THE AVTUNE NOISE MODEL

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ABSTRACT

This article briefly describes the implementation of a new road traffic noise prediction facility, AVTUNE (Airviro Traffic and Urban Noise Evaluator) within the framework of the existing Airviro pollution management system. The joint noise and air quality modelling system forms a major component of the Leicester element of the European Union Fifth Framework project, HEAVEN (Healthier Environment through the Abatement of Vehicle Emissions and Noise).

The noise model itself has been broken down into two major components: the SNEM (Source Noise Emissions Module) that works in quasi real-time and compliments the Airviro system's ability to acquire directly from Leicester's UTC (Urban Traffic Control) centre in predicting pollutant emissions, and the SPM (Sound Propagation Module) that provides additional long-term prediction and noise mapping facilities outside of the real time framework.

At the time of writing, the model has just completed a validation exercise covering a section of Leicester's road network. Initial results from this exercise are presented here. A larger demonstration exercise is planned to run throughout the Summer of 2002.

Keywords: urban traffic control, decision support systems, noise modelling, noise mapping, emissions modelling

1. INTRODUCTION

The European Union Fifth Framework HEAVEN project has as its main goal the development of a Decision Support System (DSS) that will allow partner cities (Berlin, Leicester, Paris, Prague, Rome Rotterdam) to:

- provide a better description, in quasi real-time, of the environmental impacts (on air and/or noise) mainly induced by traffic and,
- assist in identifying TDMS (Traffic Demand Management Strategies) that reduce the impact of traffic on the environment.

In the City of Leicester a primary objective for the HEAVEN implementation is the inclusion of traffic noise data into the DSS. The DSS is also being built upon existing air quality management infrastructure, the centrepiece being an Airviro system from SMHI (Swedish Meteorological and Hydrological Institute). This system is currently capable of incorporating traffic information, meteorological data, and monitored pollutant concentrations to provide near real-time emissions calculations, 24/48 hour concentration forecasting and offline scenario analyses.

Given that the stages of noise modelling are almost directly analogous (see Figure 1) to those involved in air quality modelling all components required for traffic noise modelling in Leicester are being incorporated into the Airviro system.

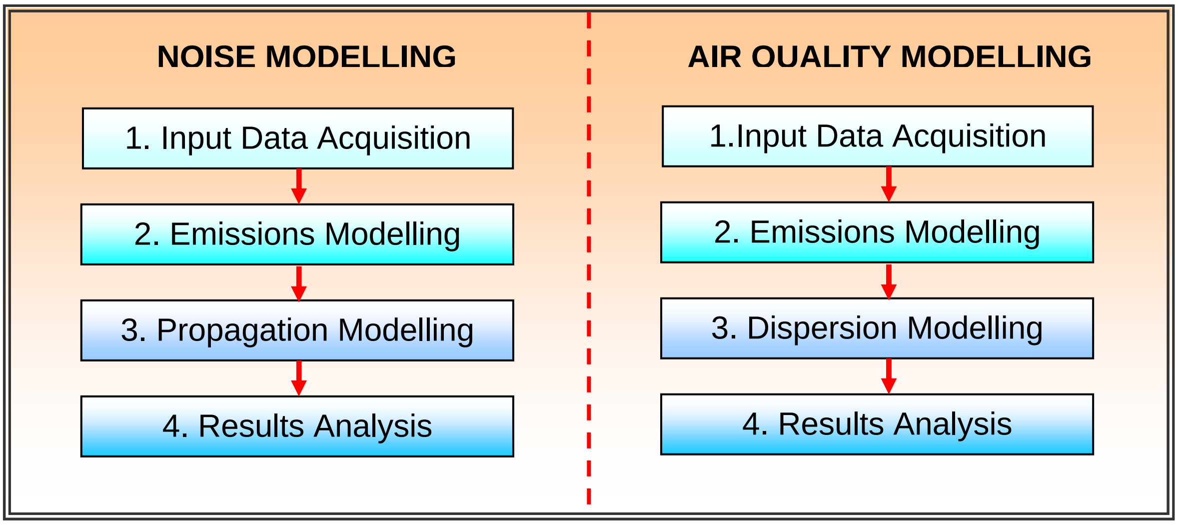

Figure 1: Stages in Noise and Air Quality Modelling

2. THE MODELLING PROCESS

The four stages (Figure 1) involved in the modelling process are handled by various components of the Airviro system. Two of these components, termed the SNEM (Source Noise Emissions Module – handling Stage 2 in Figure 1) and the SPM (Sound Propagation Module – handling Stage 3 in Figure 1) are completely unique to the Leicester Airviro system. The other modelling stages are handled by modifications to existing Airviro components.

