Managing Air Quality and the Impact of Traffic Leicester – A Co-ordinated Approach

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Abstract. Leicester, the United Kingdom's first Environment City, was European Sustainable City in 1996. Urban Traffic Control, installed in 1970 with the SCOOT (Split Cycle Off-set Optimisation Technique) demand responsive traffic control system, was upgraded in 1988 and again in 1996. Integrating this with Air Quality Monitoring, Modelling and Forecasting identifies in 'near realtime' and 24/48 hour horizons pollution 'hot spots' providing information to enable dynamic traffic demand management and allow an informed public to exercise choice concerning intermodal travel. The HEAVEN Decision Support System has been developed. Differential Global Positioning System provides real-time bus location and passenger information. Integrated Application for Digital Sites project uses dynamic data injection and retrieval, virtual private networks, CCTV, to disseminate information to the community via a variety of media including VMS (Variable Message Signs), RDS-EON (Radio Data System – Enhanced Other Network), cable networks and http://www.leicesterequal.co.uk. In the context of the Central Leicestershire Local Transport Plan 2006 – 2011 and Leicester Air Quality Review and Assessment 2000/04, the Air Quality Action Plans are reviewing a variety of Traffic Demand Management Strategy options. Particular emphasis is placed on the role of the Intelligent Transport System in providing solutions. The impact of traffic on health is being investigated with the World Health Organisation. Air Quality Reporting and Management is being explored within the CITEAIR project http://citeair.rec.org. Work is being undertaken on the assessment of noise from traffic. Areas for further research are highlighted.

1 Leicester - Environment City

1.1 Background

Since designation as the United Kingdom's First Environment City in 1988, Leicester has worked to enhance the Community's understanding of its impact on the environment. An informed public has been encouraged to participate in the development of environmentally friendly policies and exercise personal choice in their implementation. The development of the Structure Plan and Transport Policies

and Programmes (and now the Local Transport Plan) have involved extensive consultation supported by the CALTRANS (Central Area Leicestershire Transportation Study) in parallel with the production of the Local Agenda 21 and EMAS (an Eco-Management and Audit Scheme). The Air Quality Review and Assessment (Environment Act 1995) has been undertaken in consultation with the neighbouring Local Authorities in Leicestershire and Rutland.

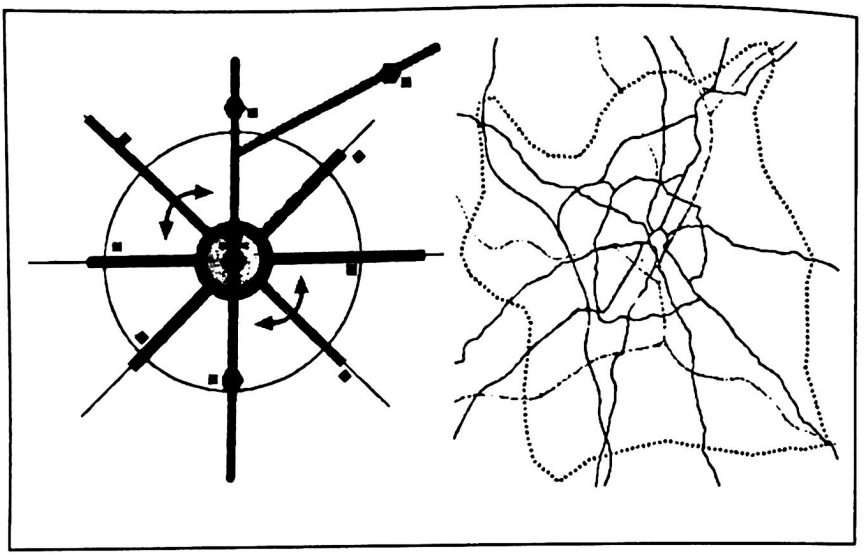

Fig. 1. Central Leicestershire Plan Area
(a) Key Land Use /Transport Elements (b) Road Network and Goods Vehicle Restrictions

1.2 Policy Context

The 1994 County Structure Plan established a common set of transport objectives for Leicester City, Leicestershire County and the neighbouring District Council areas referred to as 'Transport Choice'. In response to the Transport Policies and Programme (TPP) procedures the City and County Councils established joint working at Member and Officer level for the development and implementation of transport proposals within the 'Central Leicestershire Plan' area covering the

City and surrounding suburbs and rural hinterland. This has formed the core for the submission of the 'Local Transport Plan for Central Leicestershire 2000 – 2006' (the LTP) (see Figure 1).

The City and its neighbours have a mutual dependency. The City has jobs but insufficient workers; the surrounding Districts have more workers than jobs; the result is significant inward commuting during the morning peak hours and outbound in the evening peak hours, which create congestion and pollution derived from traffic. Leicester, as a Regional Centre, also influences travel for educational, recreational

and shopping purposes. Through the development of the Local Agenda 21, the authorities have each identified common goals involving the management of traffic within the road network and the encouragement of environmental friendly travel.

