POLLUTION ASSESSMENTS AS AN AGENT FOR CHANGE

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1. GENERAL INTRODUCTION

It is now widely accepted that transport is the fastest growing source of pollution in the UK today. Around 130 district, unitary and metropolitan authorities, including all London Boroughs, have declared 'Air Quality Management Areas' (AQMAs) following Stage 3 of their review and assessment obligations under the Local Air Quality Management (LAQM) regime. Some 95% of these AQMAs are reported to be heavily related to transport pollution. It is now known that objectives set out for key pollutants in the UK's Air Quality Strategy have been breached in many locations. Of particular concern are particulates (PM_{10}) and nitrogen dioxide (NO_2).

However, it is also important to recognise that, in addition to its impact on the quality of the air that we breathe, transport is a major reason that the UK will fail to meet its Kyoto obligations to reduce carbon dioxide (CO_2) emissions. Road traffic emissions contribute around 20% of the UK's total CO_2 budget and transport is responsible for 34% of total energy use in the UK.

Reducing transport pollution is therefore doubly challenging. As technologies develop to reduce tailpipe emissions and make transport 'cleaner' we, as transport professionals, faces the onerous challenge of making transport 'greener'; ultimately reducing the need to travel and hence, the energy consumed.

The paper presented builds the case for using pollution assessments as a critical element in the planning process, and an important tool for encouraging behavioural change.

It describes a scenario where transport pollution (in this instance, air quality rather than energy-related CO_2 pollution) was considered in the design stage of a transport scheme. It therefore builds a strong case for considering transport pollution at the earliest convenience to ensure that the transport solutions fully represent integrated transport, air quality and, perhaps more importantly, energy policies.

2. THE AIR QUALITY CONTEXT

2.1 Air Quality in the UK

In 1952, the infamous London smog lasted for five days and killed upwards of 4,000 people, as many as 900 in one day at its peak. By 2002, some 12,000 deaths were attributed to that one event.

The London smog was caused by a build up of sulphurous soot from coal fires and lead to the introduction of the first Clean Air Act in 1956. Thankfully, due to that Act and subsequent legislation, the days of acrid smogs are now a point of historic reference. Concerns about local air quality, however, are not.

Today's air quality problems are largely transport-related. Primary emissions from road traffic are responsible for toxic nitrous fumes and sooty particles at roadside locations throughout the UK. There are also secondary pollution effects arising from the chemical reaction of these pollutants in the atmosphere. A common sight on hot, sunny days is the build up of a haze over towns and cities. This haze is caused by ozone, a secondary pollutant produced by the chemical reaction of NO_2.

Primary transport pollutants such as NO_2 and PM_{10} and the secondary pollutant, ozone, are all respiratory hazards. Latest studies estimate that transport pollution and poor air quality causes more than 32,000 premature deaths a year.[1] It is also thought to be linked to a large increase in childhood asthma over recent years. So, while air quality problems today may be less dramatic than the London smog event, they are by no means less devastating.

As with the production of the first Clean Air Act, air quality policies have developed in response to this new challenge – the struggle is meeting the targets.

A brief summary of relevant air quality policies and legislation is provided in the following section.

2.2 Air Quality Standards and Objectives

The European Council Framework Directive (96/92/EC) provides a framework for monitoring, modelling and assessing key pollutants to establish ambient air quality. The subsequent Daughter Directives (including 99/30/EC) prescribe numerical limit values for each of the key pollutants.

These limit values dictate threshold concentrations of key pollutants and a date by which they should not be exceeded. For reference, the EU limit values for key transport pollutants nitrogen dioxide (NO_2) and particles (PM_{10}) are shown in table 2.1 below.

In accordance with the Directives, the Government and Devolved Administrations have adopted either the same or, in some cases, more stringent UK air quality 'standards' and 'objectives', which govern the conditions for ambient air quality in the UK.[2]

[1] See recent European Commission publications at http://europa.eu.int/comm/environment/air/cafe/general/keydocs.htm

[2] As set out in the Air Quality Strategy for England, Scotland, Wales and Northern Ireland, published in January 2000, the Air Quality Regulations 2000, the Air Quality (England) Amendment Regulations 2002, the Air Quality (Wales) Amendment Regulations 2002, and the Air Quality (Scotland) Amendment Regulations 2002.

