Transactions on the Built Environment vol 23, © 1996 WIT Press, www.witpress.com, ISSN 1743-3509

The environmental impacts of traffic management schemes

J. Cloke, R.E. Layfield
TRL, Old Wokingham Road, Crowthorne, Berkshire, UK

Abstract

The primary concerns of traffic management are to reduce congestion and/or accidents. However traffic management schemes will have an environmental impact, either beneficial or adverse, as a result of the changes in driver behaviour. This in turn has an impact on the operation of vehicles and hence exhaust emissions, noise and vibration. In addition the public's perception of traffic management schemes may be influenced by factors such as disruption encountered during the construction phase, visual intrusion caused by, for example, extra traffic signs, severance and perceived danger.

Schemes which reduce congestion can lead to a reduction in the number of stop-start journeys and a corresponding reduction in fuel consumption and vehicle emissions. However, the relief of congestion could lead to trip generation, cancelling out any benefits gained by increasing the average speed through an area.

Accident reduction schemes generally have the aim of reducing traffic speeds which may lead to increased fuel consumption and vehicle exhaust emissions. Noise levels of light traffic may be reduced, but there is evidence to suggest that noise from heavy vehicles may increase for certain traffic calming measures such as road humps.

There is a need to examine in more detail the environmental implications of traffic management schemes, given that local and central government face a dilemma over the increasing congestion in our towns and cities and the subsequent potential for environmental degradation. This paper describes the findings of preliminary research by TRL, commissioned by the Driver Information and Traffic Management Division of the Department of Transport, of the likely environmental benefits and disbenefits of traffic management schemes and describes in detail TRL's continuing research programme in this area.

Transactions on the Built Environment vol 23, © 1996 WIT Press, www.witpress.com, ISSN 1743-3509

1 Introduction

Road transport is highly valued both by individuals, who spend a significant amount of their income on the purchase and use of cars, and industry where the transport of goods on an efficient road network is vital for national and international trade. However, the widespread and escalating existence of road traffic is increasingly recognised as a major contributor to a range of environmental impacts. For example urban air quality is causing public concern largely as a result of vehicle emissions, with road traffic now the largest source of urban pollutants in the UK. For many compounds the road traffic contribution makes other sources insignificant as can be seen in Table 1.

Table 1 Sources of principal air pollutants in London (1991)[1].

Source of emission	Percentage of total emissions				
	Carbon dioxide	Black smoke	Carbon monoxide	Nitrogen oxides	Volatile organic compounds
Road transport	33	96	99	76	97
Other transport	3	2	1	4	1
Electricity supply industry	2	0	0	1	0
Other industry	13	1	0	5	1
Domestic	30	0	0	6	1
Other	19	2	0	8	0
Total (kt/yr)	8508	19	648	137	116
Note: percentages do not always total 100 because of rounding					

The adverse impacts of road traffic can be minimised in three principal ways: changes in vehicle technology such as the introduction of catalytic convertors to reduce emissions from an individual vehicle; modifying vehicle operation characteristics such as reducing congestion in order to reduce emissions and fuel consumption during a journey, and; modification of transport demand to reduce the amount of travel undertaken in private vehicles.

Traffic management is the general term given to schemes which control the operation of vehicles and the demand for transport. This paper briefly describes a review carried out by the Transport Research Laboratory , commissioned by the Driver Information and Traffic Management Division of the Department of Transport, on how traffic management might minimise the

Transactions on the Built Environment vol 23, © 1996 WIT Press, www.witpress.com, ISSN 1743-3509

impact on the environment, in particular on urban air quality. The detailed findings and a full reference list are given in Abbott et al[2].

2 The Impact of Traffic Management Schemes on Urban Air Quality

2.1 Background

The objectives of traffic management are usually a reduction in congestion and/or an improvement in safety. Schemes have generally been assessed in terms of their success in optimising journey time, controlling traffic speeds and flows and reducing accidents. More recently engineers and planners have become interested in the environmental consequences of traffic as a criterion in the design of control methods, but more often than not this has been of secondary importance. As traffic in our towns and cities grows, environmental degradation will also increase and there is a need to know how traffic management can contribute to minimising the impact on the environment.