The road network hierarchy includes the M1 and M69 Motorways, Trunk and Principal, Ring and Radial, Primary and Secondary Distributors, and Local Roads. Access for non-essential traffic is restricted by a cordon of Goods Vehicles Restrictions around the City, with traffic calming and pedestrianised zones within the City. Parking is controlled by Loading and Waiting Restrictions, On-Street Parking Charges, with a cordon of Controlled Parking Zones around the Inner Ring Road. Peak Hour or 24 hour bus lanes are provided on the key radial routes. Significant progress has been made in implementing a network of cycle facilities (see Figure 1)

The Environment Act 1995 with its requirement for Air Quality Review and Assessment is driving the identification of Air Quality Management Areas. Given the significant impact traffic has on the pollution levels, research has focussed on the use of Intelligent Transport Systems to deliver Traffic Demand Management Strategies (TDMS) which may be used in short term or near real-time horizons to reduce the impact of traffic on pollution 'hot spots'.

1.3 Infrastructure

In 1970 Leicester installed the first Urban Traffic Control system outside of metropolitan areas. In partnership with Leicestershire County Council the system has been upgraded in 1988 and 1996 to provide a 'state of the art' Urban Traffic Management and Control (UTMC) system to manage over 600 traffic control installations, many of which operate within SCOOT demand responsive regions (see Figure 2). CCTV cameras are deployed on the Motorway and within the City, along with a network of flow monitors.

In collaboration with the Institute for Transport Studies, University of Leeds (ITS), the 'Instrumented City' Research and Development facility has been developed with support from the Department of Environment, Transport and the Regions (DETR). An AUN (Automatic Urban Network) pollution monitoring station is operated on behalf of DETR, complementing the Council's own network of precision and roadside monitoring equipment.

2 Research Technology Development and Demonstration Projects

The Council responded to the opportunity to participate in several projects within the European Union's Fourth, Fifth and Sixth Framework Programmes for Research Technology Development and Demonstration (RTD) and the DETR's R&D Programmes which all had a focus on improving the environment in different and complementary ways

