council as the original OS DXF files. The DXF data was imported into LIMA, redundant information removed and the buildings layer converted to closed polygon building objects using the built in LIMA macros. The automatic processing of the base data correctly handled approximately 95% of the OS building layout into final LIMA building objects. This left approximately 5% of building polygons which then had to be processed by hand to ensure closed polygon building objects in good condition. The full OS data set produced approximately 60,000 building objects. The buildings were initially given default heights of either 8m or 15m, determined by floor area. With the growing availability of OS MasterMap data, which contains closed polygon building objects, it is hoped that this type of conversion will become less common in future.

Building height data has come from the GeoInformation Group building height flyover data. This was supplied for the whole of central London. The height data came with polygon data which describes the building location (however not to the accuracy of the OS data), and with polyline data for roof ridgelines. The ridgeline data was not used and discarded, whilst the polygon buildings were closed and cleaned up to provide building layout and height data for the area outside the OS coverage. Inside the OS coverage area the building height flyover data was matched onto the OS derived buildings using a number of commands and macros within LIMA. The accuracy of the height match was inspected using visual printouts of the two files, and shows very good agreement. Outside the OS coverage area, thus not within Westminster's boundary, the flyover polygons were used to create building objects. These are geometrically less accurate than the OS buildings.

Figure 3.2.1: 3D view across the Thames towards Westminster as presented in the LIMA model



3.2.2 Ground Contours

The originally supplied ground height information came from GIS and consisted of 10m interval equal height contours within the Westminster boundary, and an area to the North and West of Westminster. As it was not possible to obtain further ground height data from OS, and there was a desire to avoid a flat ground model, the height data within the OS Land Line tiles has been used.

To obtain the additional ground model data, the OS bench marks and road height data were searched out of the imported DXF files. These points were converted to Lima ground height points and a calculation of possible ground contours was carried out within Lima using these spot heights as the input data. The 1m contours produced agree well with the 10m interval contour data originally supplied, and were selected as the basis for the calculations in the absence of more accurate data.

As the model was later extended outside the OS coverage area, some ground height data was required to cover these additional areas. As there was little additional information available the ground height contours were added manually with reference to the building height information. This appears to give a reasonable agreement, but the degree of accuracy cannot be firmly quoted.

3.2.3 Ground Model Elements

Other ground model elements have been added to the model where thought to be of significant acoustic impact. These elements have included:

- Bridges over the Thames, and elevated road on the Westway
- Embankments either side of the Thames
- Railway cuttings into Marylebone, Paddington and near Swiss Cottage
- Road underpasses at Hyde Park Corner, Waterloo Bridge and Euston

These have largely been added manually with the source OS layout data, or in some case GIS data, as a guide for location. Where required the height data has been assessed with reference to the ground contours.

During the calculation of road and rail noise according to ‘Calculation of Road Traffic Noise’ (CRTN) and ‘Calculation of Railway Noise’ (CRN) respectively, the potential noise absorbing effect of “soft ground” is included within calculations. To facilitate the inclusion of soft ground attenuation, it was decided to define the whole of the model area as soft ground, apart from the Thames, which is defined as hard ground. As soft ground attenuation is only used instead of barrier attenuation when it provides greater attenuation, it was considered that for most of the built up area the barrier attenuation would prevail, and only for the open spaces would the ground type have any significant effect. With the number of parks and open areas of vegetation it was decided that each could not be identified separately so a blanket “soft ground” value would be applied except for the river.

3.3 Other Factors

Almost all of the source data was supplied in some form of electronic format. AutoCAD DXF, ArcView Shapefile, MapInfo DAT, MS Excel spreadsheet and MS Access database files made up the majority of the received information. The successful completion of any large scale noise mapping project requires the means to explore and link all of these various data sources, and the ability to bring them together into some common environment in order to build the 3D environment required for the model.

There are two main approaches to how this can be done:

1. Model construction and geometric manipulation within a GIS environment, exporting the completed model into the noise calculation package, followed by noise calculations within the chosen package.

2. Import all the disparate data sources into a noise calculation package with powerful geometric manipulation tools, construct model within the package, and carry out the calculations within the same noise package

The first approach is more favourable within large scale organisations that may have secondary uses, or separate departments, for the sizable investment in software, hardware and training required to properly develop a GIS capability.