2.2 Urban Traffic Control

Urban traffic control (UTC) is the optimisation of traffic light control systems to minimise delays in relation to expected traffic flows. Developed in the 1960s, the earlier systems such as TRANSYT were fixed and could not respond to real time changes in flow, but needed to be updated on a regular basis. The more modern systems such as SCOOT optimise traffic lights in relation to actual flows. Smoother flows can lead to reductions in fuel consumption and therefore vehicle emissions. Robertson et al[3] has shown that TRANSYT can achieve savings in fuel consumption by up to 15%, whilst Hunt et al[4] and Mulroy[5] have calculated savings due to SCOOT of 5-10% on top of that. Provided extra traffic does not take advantage of the reduced congestion, the implementation of UTC systems can result in reductions in fuel consumption, and hence vehicle emissions, within the area covered by the traffic signal network, but the amount of saving depends on the degree of signal coordination already present. The information on change in vehicle emissions is less well known, with changes in CO and HC likely to be larger than changes in NO_x. The emission reductions relate to the roads covered by the UTC network so that citywide, the emission benefits may be smaller in percentage terms. UTC systems can also be used as described above to give priority to public transport vehicles and to achieve area-wide traffic restraint[6].

2.3 Traffic restraint

Localised restraints, such as pedestrianisation, have been very successful in many cities where their application has typically focused on historic cities, busy commercial centres and sensitive residential neighbourhoods. In some circumstances an area ban may cause a significant degree of inconvenience to traffic and result in the total volume being reduced, and this effect can be enhanced if accompanied by improvements in public transport services and improved access to walking and cycling[7].

Area traffic bans can have a dramatic effect on the traffic levels within the banned area and are therefore likely to considerably reduce vehicle emissions within the banned area. However traffic flows outside the banned area may increase with a consequent deterioration in their environment. Citywide the effect on vehicle emissions is likely to be small unless the banned area is extensive.

An alternate number plate scheme and city centre traffic ban has been in operation in Turin during the winter months. Instead of obtaining an estimated 20% reduction in car use, only 10% is achieved. The relief of congestion has encouraged people who don't normally drive to use their cars, and it is also not uncommon for people to buy a second car with the alternate number plate. Away from the centre, congestion has become unpredictable as drivers try to take advantage of fluctuations in congestion[8].

Parking and stopping controls on major urban routes (eg 'Red Routes') can reduce vehicle congestion, increase speeds and lead to a moderate reduction in emissions, assuming that no additional traffic is drawn onto the routes[9].

The availability of parking spaces has a major influence on the choice of means of transport. Parking controls such as increasing charges or reducing the number of spaces can greatly affect car use within the central area. However, the implementation of these measures is hindered by the availability of private non-residential parking and the need to ensure that economic activity is not depressed by car users transferring to another area where parking is cheaper or more readily available.

Changes to emissions citywide as a result of parking controls are likely to be relatively small, at about 2 to 6 per cent, and will depend on the relative contribution that is made by such schemes in terms of veh-km travelled within the citywide network.

2.4 Public Transport, Cycling, Walking and Car Sharing

Bus priority measures such as dedicated lanes are capable of increasing the reliability of services and reducing journey times, and have been shown to reduce bus emissions by up to 35%[7]. Vehicle detection systems can also be used to give priority to buses at junctions, increasing the average speed of vehicles along the route and reducing emissions by a further 15 to 30%[10]. However observations suggest that the average speed of the rest of the traffic may suffer and off-set any environmental benefits achieved by the buses. The overall effect of bus priority measures on vehicle emissions has not been quantified but is likely to be small unless the priority measures greatly increase congestion for non-bus traffic[7].