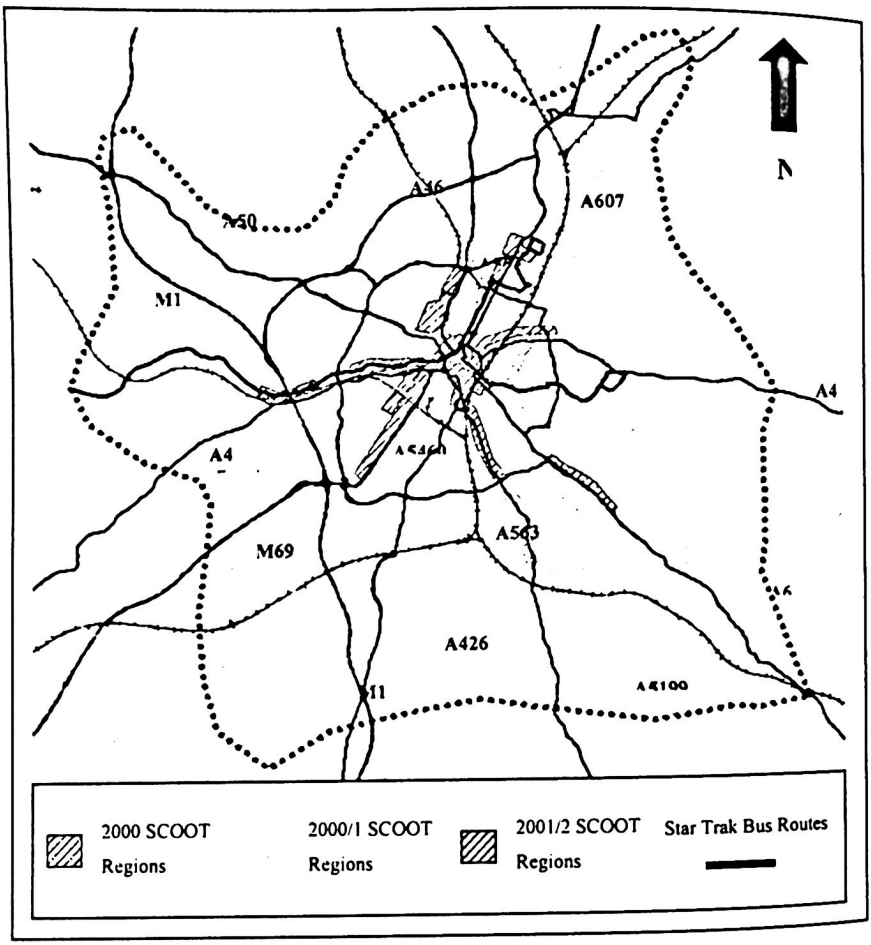

Fig. 2. SCOOT development map including real time bus routes

2.1 What has been done?

EFFECT [1] utilises the Swedish Meteorological and Hydrological Institute's (SMHI) AIRVIRO Air Quality Modelling suite using a 15 x 17 Km Eulerian Grid Model. The Emissions Database (EDB) has been enhanced by linking it with a TRIPS Traffic Model to set up the traffic emissions database, and then interfacing it with live output from the SCOOT system. Data from the AUN and other traditional air quality monitoring equipment is supplemented by data from 10 Roadside Pollution Monitors developed with ITS and Siemens and fed into the EDB. A local meteorological mast automatically provides weather data for AIRVIRO (see Figure 3). The model can be updated easily (i.e. construction of By-Pass or for scenario calculations) and using the SCOOT data provides near real-time 'hourly now casts' of pollution levels within the City. Since traffic represents over 60% of the pollution in the City, then the AIRVIRO predictions can be used by the UTMC system to implement TDMS in real-time.

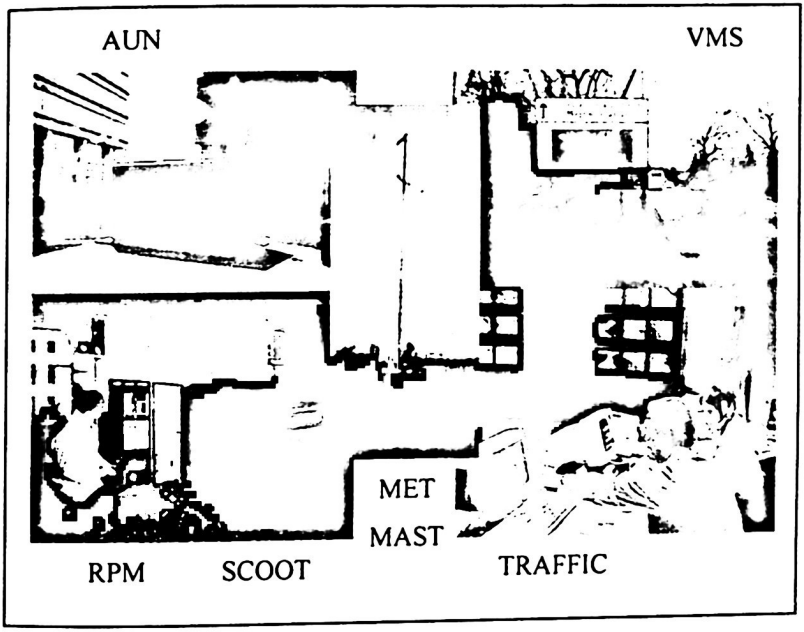

Fig. 3. Air Quality and UTMC Infrastructure

EMMA [2] uses the EFFECT system and enhances the information with 'T+72 hr' weather and NAME model Imported Pollution forecasts received automatically from the UK Meteorological Office (UKMO) at Bracknell. Both sets of UKMO data are also automatically transmitted to an ADMS model being developed by CERC at

Cambridge. 24/48 hour forecasts of air quality can then be used to instruct the UTMC to set up tomorrow's TDMS. During the afternoon the forecasts are broadcast by the Council's Traffic Information Service over BBC Radio Leicester 104.9FM and its RDS-EON system, as well as being displayed on roadside VMS (Variable Message Signs) and the EQUAL Website (www.leicesterequal.co.uk) (see Figure 3). During a Particulate Matter (PM_{10}) incident in January 1998 a survey was undertaken of people in the City Centre and then in the evening at home to assess how effective the dissemination had been and how they had reacted. The results were encouraging. The forecasts were also used with volunteers in the EUROTOLL/ LERTS [3] project to assess response to environmentally based tolls and the extent to which drivers would switch to a quality 'Park & Ride' bus service running down a 5 Km A47 Hinckley Road UTMC/SCOOT controlled corridor with a dedicated bus lane.

EFFECT PLUS [4] successfully explored how the infrastructure can be used to provide dynamic TDMS utilising for example the relocation of vehicle queues to areas where natural ventilation can better cope with the pollution load and where the population is not so close to the traffic emissions. Figure 5 provides an overview of the trial site.

