
World Transport Policy & Practice

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Volume 4, Number 2, 1998

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ISSN 1352-7614

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Abstracts and keywords

Solving the rural transport dilemma: a case study of North Devon

Camilla Swiderska & William R. Sheate

Keywords: North Devon, Policy options, Rural transport.

This paper attempts to demonstrate how both rising traffic levels and rural travel poverty can be alleviated through the development of a range of small-scale measures. Using North Devon in South West England as a case study, specific issues such as land use, walking, cycling and tourism are examined. A tailor made scenario technique was used to engage local decision-makers and interest groups in a discussion of the appropriate mix of policy solutions. Many of the proposed solutions could be translated to other areas of rural Britain.

Children's Perceptions of Transport Modes: car culture in the classroom?

Julia Meaton & Simon Kingham

Keywords: Advertising, Children, Social conditioning, United Kingdom

Children learn at a very early age how to identify between different modes of transport and which are preferable. Breaking the cycle of car dependency among future generations will not be easy.

Transport Policy in the EU: A strategy for sustainable development?

Sarah Wixey & Steve Lake

Keywords: Policy formulation, Trans-European Networks

This paper seeks to analyse the European Union's approach to transport policymaking and the programme of Trans-European Networks. The strategic considerations at the heart of this programme bear little relation to the Union's stated commitments to sustainable development in all policy areas. Sustainable development can only be implemented on a strategic level in policy formulation and not, as seems to be the case with TENs, as an afterthought. The paper concludes by identifying the issue of transport for 'need' as a guiding principle in the formulation of 'sustainable mobility'.

The Comparative Pollution Exposure of Road Users - A Summary

David Taylor & Malcolm Fergusson

Keywords: Air pollution, Exhaust gases, Health impacts, Literature review

Levels of vehicle-derived pollutants found inside and immediately outside motor vehicles are a cause of concern. It is now generally recognised that car drivers, in particular during rush hour, are travelling through a 'tunnel of pollutants' and are exposed to significantly higher levels of pollution than background readings would suggest.

Mortality from vehicular particulate emissions in Tel-Aviv-Jafo

Gary Ginsberg, Aharon Serri, Elaine Fletcher, Dani Koutik, Eric Karsenty & Joshua Shemer

Keywords: Air pollution, Deaths, Tel-Aviv-Jafo

The present level of emissions due to motor vehicles in Israel's second largest city, based on kilometres travelled by vehicle and fuel type, was estimated. By applying co-efficients relating changes in mortality levels with changes in ambient PM₁₀ levels, it is estimated that tailpipe emissions annually cause around 293 premature deaths, primarily among the elderly. This annual toll is in excess of the combined total of deaths whose primary underlying causes were falls, homicides, infectious diseases, suicides, traffic and non-traffic accidents.

High Occupancy Vehicle (HOV) Lanes: Highway expansions in search of meaning

Preston L. Schiller

Keywords: HOV lanes, Transport investment, USA.

High Occupancy Vehicle lanes have been widely promoted and constructed in the USA in a belief that the provision of such facilities would improve transit performance, stimulate car and vanpool formation, and improve land use and air quality in urban areas. Critics, especially among environmentalists and alternative transportation advocates, assert that HOV lanes are merely highway expansions which promote more driving, weaken transit, increase air pollution, and facilitate suburban sprawl. This article demonstrates that, generally, HOV lanes are effective only to the extent that they are designed to fill transit and formal carpool program needs. Questions are also raised about the efficacy of HOV criteria, and the extent to which these programs are shaped by ideological and political considerations, rather than by careful analysis and planning.

Car Sharing and Mobility Management: Facing new challenges with technology and innovative business planning

Conrad Wagner & Susan Shaheen

Keywords: Business planning, Car sharing, Innovation

More car sharing organisations are beginning to appear throughout Europe and North America. The use of existing and new technologies in an innovative way offers tremendous opportunities for this industry to grow.

Editorial

In 1995 the UK government was committed to building 500 new road schemes. In 1997 this was reduced to 140 and in July 1998 reduced yet again so that now only 37 schemes remain in the pipeline. This particular indicator of sustainable transport might well have a claim to represent one of the most dramatic reversals of any government policy in any area in recent years. More interestingly the reversal is associated with a great deal of rhetoric about the need to reduce car dependency. Transport 2000, the well-known national campaigning organisation welcomed the change in policy with the phrase "This White Paper marks a welcome end to 30 years of car-based transport policies". So is this all as good as it looks and should we in the UK be out celebrating the success of 25 years hard work in turning around the super-tanker of a land-grabbing, energy-greedy, socially-irresponsible transport system?

Sadly the answer is in the negative. The steep reduction in new road schemes in the Roads Review and the policy change which preceded it by 10 days - the White Paper - still miss the main points and carefully avoid the most effective things that government could do if it really wanted to reduce traffic. The new roads will cost the tax payer approximately £1.5 billion compared with the £1.1 billion that has been allocated to everything else (public transport support, pedestrian facilities, cycle facilities). The allocation of cash is at sharp variance with the language and the rhetoric, and every government official and politician knows that cash 'means business' and words don't really amount to very much at all. In very crude terms about 60% of the cash government is willing to allocate to transport has been allocated to a particular form of transport (mainly the car) which we have been told must be reduced. This will ensure that the car continues to dominate the choices that people make about how to travel and will continue to act as a deterrent to a large mass of potential bike and foot journeys which are there to be revealed but are suppressed because the road, walking and cycling environment are so irredeemably awful.