2.1 Stage 1: Input Data Acquisition

The data input may be divided into two categories, data required for the SNEM and the data required for the SPM.

For the SNEM, data requirements include:

- Traffic network information: i.e. the spatial coordinates of road links.
- Traffic data: e.g. flow levels, flow speeds, proportion of heavy vehicles etc.

Traffic data may be provided either as static information, entered manually through Airviro's GUI (Graphical User Interface) or dynamically through a link to Leicester's SCOOT (Split Cycle Offset Optimisation Technique) system (Hunt et al, 1982). The SCOOT data provides flow counts from on-street detectors, as well as journey times and estimates of the delay to vehicles due to traffic signals. From this additional data average link speeds may be calculated. If SCOOT information is unavailable, flow levels and speeds on links may be provided from a calibrated standard traffic assignment model, TRIPS.

For the SPM, data requirements include:

- Topographical data: i.e. spot heights, benchmarks and/or Digital Terrain Model (DTM) data.
- Building/barrier data: building polygon footprints, heights and acoustic properties.

- Soft ground areas: i.e. grassland, cultivated or wooded areas.
- Land use data: e.g. commercial, residential, recreational areas.
- Meteorological data: i.e wind direction and speed, temperature etc.

The first three datasets may be found within the standard Airviro system, but a far too crude a level to be of use in sound propagation modelling. Hence additional data needs to be manually input through a GUI or extracted from appropriate data sources (e.g. the use of OS LandLine 1:1250 map tiles and aerial photography to generate building polygon data – see Figure 2).

For meteorological data Airviro's own time series data, gathered live from a met mast within the City may be used to provide average meteorological conditions to the SPM.