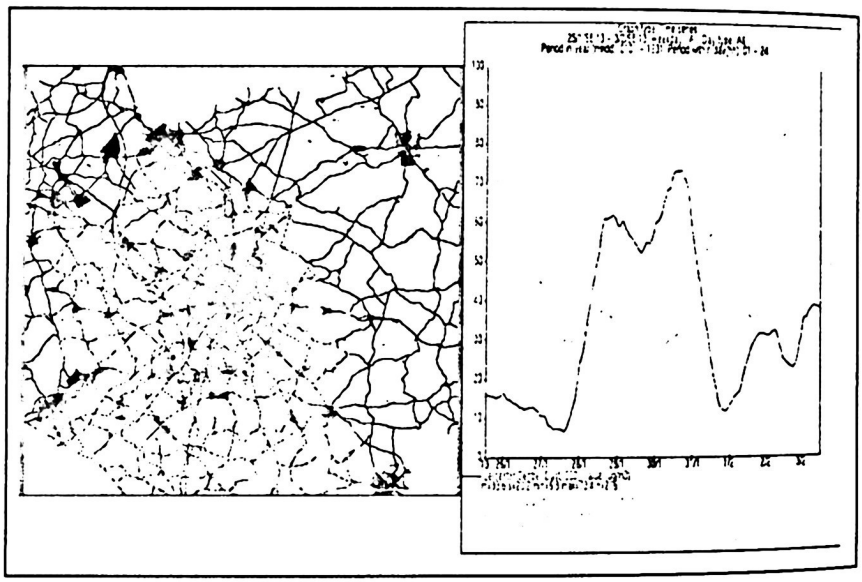

Fig. 4. Image showing AIRVIRO PM_{10} levels for 30th January 1998 Pollution Incident Graph indicates decreasing wind speed and mixing height with rising PM_{10} levels

Carbon Monoxide (CO) was monitored, using 'Streetboxes' in SCOOT Region R and London Road alongside the Victoria Park during a control and test periods, each of four weeks duration in February and March 1998. During the test period the SCOOT criteria for the London Road/Evington Road junction were modified to give

the side road priority, resulting in peak hour queues being relocated alongside Victoria Park, whilst flow conditions inbound along Regent Road were smoothed. After weather effects were eliminated, reductions in CO along Regent Road, with increases on London Road without an overall increase in pollution were detected.

MATTISSE and EQUAL are being developed to improve the integration of applications and make the full range of information and data available in an accessible and digestible format to the whole spectrum of potential users. MATTISSE is a regional database, which enables traffic information to be disseminated to local authorities, motoring organisations, the police and the public in the Midlands. EQUAL is developing an integrated mechanism to deliver traffic, public transport and air quality information in an easily comprehensible format to a range of users. These include Primary and Secondary Schools, the general public, Technical Administrators and University Academics. WebCOMIS an interactive COngestion Management Information System can be accessed via www.leicesterequal.co.uk. Under EQUAL the air quality forecasting facilities at Leicester are being further enhanced through the implementation of the OPANA regional air quality model. This model operates over a 150km x 150km domain and through an interface with the AIRVIRO model, will allow improved understanding of how imported pollution influences air quality in Leicester and the neighbouring authorities. Initially the model is being run remotely using the internet from Madrid, before being transferred to Leicester, for integration with AIRVIRO.

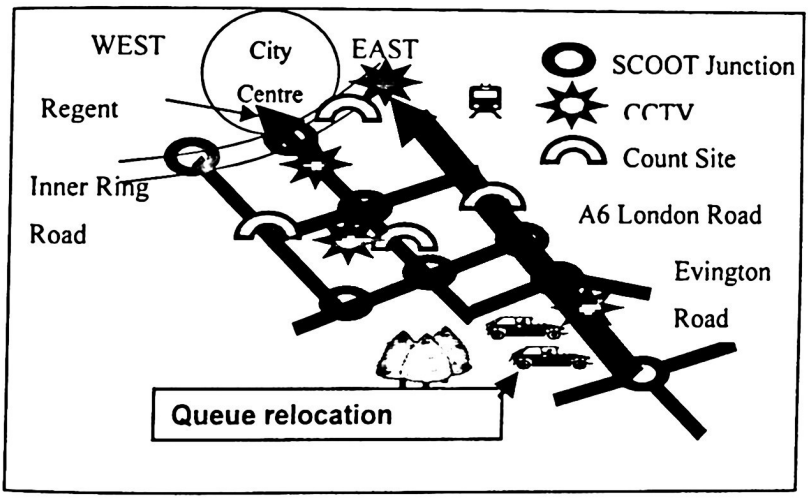

Fig. 5. EFFECT PLUS trial site – SCOOT Region R and A6 London Road

STAR TRAK [5] is using Differential Global Positioning System to Automatically Locate Vehicles and provide Real Time Passenger Information, "on-bus", over the Internet, Cable Network and at Bus Stop displays. Virtual Loops can adjust the

priority given to buses at signal controlled junctions according to the time of day and whether the bus is running late (see Fig.2)

UTMC 03 [6] and [8] has used ITS to control the movement of traffic within a network (see Figures 5 and 6) based on pollution minimisation criteria

The A5460 Narborough Road forms the main radial route from M1 Junction 21 to the city centre. The trial site comprises the stretch of Narborough Road running from the Fosse Park Retail Complex, within Blaby District, to the Upperton Road junction within Leicester city (see Figure 6). Here the traffic bifurcates to access the western or southern quadrants of the inner ring road.

The southernmost section of the Narborough Road trial site is a dual two-lane carriageway, which continues up to the junction with Braunstone Lane. Along the length of this section, known as Narborough Road South, two distributor roads run parallel to the dual carriageway. As a result, housing is set well back from the main carriageway.