Table 2.1 – EU Daughter Directive Limit Values for NO_2 and PM_{10}

Pollutant	Limit Value	Concentration measured as	To be achieved by
Nitrogen dioxide (NO_2)	200 µg/m^3 not to be exceeded more than 18 times a year	1-hour mean	2010
	40 µg/m^3 not to be exceeded	annual mean	2010
Particles (PM_{10})[3]	50 µg/m^3 not to be exceeded more than 7 times a year	24-hour mean	2010
	20 µg/m^3 not to be exceeded	annual mean	2010

The UK objectives for NO_2 and PM_{10} are shown in table 2.2 below for information.

Table 2.2 – UK Objectives for NO_2 and PM_{10}

Pollutant	Objective	Concentration measured as	To be achieved by
Nitrogen dioxide (NO_2)	200 µg/m^3 not to be exceeded more than 18 times a year	1-hour mean	31 Dec 2005
	40 µg/m^3 not to be exceeded	annual mean	31 Dec 2005
Particles (PM_{10})[4]	50 µg/m^3 not to be exceeded more than 35 times a year	24-hour mean	31 Dec 2004
	40 µg/m^3 not to be exceeded	annual mean	31 Dec 2004
Scotland only	50 µg/m^3 not to be exceeded more than 7 times a year	24-hour mean	31 Dec 2010
	18 µg/m^3 not to be exceeded	annual mean	31 Dec 2010

To understand how the EU Limit Values, and subsequent UK standards and objectives have been derived, it is useful to note that ‘standards’ are defined as those concentrations required to achieve a certain level of environmental quality and minimise the impact on health. These are set purely on the basis of medical and scientific evidence of the health impacts of each pollutant.

‘Objectives’ are policy targets which are expressed as maximum ambient concentrations to be achieved by a certain date, either without exception or with a permitted number of exceedances. Essentially, they prescribe the dates

[3] These are indicative Limit Values to be reviewed in light of further information on health and environmental effects.
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by which the standards must be achieved. They take account of the cost, benefits, feasibility and practicality of achieving the standards.

In the UK, local authorities are, through a system of Local Air Quality Management (LAQM), required to undertake monitoring and modelling to assess whether air quality in their boundaries will meet the UK air quality objectives. The first round of LAQM has now been completed by all local authorities. LAQM is described briefly below.

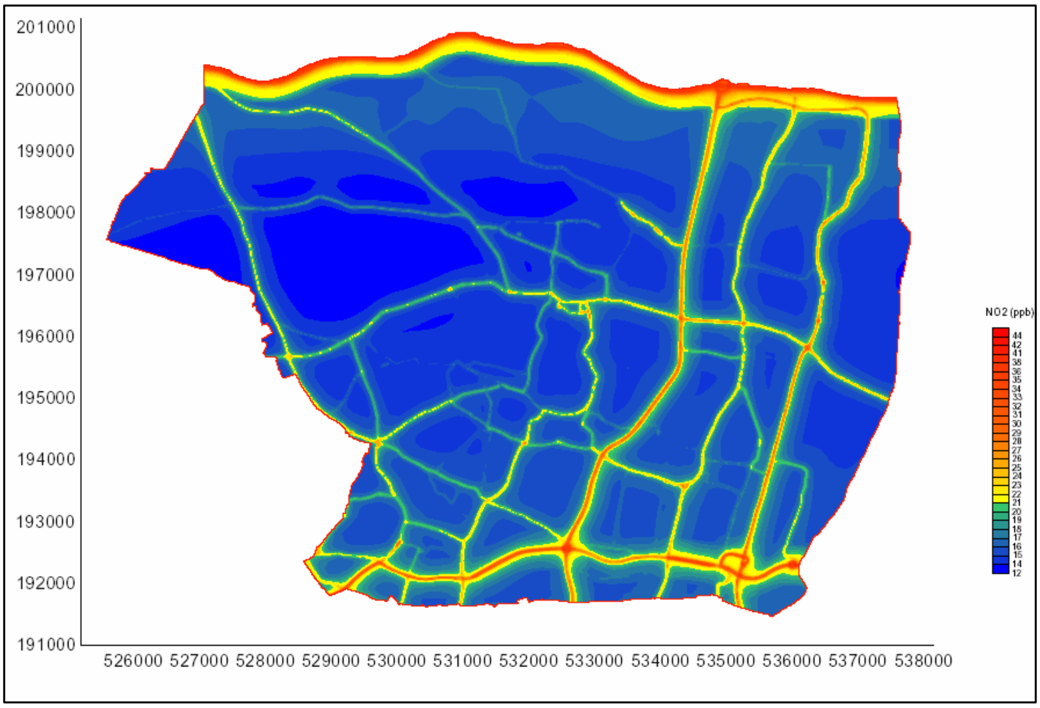
2.3 The Local Air Quality Mangement Regime