Park and ride schemes which provide parking on the fringes of urban areas or city centres and served by public transport may achieve congestion reduction. Park and ride has the potential to reduce car use within the inner city area but the extent to which this is achieved has generally not been well documented. A study of park and ride schemes in several UK cities[11] has however suggested that additional trips are generated and drivers travel further distances. Some form of car restraint for example central area parking control, is likely to be required to encourage drivers to transfer to park and ride from car use and prevent any reduction in congestion from being offset by suppressed demand. Similarly new/expanded mass transit systems such as light railways, have the potential to reduce vehicle emissions by reducing the volume of road traffic and congestion. This is not always achieved and some form of car restraint is needed to encourage the transfer.

The promotion of cycling and walking has the potential to reduce the use of motorised transport in urban areas and thereby help improve the environment. A national travel survey[12] found that of all journeys in Great Britain, 73 per cent were less than five miles and 29 per cent were less than 1 mile. The car was used for 45 per cent of journeys less than 5 miles long and walking accounted for 81 per cent of all journeys less than 1 mile. Shorter trips tend to generate higher emissions due to the greater level of energy consumption when driving with a cold engine. Increasing the number of short journeys undertaken by bicycle or on foot could therefore have a disproportionately beneficial impact on energy consumption and emissions. However, the provision of improved cycling and pedestrian facilities alone is not likely to have a large impact on their use. To initiate changes in mode the "community climate" needs to be favourable and cycling and pedestrian facilities need to be integrated into a comprehensive traffic management plan. In the UK a strategy for encouraging increased use of bicycles for all age groups is being developed. This recognises the part which cycling can play as a genuine mode of transport for local journeys within a wider framework of establishing sustainable transport options.

Finally for the motorist very reluctant to travel with a large number of people, car sharing is an option. The potential benefits of car sharing are clear: where average occupancies are 1.5 or less (typical for European and North American cities), filling all car seats with other car drivers could reduce vehicle exhaust emissions by up to 80% as a result of far fewer vehicle-km travelled and the virtual elimination of congestion[7]. The provision of high occupancy vehicle (HOV) lanes can reduce travel time and increase travel reliability and, at some locations, increase car occupancy to about 2 persons per vehicle. The real effect of car-sharing on emissions is however uncertain as some car passengers may transfer from public transport.

2.5 Financial Measures

Financial disincentives to bring about changes in transport modes and/or travel periods may be temporary measures intended to encourage first-time use or more permanent measures designed to encourage their continuous use. Tolls and area licensing schemes, where permits are required for travel in certain zones, can produce large reductions in car trips and vehicle kilometres within the cordoned area, depending on the level of the charge, but car trips in the outer area are likely to increase (OECD[13]). The reduction in vehicle emissions within the cordoned area may be substantial (about 10 to 40 per cent) but the overall city wide reduction in emissions are likely to be smaller at about 5 per cent. In order for the cordon charges to be successful, other travel modes must be available to encourage transfer from car use, for example by financing improvements in bus services and bus priorities and improved accessibility to walking and cycling.

Subsidised fares may be used to increase the attractiveness of public transport and increase bus patronage. However, it is likely that this will lead to only modest environmental improvements, as studies have shown that although halving bus fares pushes up the occupancy, this is at the expense of walkers rather than car users. The additional buses required may also offset any emissions savings due to the small number of car drivers switching mode.

2.6 Lower Speed Limits and Traffic Calming

The introduction of 20 mph (30 km/h) speed limits and zones including physical traffic calming measures usually reduces NO_x emissions on the affected roads (eg Sammer[14] and GFMPT [15]). However, the effect of the measures on fuel consumption and emissions of CO and HC are less certain and may lead to an increase. To achieve a general reduction in emissions, traffic calming schemes require a road design that allows and encourages smooth driving behaviour. On individual streets, possible increases in vehicle emissions due to traffic calming may be offset by lower traffic volumes. Because the residential network carries a small proportion of the total traffic, changes in whole-town vehicle emissions due to residential traffic calming schemes are likely to be small. However consideration also needs to be given to the high emission rates due to cold starts about half of which will be occurring in residential areas.

3 Summary and Discussion

An indication of the effectiveness of each traffic control measure at reducing car use, fuel consumption or vehicle emissions is summarised in Table 2. The changes in car modal split and CO_2 emissions are based on estimated changes from a modelling study of the effect of different transport policies on cities with populations of 180,000 to 500,000[16].