The section from the Braunstone Lane junction to the Fulhurst Avenue junction is a dual two-lane carriageway with a wide tree-lined central reservation. Fulhurst Avenue was part the old Ring Road and is known to feature as a rat-run. Up to the Imperial Avenue junction, Narborough Road continues as a dual two-lane route, but roadside housing and retail property is in closer proximity to the kerbside. The final section of the trial site is a wide two-way carriage way up to the junction with Upperton Road. This section can hold up to 4 la lanes of traffic during peak periods and again features property in close proximity to the road.

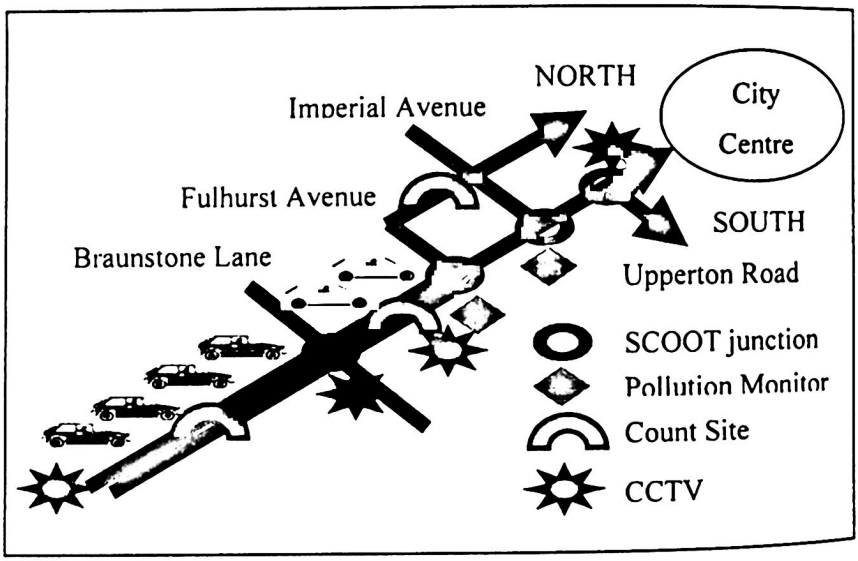

Fig. 6. UTMC 03 A5460 Narborough Road Test Site

The initial trial involved a 'gating trigger' at the Narborough Road/Upperton Road junction inducing queuing on the approaches to the Narborough Road/Braunstone

Lane junction. Significant queues of vehicles developed during the morning peak hours (07:30 to 09:30 hrs), resulting in driver complaints and some re-routing (mainly down the parallel local distributor roads). The main trials then focussed on the 'trigger' initiating first queuing at Narborough Road/Imperial Avenue junction and then at Narborough Road/Braunstone Lane junction. Scenarios were compared using the standard SCOOT congestion algorithm, 'SCOOT gating' and 'Fixed Time gating'. Emissions calculations were prepared using the SCOOT data, covering a variety of pollutants for inbound and outbound traffic on the A5460 and its side roads. The Leicester De Montfort University deployed an electric vehicle to measure journey times for calculating theoretical emissions using the Design Manual for Roads and Bridges criteria. The Council undertook journey time survey work and used precision and roadside monitors to assess levels of Particulate Matter (PM_{10}), Nitrogen Oxide (NO_2) and Carbon Monoxide (CO). Analysis of data is still in progress. The indications are that pollution levels at 'hot spots' can be reduced at the expense of those within queue relocation areas. Further work will be undertaken within the HEAVEN project, together with the mechanism for obtaining Political and public support for alternative TDMS which may include cross-boundary impacts.

UTMC 04 is developing an integrated traffic modelling, forecasting and decision support facility for UTMC systems including the necessary historical database and live data capture facilities. RETTIS will provide traffic flow predictions outside SCOOT regions to complement flow data.

3 The Heaven Concept

The concept of UTMC is to enable legacy traffic control and management systems to be integrated and to enable novel and future technologies including ITS to be incorporated so that an effective decision support system is delivered. The EU funded Fifth Framework project HEAVEN, Healthier Environment through Abatement of Vehicle Emissions and Noise, developed a generic systems architecture, consistent with the philosophy of UTMC to enable the existing infrastructure for monitoring and simulation of traffic to be integrated (a) to provide a better description, in quasi real-time, of the environmental impacts (on air and/or noise) mainly induced by traffic; and (b) to assist the cities in identifying TDMS that reduce the impact of traffic on the environment. This requires monitored and modelled data to be integrated in real time to produce a Decision Support System (DSS) to inform key actors including the public) on the state of air and noise pollution levels and their potential effects health. The system requires a common data exchange platform and methods to design and quantify the benefits of TDMS for sustainable urban development and improved quality of life for cities. The six cities involved in the HEAVEN project are Leicester, Berlin, Rotterdam, Paris, Rome and Prague and wider application of the HEAVEN concept to other has been made possible through the implementation of a generic systems architecture.