Under Part IV of the Environment Act 1995, local authorities are required to monitor and assess air quality within their boundaries. The first round of Review and Assessment (R&A) required a four-staged review, as prescribed in Local Air Quality Management Technical Guidance LAQM.TG4(00). During Stage 3, local authorities declared Air Quality Management Areas (AQMAs) where the UK objectives would not be met. Potential future scenarios and solutions were then presented in Stage 4 and Air Quality Action Plans were produced to show a strategy for improving air quality.

Following the first round of R&A, some 130 local authorities reported AQMAs, where UK objectives for NO_2 and PM_{10} would not be met.

Most AQMAs are located close to major and heavily trafficked roads with pollutant concentrations and exceedances highest at roadside locations. Figure 3.1 below shows modelled average annual mean concentrations of NO_2 throughout the London Borough of Enfield (LB Enfield).

Figure 3.1 – Annual mean nitrogen dioxide (ppb) for 2005



Source: London Borough of Enfield (2002), Stage 4 Report, ERG, Kings College London.

Figure 3.1 has been included as a visual aid to show the correlation between traffic and pollution. Areas of highest NO_2 clearly correlate with major roads in the Borough, not least the M25, which runs along the northern edge.

A commonly cited problem of the first round of R&A was that great emphasis was put on understanding air quality problems with very little guidance available on what should be done to improve it. The Air Quality Action Plans therefore fell short of setting realistic, achievable actions to improve air quality. Early reports indicate that, as expected, the 2005 objectives for NO_2 and 2004 objectives for PM_{10} have been exceeded at many locations throughout the UK.

The second round of R&A now requires local authorities to undertake a more thorough investigation of AQMAs (LAQM.TG(03)). The focus is, however, shifted and requires local authorities to identify areas where there is a real risk of pedestrian exposure rather than simply an exceedance. For example, LAQM.TG(03) states that local authorities should:

> *Identity all busy streets [> 10,000 vehicles per day] where members of the public may be exposed within 5m of the kerb for 1-hour or more.*

The second round R&A provides a way to assess and prioritise those locations where air quality is poor and people are most likely to be exposed, rather than simply assessing ambient air quality at all locations.

Most local authorities have now produced Updated Screening and Assessment (USA) reports and undertaken detailed assessments in areas where air quality objectives are not being met. It follows, therefore, that local authorities are in a prime position to pinpoint air quality hotspots. Air Quality Officers in every local authority should now have an understanding of where air quality mitigation measures, ultimately traffic demand initiatives, can be targeted to have the greatest benefit to human health.

2.4 The UK Air Quality Challenge

Pollution is a problem of scale, from roadside fumes to city-wide hazes, and there is therefore a scale of potential solutions available to local authorities and transport professionals. In the first round of R&A, many local authorities struggled to propose, test and implement measures at all scales and there was a general feeling that only regional, or large-scale measures would have any real impact on air quality.

Air quality and pollutant concentrations are surprisingly sensitive. Ambient air quality at any given time depends on a number of critical factors, such as the prevailing meteorology, background levels and, of course, the local sources such as road traffic. We can do little to control the weather, but the emission of pollutants from road traffic fluctuates greatly depending on the fuel and engine type and driving conditions.