Although hard evidence is scarce, the main conclusion is that whilst some schemes have the potential to reduce vehicle emissions, to achieve an optimum reduction requires some form of vehicle restraint.

Schemes such as UTC and parking controls on main urban routes have been shown to reduce emissions and fuel consumption on a local level, but the effectiveness is not clear as without some form of car restraint the reduced congestion may attract more vehicles, off-setting any benefits achieved.

On their own, improvements in public transport services, bicycle facilities, car pooling schemes and the provision of park and ride sites, are unlikely to reduce car use and hence vehicle emissions, unless integrated into a traffic management plan with some form of car restraint.

Overall it can be concluded that whilst the local or inner city effects of individual traffic management measures may be large, the citywide effects will generally be relatively small (eg 5 per cent reduction in CO_2 equivalent emissions). Combined measures may have a greater effect but are unlikely to produce citywide reductions in CO_2 emissions greater than, say, 10 per cent unless very substantial restraint measures are used. Significant benefits in terms of urban air quality are more likely to be achieved by improvements in vehicle emissions control technology.

4 Future Research

The review of traffic management schemes carried out at TRL[2] has shown that there is a lot of uncertainty in the impact of different traffic management schemes on vehicle emissions and urban air quality. In particular little information exists on the effect of a particular scheme on driver behaviour and the relationship between driving style and vehicle emissions. TRL are now involved in the initial stages of research which includes:

- the development of representative driving cycles from before and after surveys of traffic flow and speed and the instrumentation of vehicles to measure engine speed during an actual journey

- modelling studies of schemes using the driving cycles developed above and an emissions database to calculate changes in emissions on both a local and area scale

Transactions on the Built Environment vol 23, © 1996 WIT Press, www.witpress.com, ISSN 1743-3509

Table 2 Summary of the effects of urban transport and traffic management measures on modal split, fuel consumption or vehicle emissions. (From Abbott et al[2]).

Urban traffic management measure	Effect on modal split, fuel consumption or vehicle emissions		
	Outer city/local	Inner city/central area	Citywide
UTC system for central area traffic signals	Not known	Reduction in fuel consumption between 5 and 15 % but easier circulation may attract more vehicles offsetting benefits	Not known
Parking control on major urban roads	Reduction in vehicle emissions of 1 to 16 % on routes affected	Reduced congestion may attract more vehicles	Not known
Doubling parking charges in central area	Increased car modal split from 61% to 64%	Reduced car modal split from 56% to 43%	Reduction in CO_2 equivalent emissions between 2 to 4 %
Provision of park and ride	May increase car trip lengths	May have little impact on car use without car restraint	Uncertain
Central area traffic ban	Increases on traffic outside banned area	Reduction in emissions in proportion to vehicles banned.	Probably quite small *eg* 5%
Central area licence/toll	Increased car modal split from 61% to 65%	Reduced car modal split from 56% to 35%	Reduction in CO_2 equivalent emissions between 4 to 6 %

Transactions on the Built Environment vol 23, © 1996 WIT Press, www.witpress.com, ISSN 1743-3509

Urban traffic management measure	Effect on modal split, fuel consumption or vehicle emissions		
	Outer city/local	Inner city/central area	Citywide
Mass transit system	May have little impact on car use without car restraint	May have little impact on car use without car restraint	Uncertain
Public Transport Priority	Bus emissions reduced by up to 60%. May increase emissions from other vehicles.	Little impact on modal split without car restraint	Uncertain but probably small changes
Car sharing	HOV lanes can increase average car occupancy	Little impact on modal split without car restraint or ride-share legislation. May cause transfer from public transport	Uncertain but probably very small
Promotion of cycling and walking	Has potential but little impact on modal split without car restraint	Has potential but little impact on modal split without car restraint	Probably very small reduction
Lower speed limits	Lower exhaust emissions	Lower exhaust emissions	Small changes (*eg* up to 2% reduction in NO_x)
Traffic calming (lower speed limits and physical calming measures)	Probably reduce NO_x but may increase HC, CO and fuel consumption.		Uncertain but probably very small

- questionnaire surveys of drivers to determine how different schemes affect driving patterns and attitudes to travel

- before and after air quality monitoring to investigate changes brought about by any changes in emissions.