Figure 7 illustrates at a high level, the HEAVEN systems architecture that forms the basis of the Decision Support System (DSS). In HEAVEN the three main components of information presented to the DSS are processed traffic data e.g. in the

form of congestion maps, environment data such as air quality 'nowcasts' and forecasts, noise emissions maps and network performance measures and specifications for TDMS implementation. This integrated platform will evolve in the future to accommodate other ITS technologies as they are implemented in the city. For example recently bus tracking data has been made available to bus operators and traffic engineers by way of a visual display on a personal computer and to the public on bus stop signs and mobile phones. This data is captured in real-time and is potentially available to supplement the HEAVEN decision support system. The next step is to integrate the HEAVEN and Startrak information platforms and provide data processing methods that will enable specific enquiries to be made of the data. As ITS develops further in the future, it may be possible that ITS, will allow data on origin destinations, vehicle fleet characteristics, journey times and speeds to be made available to enrich the inputs to the traffic and pollution models. These could then be used as part of automatic evaluation procedures to fine-tune the operation of traffic demand management strategies and Urban Traffic Control (UTC) to further reduce pollutant emission. Smart card technology can be used to pay for car parking, to ride a bus or train. The data from these systems would allow information on people activity to be collected. This may then be used as input to exposure models to better reflect the impact of demand management strategies and policy on health rather than simply minimising pollutant concentrations in AQM areas as they do in the present day.

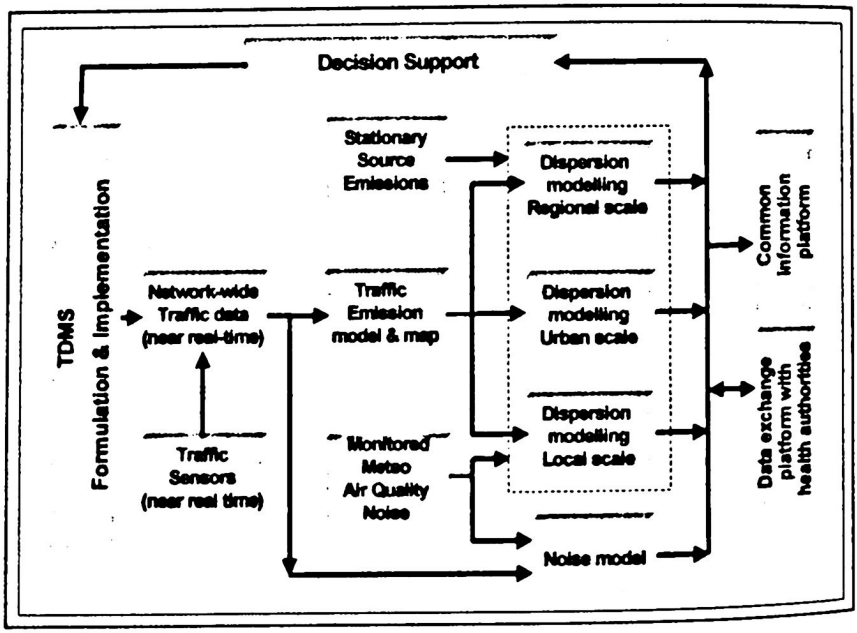

Fig. 7. The HEAVEN Concept

As more data becomes available from more sophisticated ITS technologies so do the challenges of information management. It is important that methods of real-time quality assurance, analysis and screening of data to provide relevant information is seen as a priority research area in the immediate future.

The AIRVIRO system is being enhanced by work on its User Friendliness, Canyon Modelling, Noise modelling, and integration with background pollution data from the OPANA and NAME models.

4 Local Air Quality Action Plans

During 2000, the Pollution Control Group completed the three stages of the Leicester Air Quality Review and Assessment leading to the adoption of the Final Report and then the designation of Air Quality Management Areas effective from 29th December 2000. The report can be downloaded in 'pdf' format from www.leicesterequal.co.uk via Environment/Air Quality/Review. Figure 8 shows the predicted Nitrogen Dioxide levels for 2005 alongside a map of the designated Air Quality Management Areas.

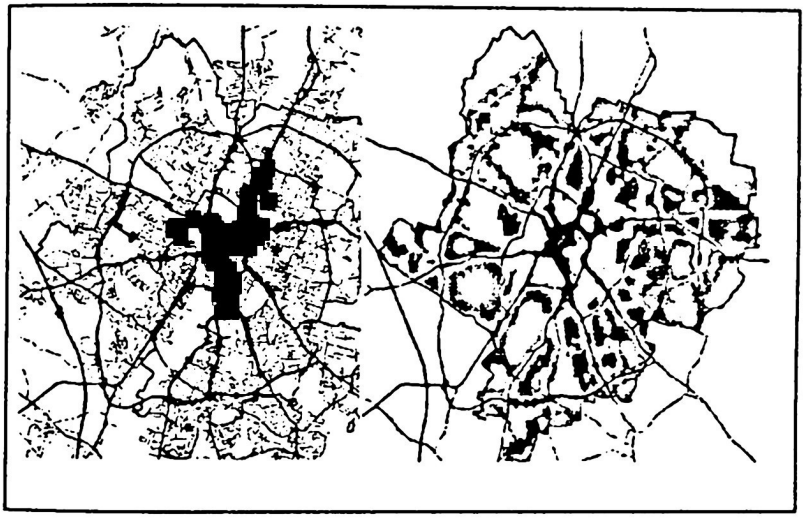

Fig. 8. Air Quality Management Areas Predicted Nitrogen Dioxide levels.