Emissions are highest from older vehicles, but they also vary greatly depending on the flow of traffic. In heavily congested urban locations, where vehicles are idling and constantly stop-starting, emissions can be as much as 50% higher than when vehicles are free-flowing at medium speeds (50mph). Likewise, emissions are highest when vehicles are travelling at high speeds and there is a high power demand.

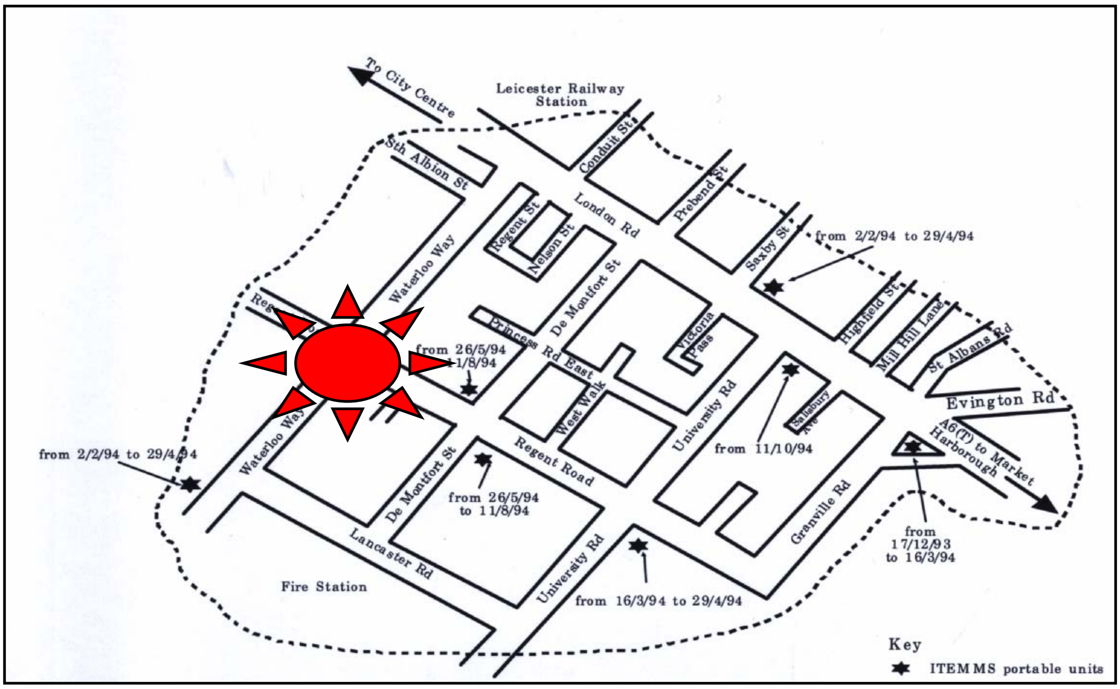
With a greater understanding of local areas where air quality is poor, the challenge now is for transport planners and traffic engineers to consider pollution at the design stage of all transport projects. Only by doing this can we ensure that transport solutions reap the most rewards, both in terms of alleviating congestion and, ultimately, protecting human health.

The following section presents a short case study of an experiment that was carried out by Leicester City Council, in conjunction with the Institute of Transport Studies (ITS) at Leeds University, to tackle a pollution hotspot in Leicester city centre.

3. A CASE STUDY

Leicester is part of a multi-institutional research project considering air quality and transport. Leicester City Council (LCC) and collaborators have established a fully integrated system of traffic and air quality monitoring and modelling with several real-time capabilities. As part of this research, an investigation was carried out in order to improve one of the major pollution hotspots in the city centre, shown in figure 4.1.

Figure 4.1 – Leicester pollution hotspot



Being part of Leicester's shopping area, the area is heavily pedestrianised and poor air quality is a primary concern due to the high risk of human exposure.

The study exploited Urban Traffic Control (UTC) systems and air quality monitoring equipment already in place. Figure 4.1 shows the location of portable air quality monitoring units.

The study comprised two investigations, described in turn below.