The second approach offers a more homogenous project environment, and reduces interoperability issues, or cross department budgeting of resources. All the work on the Westminster project was carried out using the LIMA software package, without the need for any external GIS capabilities beyond viewing the source files.

Staffing such a project also needs to be considered. With the increasing rarity of trained, qualified acoustics personnel within the UK it is important to understand that construction of large scale noise calculation models is primarily a geographic data manipulation exercise which must be overseen and managed by an acoustics expert in order for the model to be well formed, however the routine tasks can be more efficiently carried out by staff members trained in CAD, GIS, IT, geography or other such disciplines. The acoustics expert then becomes heavily involved when selection of calculation parameters and model validation arises.

4 VALIDATING THE MODEL

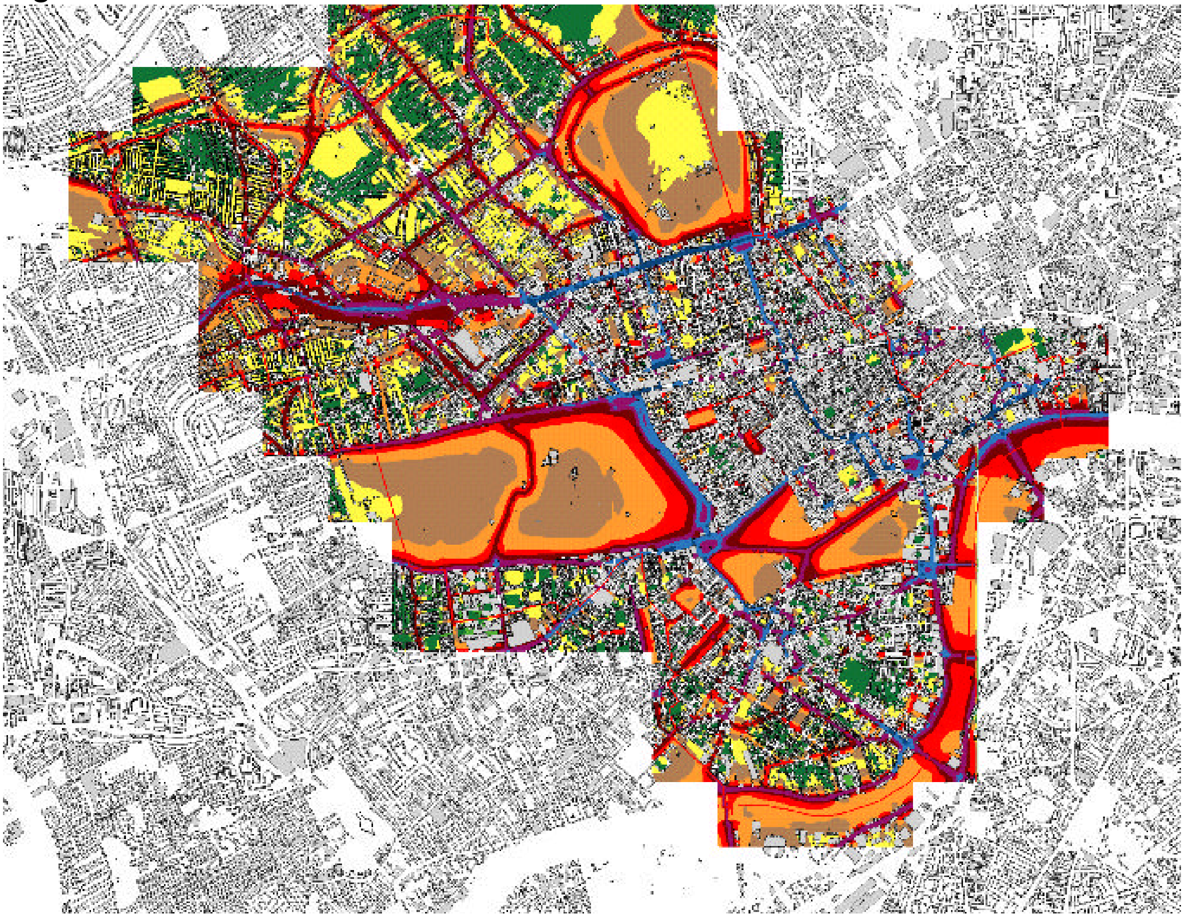
It is quite possible that noise maps will develop to form the backbone of future noise policy. As such, they will be used by a wide range of users and decision-makers from lay people to experts. Confidence in the results forms a key part in the acceptance and future use of the resultant maps. Methods for accessing and reducing uncertainties within noise maps by utilising long term measurement sites have been reported previously[x], and there is also a draft German DIN 45687[xi] standard which proposes calculation methods to be adopted within modelling software for assessing accuracies within the grid results by comparison with single point calculations.