A further Review and Assessment of Air Quality within the Air Quality Management Area was completed in 2004. In parallel a time-based Action Plan has to be prepared aimed at making good any failure to meet the Air Quality Objectives through the exercise of any of the Council's powers. The statutory Guidance requires this work to be taken account of in the LTP2.

In the EFFECT project a list of Traffic Demand Management Strategies was identified. The list set out in Table 1, refers to 'hard measures' implying capital (civil engineering) works with long lead times and 'soft measures' which imply more responsive and easier to implement, some in near- real time.

Table 1. "Hard" and "soft" measures for traffic demand management strategies

"Hard" measures	**"Soft" measures**
Pedestrian networks	Raise public awareness
Cycle networks	Priority for peak-hour traffic
'woonerf' housing areas	Bus priority
Traffic calming	Traffic signal co-ordination
Low emission zones	Controlled parking
Park and Ride	Encourage other modes
Capacity reduction	Variable message signs
Road user charging	Public information
	Teleworking

The 'Local Transport Plan for Central Leicestershire 2000 – 2006' can be downloaded in 'pdf' format from www.leicesterequal.co.uk via Environment/Transport Plan. This includes a range of projects to be implemented by 2006, some of which may have an impact on Air Quality. Traffic modellers will be assessing what can be reasonably modelled within the Greater Leicester Traffic Model . The most practical of these will be analysed with the Air Quality Model together with:- . UTMC 03 and EFFECT + methodologies . Low Emissions Zone . Green Vehicle Fleets

Once the traffic modellers have identified those TDMS which produce reasonable changes in traffic flows, the relevant scenarios will be tested alongside the UTMC , LEZ and Green vehicle options. The LTP programme may have to be revisited if sufficient improvements in Air Quality are not identified. Some of the other TDMS listed in Table 3 if adopted will not be completed until after 2005. However the Council will be reviewing these once the AQMA Action Plans have been identified.

5 The CITEAIR project

This project seeks to jointly develop better and more efficient solutions for assessing the impact of traffic on air quality in large urban areas, informing professional users and the public on the environmental situation and giving guidance on efficient measures to abate adverse environmental situations through the close co-operation, experience exchange and joint developments with European Cities and Regions. Other Municipalities are encouraged to contribute to the work via a user network. Its main products will be:

- **Guidebook on Environmental Management** – This will include a common reporting format of air quality for professional users and will review, through cases studies, abatement measures for poor air quality

- **Guidebook on Public Information** – Provide a strategy for public information on air quality. for the conversion and interpretation of existing technical air quality data into accessible and interesting data for the public.
- **Common Operational Website (COW)** – Will implement the guidance of the guidebooks to achieve comparability of air quality information between cities.
- **Guidebook on Transfer** – This guidebook will be based on the extensive transfer of knowledge. experiences and best practices of environmental management to the Emilia-Romagna Region. as model for future transfers to other European cities and regions.
- **Network of Interested Parties** – as a user community

6 Future Research Areas

The Diagram in the **Appendix** provides an overview of the concept for possible future projects. The central core of the diagram illustrates five different levels of operation. These are European. Regional. Urban. Local and Street levels. The columns on the right hand side provide examples of the type of Air. Noise and Traffic models currently available at each level. The columns on the left hand side illustrate that the spatial and time resolutions increase with each higher level of the hierarchy. They also summarise the variety of research efforts required to support a successful outcome to the projects.

The **European level** work will be focussed on the use of satellites to provide Global Positioning (to assist with vehicle tracking for modelling and public transport operation). Communications (to provide 3G and 4G services to facilitate economic operation of the services within Europe and Worldwide). Earth Observation (to provide alternatives to terrestrial sources for air quality,traffic etc). Meteorology and Pollution transport modelling. Rationalising the geo-referencing will be required to integrate terrestrial and satellite data. To facilitate the remote operation services the project will seek to use the Computing and Information facilities of the GRID network

The **Regional level** will be the main platform for integrating Regional and Urban Air Quality Modelling. Emissions Database (EDB) information will be supplied by the Cities and Towns who will receive background data in return. Methodologies for infrastructure rich cities to support satellite towns with local Air Quality Modelling or for Industrial Partners to supply remote operation or support services will be explored. Air Quality Modellers and Meteorologists will work on the integration of statistical and deterministic forecast air quality dispersion and meteorological models with existing dispersion models. Aerosols Research will focus on the Primary and Secondary Chemical Reactions and the understanding of Particulates (Area and Number measurements).