3.1 'SCOOT Emissions' investigation

As with many UK cities, traffic controls in Leicester are controlled by UTC systems - in this case, a series of SCOOT loops. SCOOT aims to alleviate congestion by minimising a traffic performance indicator (TPI), conventionally a combination of the delay time and the number of 'stops' the traffic experiences. As emissions from road traffic are greater when vehicles are idling or moving slowly, SCOOT inherently reduces pollution by striving to reduce the occurrence of congestion.

An initial investigation was carried out to examine whether SCOOT systems could be altered to reduce the level of emissions from traffic (rather than simply congestion) and whether this would benefit local air quality.

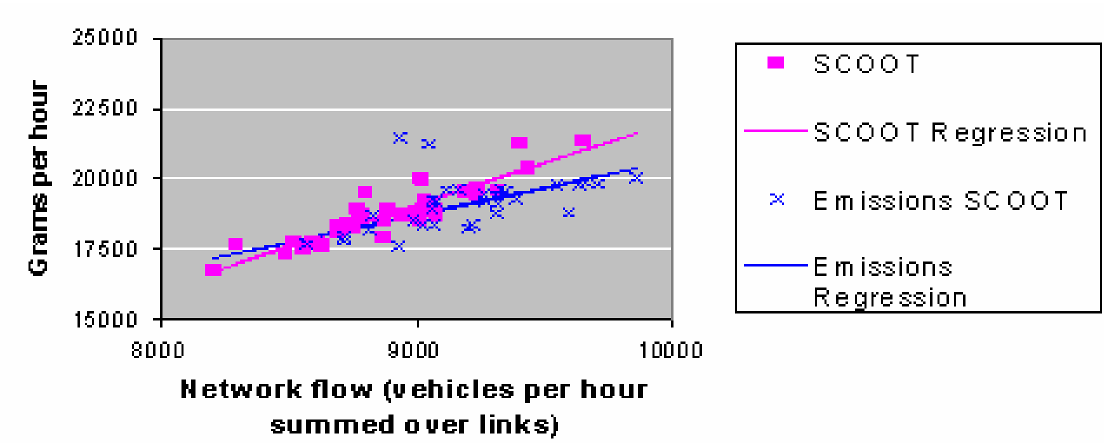
An additional module was included in the SCOOT programming unit to calculate estimated pollutant concentrations. The module used emissions factors from the UK Emissions Factor Database and measured traffic flows and speeds to estimate emissions of key pollutants. The system was then programmed to minimise a weighted function of these emissions rather than the conventional TPI.

The experiment was conducted over a 4-month period. Air quality was recorded at the hotspot location for two months with normal SCOOT operation and two months with SCOOT altered to reduce emissions.

Figure 4.2 below shows the results in terms of the quantity of carbon monoxide (CO) – a primary transport pollutant not to be confused with the greenhouse gas, CO_2 – measured at the hotpot location per hour. CO results are presented here, but it follows that the results are similar for all other primary tailpipe emissions.

The results indicate that altering SCOOT did lead to some improvement in air quality. However, the improvement was not statistically significant, largely due to the fact that the network remains congested despite the UTC mechanisms in place. The volume of traffic is such that, at times, congestion, and hence poor air quality, is simply unavoidable.