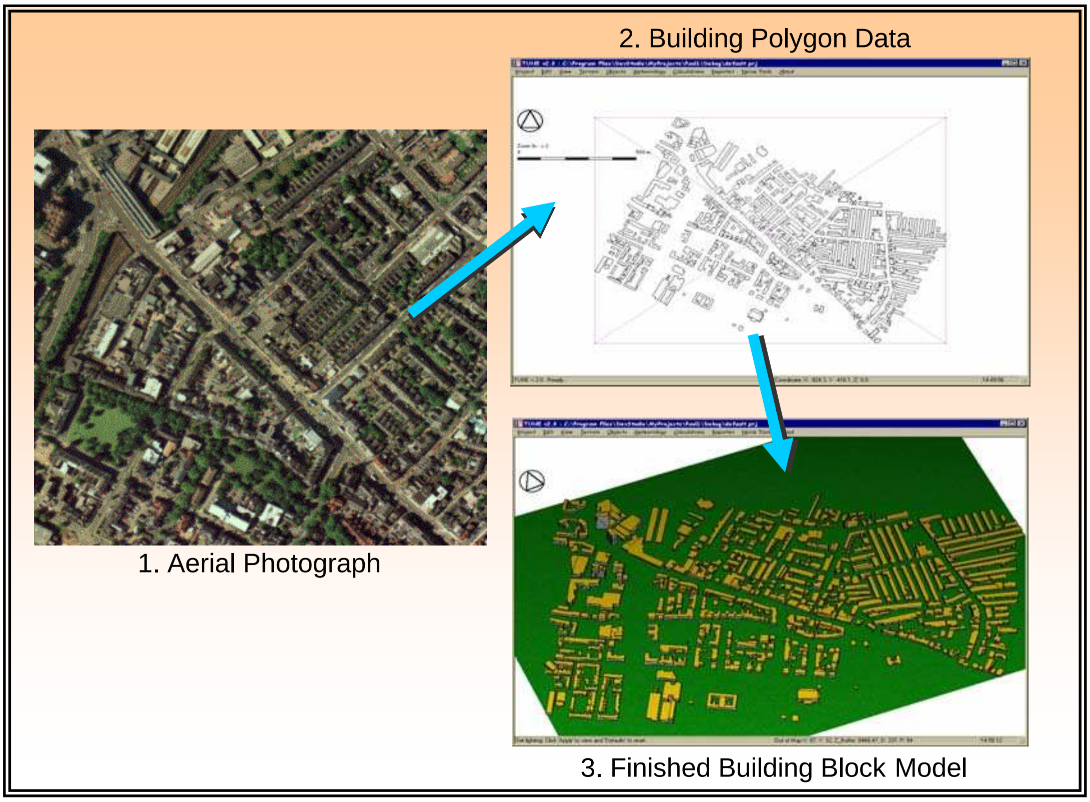

Figure 2: Building data acquisition from Aerial photography

2.2 The Source Noise Emissions Module

The source noise emissions module may work either online in real-time, using SCOOT data to predict traffic noise levels every hour, throughout the day, or offline using previously stored or manually input traffic data.

At the present time link based emissions levels may be calculated using one of two national standards:

- Calculation of Road Traffic Noise (CoRTN), UK (DoT. 1988).
- NMPB (Bruit Des Infrastructures Routières), France (CERTU, 1996).

The actual noise level calculated is either equivalent power of sound emission per unit length (dB/m) along a link. For the UK standard this involves conversion from an L_{A10} emission level at a given distance from the road.

A separate Airviro Edb is updated and maintained for each of the emissions models used. The Airviro GUI for the SNEM is shown in Figure 3.

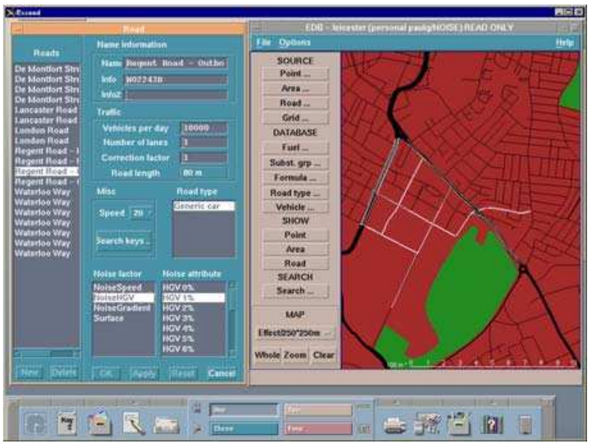

Figure 3: The AVTUNE SNEM User Interface

2.3 Stage 3: The Sound Propagation Module

The sound propagation module works by using the principle of inverse acoustic ray tracing. This procedure involves the casting of rays, representing the paths of sound wave fronts, from a defined receiver location backwards towards potential source objects. As a ray travels it may be specularly reflected from or diffracted around building/barrier objects, creating further ray paths for consideration. If a ray intercepts a source point or line, then attenuation from all factors along the ray path is calculated, deducted from the source level, and the contribution of the final calculation added to the current noise level at the receiver.

At the present time the levels of attenuation are calculated in accordance with ISO 9613-2: Attenuation of sound during propagation outdoors, Part 2: General method of calculation (ISO, 1996).

Given the computationally intensive nature of the ray-tracing operations the SPM is not run in real time. Large areas are modelled by being broken down into in smaller, overlapping tiles. Receivers may be positioned at single points, or as vertical or horizontal grids. The $L_{Aeq,\ 1\text{-hour}}$ level is the primary parameter modelled. Post-processing may be used to convert calculated L_{Aeq} levels into L_{day}, $L_{evening}$, L_{night} or L_{DEN} parameters in accordance with the new European Commission Directives on Ambient Noise.

Currently the SPM runs on a stand alone PC Windows platform. Figure 4 shows the GUI from the SPM. Output from the SPM will be passed to the HEAVEN DSS platform to allow comparisons between modelled scenarios.