Another aspect of the research project is to investigate the noise and vibration impact and also public's perception of different schemes.

Acknowledgements

The work described in this paper forms part of a Department of Transport funded research programme conducted by the Transport Research Laboratory and is published by permission of Driver Information and Traffic Management division and the Chief Executive of TRL.

The authors would like to thank Mr J Hickman and Dr P Nelson of TRL and Mr E Wyatt of DoT for their comments and assistance in the preparation of this paper.

References

1 Chell M and Hutchinson D. *London Energy Study - energy use and the environment.* London Research Centre, London, 1993.

2 Abbott, P G, Hartley S, Hickman, A J, Layfield R E, McCrae, I S, Nelson P M, Phillips S M and Wilson J. *The environmental assessment of traffic management schemes: a literature review.* TRL Report 174, Crowthorne, Berkshire, 1995.

3 Robertson D I, Lucas C F and Baker R T. *Coordinating traffic signals to reduce fuel consumption.* Department of Transport, TRRL Laboratory Report LR934. Transport and Road Research Laboratory, Crowthorne, Berkshire, 1980.

4 Hunt P B, Robertson D I, Bretherton R D and Winton R I. *SCOOT -a traffic responsive method of coordinating signals.* Department of Transport, Transport and Road Research Laboratory Report LR1014, Transport and Road Research Laboratory, Crowthorne, Berkshire, 1981.

5 Mulroy T M. Fuel savings from computerised traffic control systems, in *Energy efficiency in land transport.* M Roma (Ed.), Directorate-General for Energy, Commission of the European Communities, Luxembourg, 1989.

6 Wood K. *Urban Traffic Control, systems review.* TRL Project Report PR41, Transport Research Laboratory, Crowthorne, Berkshire,1993.

7 Bayliss D. Urban traffic management. *Transport Policy and the Environment, European Conference of Ministers of Transport.* Organisation for Economic Co-operation and Development, OECD Publication service, Paris, 1990.

8 Vito M. Environmental Traffic Control. *Proceedings of a Workshop held on 30 March 1993 in Athens organised by the QUARTET/APOLLON Consortium*, QUARTET/APOLLON, Athens.

9 Wood K and Smith R. *Assessment of the pilot priority (red) route in London.* Department of Transport, TRL Project Report PR31. Transport Research Laboratory, Crowthorne, Berkshire, 1993.

10 Krawack S. Traffic management and emissions. *The Science of the Total Environment*, 134 (1993), pp 305-314.

11 Pickett M and Gray S. *The effectiveness of bus-based park and ride.* Department of Transport, TRL Report 207, Transport Research Laboratory, Crowthorne, 1996.

12 Department of Transport. *Transport statistics report - National Travel Survey 1989/91. Department of Transport.* HMSO, London, 1993.

13 OECD. *Road transport research - congestion control and demand management.* OECD, Paris, 1994.

14 Sammer G. Effects of the 30 km/h speed limit on exhaust gas - a holistic view. *Symposium on Traffic Induced Air Pollution: emissions, impact and air quality, held on 10 & 11 September 1992 in Graz.* Institute for Internal Combustion Engines and Thermodynamics, Graz University of Technology, Graz.

15 German Federal Ministries of Planning, Transport and Environment. *Forschungsvorhaben, Flächenhafte verkehrsberuhigung, Folgerungen für die Praxis.* Bundesministerium für Raumordnung, Bauwesen und Städtebau; Bundesministerium für Verkehr; Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit, Bonn, 1992.

16 Dasgupta M, Oldfield R, Sharman K and Webster V. *Impact of transport policies in five cities.* Department of Transport, TRL Project Report PR107. Transport Research Laboratory, Crowthorne, 1994.