Figure 4.2 – SCOOT emissions experiment results

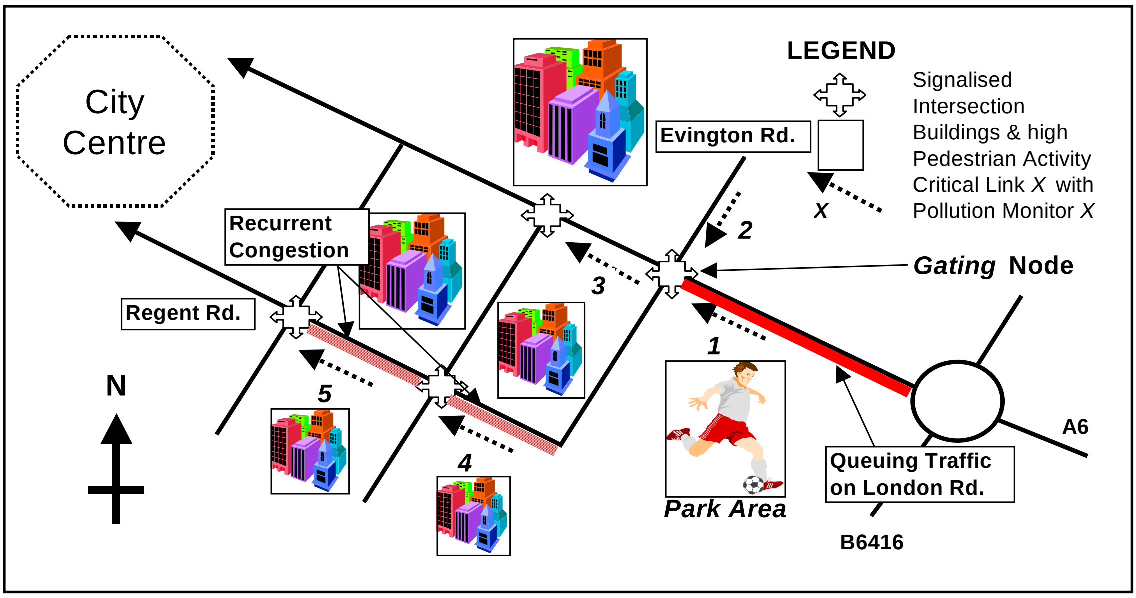


The second investigation, described below, aimed to tackle the congestion directly using a traffic demand management scheme (TDMS).

3.2 Congestion relocation

Figure 4.3 below shows a schematic of experimental area surrounding the pollution hotspot. As described above, recurrent congestion on Regent Road (links 4 and 5) means that the air quality in this built up area is very poor. The area is heavily pedestrianised and there is therefore a high risk of human exposure at roadside locations. The second investigation was designed to examine whether queuing traffic could be relocated away from this populated area to an open space area on London Road.

Figure 4.3 – Schematic of experimental area



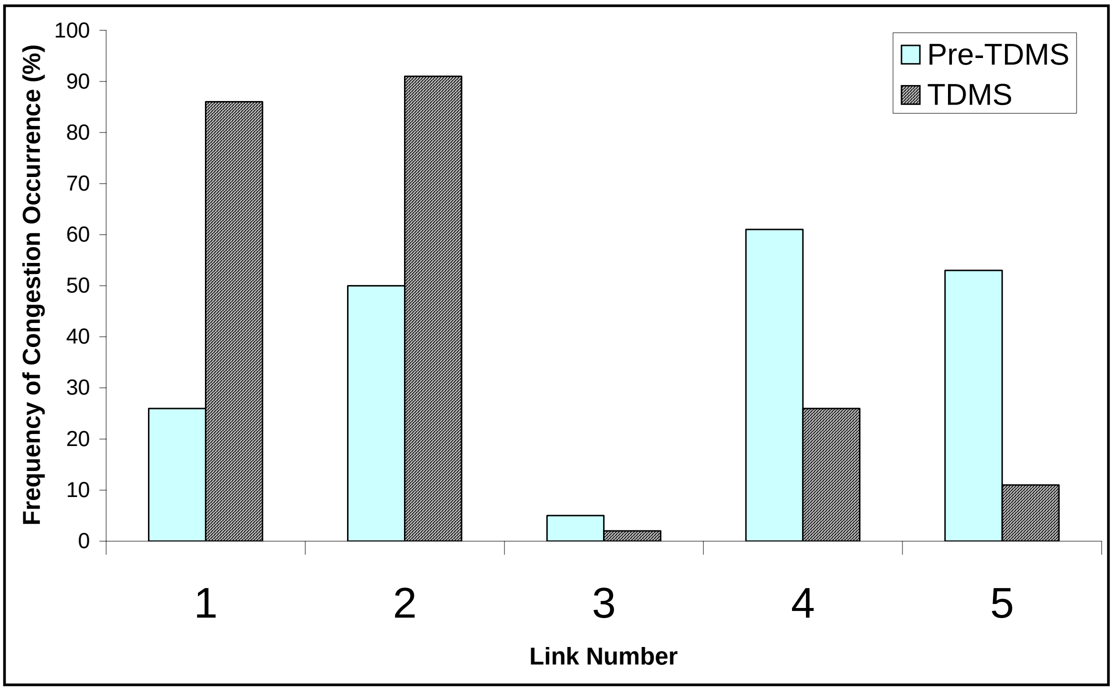
Each of the junctions marked in figure 4.3 is under SCOOT control. In addition, each of the marked links has a pollution monitoring station to continuously monitor roadside emissions. The investigation used the gating facility in SCOOT to design a TDMS to adjust signal times and relocate the queues to London Road.