At present the Westminster model is being assessed by comparison with the large existing set of ambient noise measurements that have been carried out by the council throughout the City. These measurements are typically of less than 3 hours each, so they do not provide like for like long term averages. However, they have already been used to confirm that there are no significant variations between the calculations and what has actually been measured in the field.

Proposals for future validation work include the use of medium and long term measurement sites, high accuracy single point re-calculations of points on the results grid and even independent re-construction of small model areas to look at potential variability.

A large database of all the short term noise monitoring carried out by planning applicants within Westminster is also being drawn up, and it is planned that this will be available alongside the noise model results within the Council's GIS system.

Figure 4.1: Noise level calculation results across Westminster



5 FUTURE USE OF THE MODEL

The future proposals for the noise model cover a wide area of potential uses. Firstly, the road emissions network, complete with LEI traffic flow data has been supplied back to the council in Shapefile format for use within air quality modelling. The linking of the LEI flows to geometrically accurate road layouts had been a goal of the section for some time. Another similar side benefit is the supply back to the Council GIS team of the OS building data as 3D closed polygon buildings with height data attached.

The model is also seen as being a dynamic entity which is to be developed and used as the basis for small scale detailed assessments. The potential future uses within the environmental team cover a number of different areas:

- Assessment of planning applications
- Noise impact of central London road toll charging
- Noise impact of road traffic management systems

- Noise impact of road traffic restriction proposals

The City wide noise mapping results are proposed to be used to assess other parameters such as total areas within noise bands, numbers of buildings within noise bands, and numbers of people within noise bands, similar to the work carried out in Birmingham[xii]. These figures can then be used as a means of assessing future scenarios or schemes and used to develop detailed noise strategy plans, similar to those encountered in continental Europe[xiii].

6 CONCLUSIONS

Hepworth Acoustics have worked in partnership with Westminster City Council to develop a detailed 3-dimensional noise model of the City. The model covers approximately 23km^2 within Westminster, and some 50km2 in the surrounding districts. The initial model creation is nearing completion, and the model validation and development into other areas is beginning. The work has taken less than six months to reach this point.

The development of large scale urban noise maps within England is not seen as a step into the unknown, more an expansion and development of the road noise calculation work which has been carried out over the past 30 years. The availability of inexpensive processing power, and the sophisticated modelling tools now available help to ensure that today's urban noise models are capable of being far more detailed, and more accurately assessed that the historic work carried out.

Experience in England and across Europe indicates that the 3D model constructed within the model should be as detailed as possible, as the calculation methodologies used at present are likely to be the limiting factors in results accuracy

The disparate data sources and formats have been discussed, along with methods of dealing with some of the issues that arise from dealing with the data sets available in England.

References:

[i] The Noise Insulation Regulations 1973 (revised 1975)

[ii] Calculation of Road Traffic Noise 1975 (Revised 1988 - ISBN 0 11 550847 3)

[iii] Design Manual for Roads and Bridges Volume 11 Section 3 Part 7 Traffic Noise and Vibration, 1993 (revised August 1994)

[iv] A Report on the Production of Noise Maps of the City of Birmingham. Birmingham Environmental & Consumer Services Department/DETR. February

2000. ISBN 1-851123-59-8
http://www.defra.gov.uk/environment/noise/birmingham/report/index.htm

[v] European Union Environmental Noise Directive 2002/49/EC of 29 June 2002

[vi] Our Countryside: The Future - A Fair Deal for Rural England, DEFRA, November 2000

[vii] Towards a National Ambient Noise Strategy, DEFRA, December 2001

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[ix] London Atmospheric Emissions Inventory (1997), London Research Centre, ISBN 1 85261 267 3

[x] Matching noise maps with reality - reducing error through validation and calibration, D. Manvell *et al*, Noise mapping - which way now? IOA Meeting, February 2002

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[xiii] Noise Strategy – European Experience, P Hepworth and S Rasmussen, Noise in London - Proc.I.O.A. Vol 23 Part 5 (May 2001)