The **Urban level** will be the focus for work to enhance existing models and compare performances. Automatic Number Plate Recognition (ANPR) will be used to feed a traffic model to provide a near real time Origin and Destination (O& D) Model. Satellite tracking of vehicles will provide additional data for the model. alongwith the

output from demand responsive traffic signal networks and fuzzy logic algorithms. ANPR will be linked to the DVLA records to identify engine types; Automatic Classified Vehicle Counters (ACVC) will be linked to provide vehicle types; which with realtime monitoring of vehicle exhaust emissions will provide an understanding of the local vehicle fleet emissions. In this way a more accurate picture of the traffic EDB will be generated. As a by-product more information will become available for the Noise modelling. Given the range of Air Quality models deployed by the Partners there will be the opportunity to run models using existing databases to understand their strengths and weaknesses according to the spatial and time resolutions; and the richness of the infrastructure and data available. The Air Quality and Traffic Network Managing Industrial Partners will seek to integrate several different systems and investigate remote operation or support services. The Meteorologists wish to investigate how a City effects the meteorology of the atmosphere above. The Air Quality modellers will investigate receptor point and similar routines to support medical research into the Health Impacts of traffic etc. The development of dissemination of information to the primary and end users will build upon existing successful near realtime display systems using the Internet, Variable Message Systems (VMS), Mobile communications equipment covering air and noise quality; traffic congestion; public transport location; traffic and travel information; CCTV (currently single shot) pictures; etc

The **Street level** will focus on developing more accurate street canyon models for both air quality and noise. The project will seek to integrate these with the suite of programmes working at the Local Level to automatically provide detailed pictures of the pollution in the city.

To ensure meaningful results and their effective dissemination, the project needs to work at the European level. This will ensure that the Partners bring a wide range of skills and experiences to the work. A significant network will be created to persue further research opportunities identified during the life time of the project.

7 Conclusions

Leicester City Council, with the support of DETR, the European Commission, EPSRC and ITS, have developed an infrastructure and gained experience in its operation, in collaboration with over 150 University Research projects which have utilised the Instrumented City facility, which will allow the development and implementation of practical Air Quality Management Area Action Plans.

Acknowledgements

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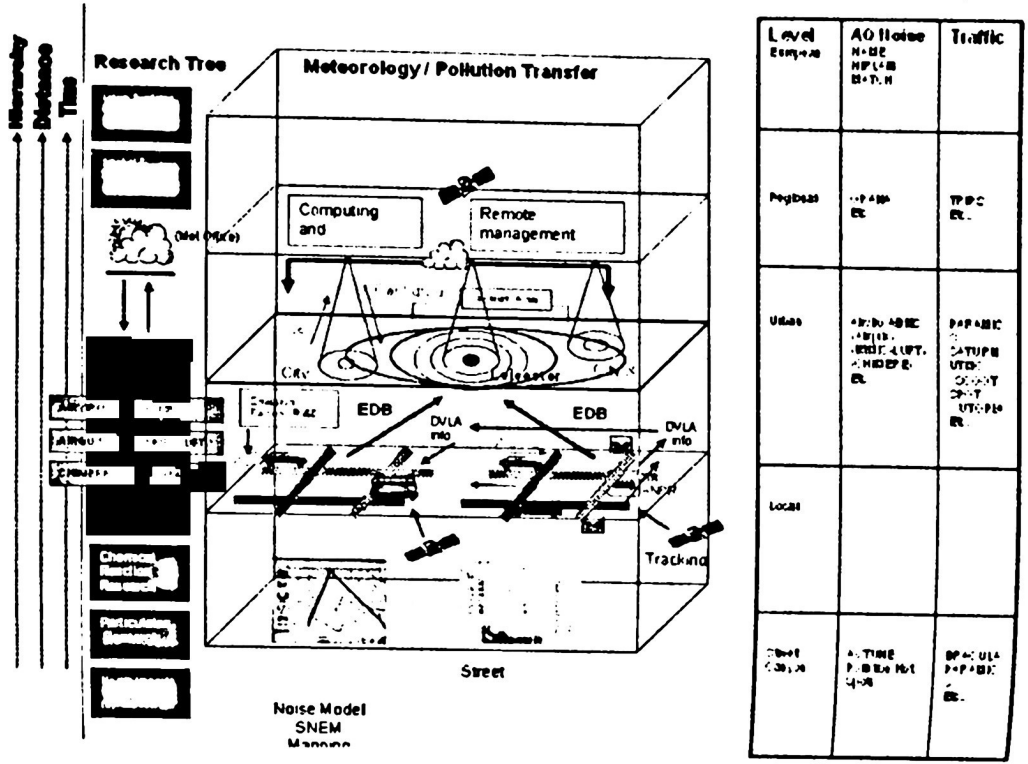
Appendix


Hierarchy
Distance
Time
Research Tree
Meteorology / Pollution Transfer
Computing and
Remote management
EDB
EDB
DVLA info
DVLA info
Tracking
Street
Noise Model
SNEM
Level
AO Noise
Traffic