Initially, the experiment monitored the existing, baseline situation over a 2-month period, recording the number of congestion occurrences on each link and the pollutant concentrations at each location. The TDMS was then introduced to relocate queuing traffic to London Road and the situation monitored continuously for another 2-month period. Prior to any analysis, the results were passed through a statistical analysis module to remove any outlier days where traffic and air quality conditions may have been skewed.

The network was modelled using SATURN and its micro simulation counterpart, DRACULA, to provide an additional comparison.

The frequency of congestion occurrences before and after the introduction of the TDMS is shown in figure 4.4 below. As can be seen, the TDMS was successful in transferring the congestion away from the heavily pedestrianised Regent Road area (links 4 and 5) to the London Road next to the open space park area.

Figure 4.4 – Frequency of congestion occurrences



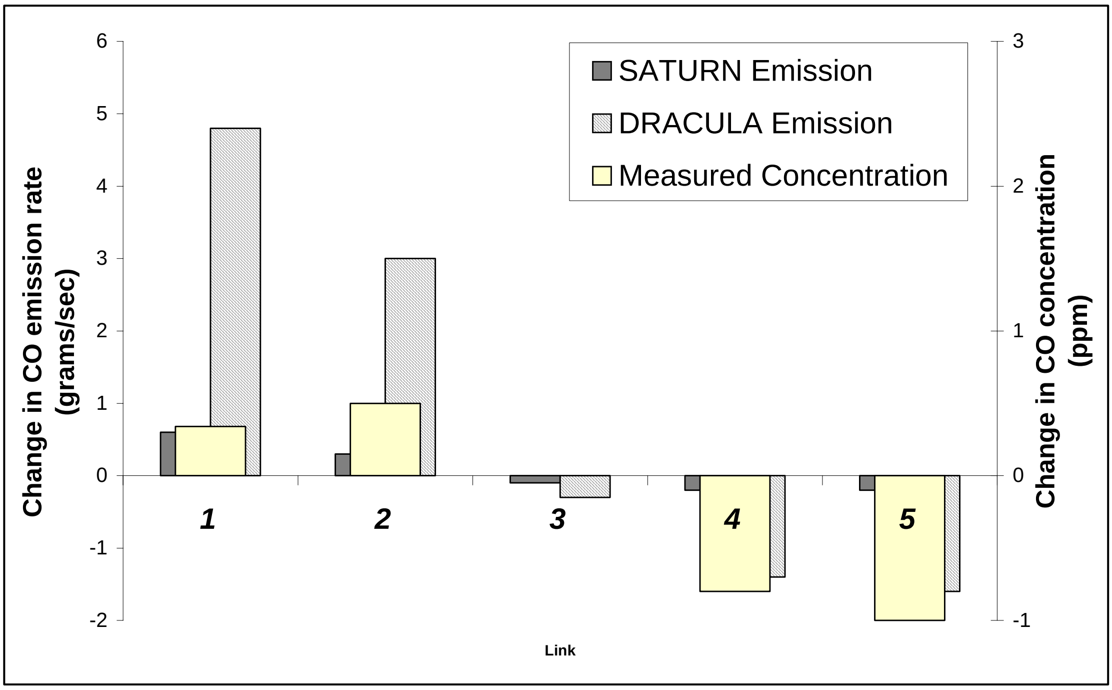
To compare the measure pollutant concentrations, rudimentary emissions modelling suites contained in SATURN and DRACULA were used generate modelled pollutant concentrations at each monitoring station site. The measured and modelled change in CO concentrations with the introduction of the TDMS are summarised in figure 4.5 below.