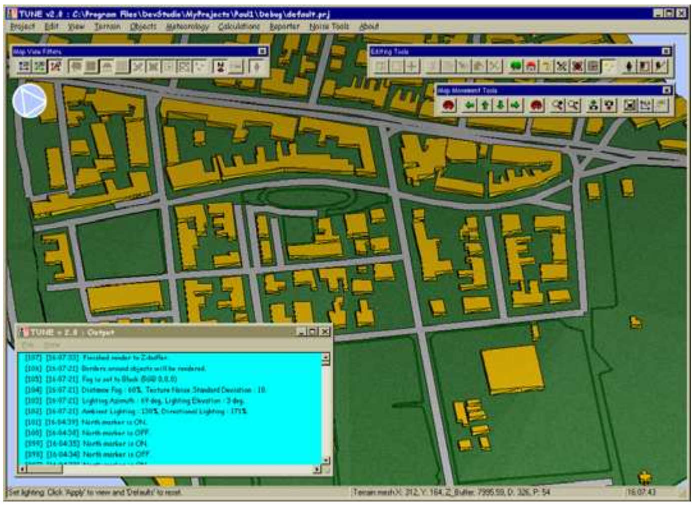

Figure 4: The AVTUNE SPM User Interface

2.4 Stage 4: Analysis of Results

This stage is still under development at the current time. Output, analysis and presentation of results will be generally be through using existing facilities in Airviro, including a presentation graphing modules, raster, grid and contour mapping. Data will also be exported for import into GIS systems. Additionally it is the intention of the HEAVEN project to make data available to City Council Staff and the General public through the internet.

3. Present and Future Work

At the time of writing the verification phase of the HEAVEN project has just been completed. Modelled values from the AVTUNE SNEM & SPM using dynamic traffic data and the modified CoRTN procedure have been compared to nearby façade $L_{Aeq,\ 1\text{-hour}}$ measurements around the London Road/Regent Road area of Leicester. A regression analysis of some of these initial results may be seen in Figure 5. Error bars show ±2dB(A) tolerances.

The HEAVEN project enters its demonstration phase during Summer 2002 and is scheduled to finish in early 2003. The demonstration area chosen is the Narborough Road corridor in South-West Leicester, leading from the M1 motorway towards Leicester City Centre. The environmental effects of various TDMS strategies, such as speed or HGV reductions within this area will also be considered.

During the remaining project time the output formats and display within the HEAVEN DSS/Airviro will be further developed. Additionally, work will continue on porting the SPM code from the current PC platform to the Airviro UNIX platform.

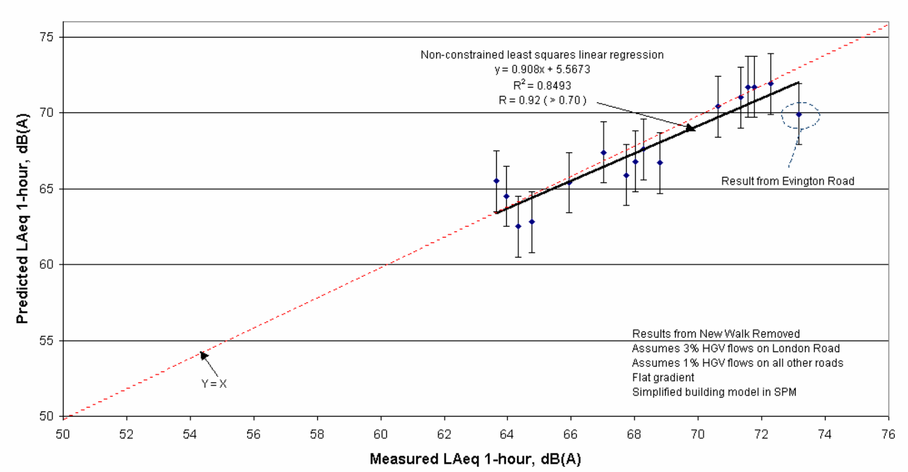

Figure 5: Results from initial AVTUNE SNEM/SPM verification surveys

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