The results indicate that pollution levels on the heavily pedestrianised Regents Road (links 4 and 5) were improved by the TDMS (negative change).

As expected, the pollution levels on the London Road open space link were increased (positive change). Overall, the experiment revealed approximately a 10% reduction over all links.

Figure 4.5 also shows that, while the models do not achieve a good quantitative comparison, they do effectively reproduce the general trend for a qualitative comparison.

Figure 4.5 – Change in CO emissions



It is worth noting that LCC received many representations regarding the TDMS. Many vehicle drivers who had previously queued within the town centre were inspired to complain to LCC on being forced to queue on London Road. All complaints received stated that the congestion problems were worse. Several residents on London Road also complained that queuing traffic posed a safety problem.

This merely serves to highlight the 'hearts and minds' nature of transport as a profession. It does, however, pose an important question: If the TDMS experiment had been more strongly marketed as a measure to improve air quality in the city centre, would as many complaints have been received?

3.3 Conclusions

The results from the experiment carried out by LCC and ITS in Leicester are an example of relatively inexpensive, simple and local level measures that can be implemented by local authorities to tackle the problems of air quality. However, the main concept that should be drawn from the study presented here is what can be achieved when pollution and air quality are at the fore of the design process.

Commonly, design and concept in the transport profession has focused on expediting journey times and tackling congestion. ‘Joined-up thinking’ has commonly been used to indicate that transport and land use policies should be integrated to create innovative urban designs that benefit everyone. However, with the integration of Air Quality Action Plans into the second round of Local Transport Plans (LTP2), pollution policies are also required to be integrated into the mix more than ever before.

Air quality in the UK is a real and present problem, and the transport profession has an obligation to strive to create schemes that improve air quality and reduce the potential for human exposure. By considering pollution at the earliest stage, we can ensure that all traffic improvement schemes achieve the greatest environmental benefits.

For example, the Leicester results show that, while not appropriate for quantitative analysis of emissions, air quality modules contained in assignment and simulation models such as SATURN and DRACULA are useful tools in a comparative study of scenarios. These can therefore be used at very little expense to provide an initial insight into the air quality benefits wrought by any traffic schemes being modelled.

Even if modelling is not required, simple pollution assessments, conducted in conjunction with conventional assessments of transport schemes, can be crucial in leading the design process. Pollution is a powerful political motivator in today’s society and improvements to air quality should be seen as a new angle to promote traffic demand management. Schemes which benefit pollution can be marketed for their improvements to public health instead of being viewed as a ‘stick’ in the battle to reduce road traffic.

4. GENERAL DISCUSSION

The paper presents a case study where transport pollution, in this case air quality, was used as a critical factor in the design stage of two different traffic demand management options.

In the future, as technologies inevitably advance so that the tailpipe emissions from road traffic no longer pose a risk to health, we are likely to end up with very ‘clean’ congestion on our roads.

Can it be concluded, therefore, that tackling the air quality problems of today means tackling the congestion problems of tomorrow? By tackling congestion, are we safeguarding a more energy efficient transport network?

Throughout this paper, I have used the term ‘pollution’ wherever possible, because it includes greenhouse gas emissions, whereas the term ‘air quality’ does not.

Transport will always require energy and CO_2 emissions arising from transport are undoubtedly the more pressing global concern. ‘Pollution assessments’ should therefore be read to include appraisals of CO_2 emissions and hence, energy demand, of transport schemes as well as air quality assessments.

As concerns about the global climate continue to grow, pollution, in every sense of the word, may become the political motivator needed to implement radical schemes. Considered at the design stage, pollution assessments may prove to be an agent for change.

5. ACKNOWLEDGEMENTS

I would like to thank Dr Margaret Bell, ITS for providing the results of the Leicester experiment and allowing the presentation of the results in this paper. LB Enfield is also acknowledged for the inclusion of their Stage 4 results as an example.

6. BIBLIOGRAPHY

Relevant documents are cited in footnotes.