The White Paper skilfully avoids any commitment to reduce traffic levels in spite of considerable popular and parliamentary support for new laws in this area. It ducks a national approach to parking standards and does not require local authorities to reduce generous parking provision for places of employment and out-of-town shopping centres. In short, it offers nothing that will turn off the engine driving the upward trajectory of car use. It does nothing at all to ensure that small locally accessible services (shops, doctors, post offices, schools) are well funded and plentiful so that in rural areas especially there is less need to travel longer distances. It does nothing to give tax incentives to employers and employees to switch away from car use for their commuter trips and it leaves in place a historically complex but generous system of incentives for using cars. It does nothing to curb excessive speeds of vehicles and offers nothing to all those who are victims of road traffic 'accidents' and also victims of the everyday discourtesies and stresses of trying to live alongside polluting, speeding and irresponsibly driven vehicles. The White Paper offers no relief for a countryside that will continue to receive ever increasing levels of traffic and towns that will continue to

breathe polluted air in a noisy and dangerous environment.

The roads left in the much reduced list of 37 schemes ring lots of alarm bells. There are widening schemes on the busiest section of the M25 (London orbital motorway) in precisely those circumstances where transport science, common sense and political acumen call for serious road traffic reduction measures and an absolute ban on more road space. Widening the M25 will encourage more cars to use the increased road space in a neat and depressing demonstration that the politicians have understood nothing of the transport debate and not even understood their own rhetoric. Other road schemes have gone ahead on grounds of boosting the economy and aiding job creation when once again there is ample evidence that either this does not happen at all or if it does it so weak and expensive that numerous other policies would win out over roads if we really wanted to target taxpayers money to create jobs.

Government has made much of the word 'integration' and yet has offered nothing to make sure it happens. Government policies themselves are not integrated. The tax system encourages car use and penalises cyclists. New hospitals (built with public money) are built in locations which are inaccessible by public transport, foot and bicycle. They are then provided with 2000 car parking places to send the very clear signal that car use is what is expected. Smaller hospitals closer to where people live are rejected. Similar perverse principles apply to schools. Out-of-town shopping centres are still being built (as are out-of-town multiplex cinema sites and huge leisure complexes) and the White Paper excluded retailing completely from the discussion about car parking taxes. Retailing is such an important pressure for more car travel that it more than merits a national tax on every car parking place, imposed immediately and the income stream recycled to help small, rural and urban, community-based shops and post offices.

Integration means making sure that everything government does pulls in the same direction to achieve government policy objectives. It means the money follows the policy and it means that we get to grips with traffic reduction. On this criteria the White Paper is a monumental failure.

John Whitelegg, Editor

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Department of the Environment, Transport and the Regions (1998) *A New Deal for Trunk Roads in England* The Stationery Office, London.

Both documents may be downloaded from the Department's website <http://www.detr.gov.uk/>

Solving the rural transport dilemma: a case study of North Devon

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Abstract

This paper attempts to demonstrate how both rising traffic levels and rural travel poverty can be alleviated through the development of a range of small-scale measures. Using North Devon in South West England as a case study, specific issues such as land use, walking, cycling and tourism are examined. A tailor made scenario technique was used to engage local decision-makers and interest groups in a discussion of the appropriate mix of policy solutions. Many of the proposed solutions could be translated to other areas of rural Britain.

Keywords

North Devon, Policy options, Rural transport.

Introduction

It is estimated that traffic levels in rural areas of England will rise by between 127% and 267% by 2025 (Transport Studies Unit, 1992). This is considerably more than in urban areas where many routes are at or close to capacity. Already, a legacy of 'predict and provide' transport policy has resulted in air, noise and light pollution invading many quiet rural areas of Britain. Although such road improvements may initially have helped rural economies (though this is debatable, SACTRA, 1997), they have also made remote and wild corners of the country accessible to increasing numbers of car-based tourists and freight lorries. The dilemma for policy makers is how to provide an acceptable level of public transport for the significant number of rural dwellers who do not have access to a car, whilst at the same time managing passenger and freight traffic levels in a manner that will protect sensitive areas from further environmental degradation. Successful working examples of cheap, popular, community services include post-buses, lift sharing, shared taxis and taxi buses. Generally they have financial support from, for example, the Rural Development Commission, or rely on volunteer drivers. It has been suggested that public transport use in rural areas can be encouraged by the development of public

transport corridors. Such corridors could include taxibuses, new railway lines, and cycleways. However the cost of rail travel is prohibitive to many rural dwellers, and in remote areas where the population is widely dispersed (such as North Devon), many villages will not be on or near a public transport corridor. If the objective is to preserve the tranquillity of the countryside then public transport corridors, even on a very small scale, may not be practical or desirable.

Rural transport problems

Travel Poverty

Many rural dwellers suffer from travel poverty. This occurs when people cannot attend events or facilities which are available to others due to a lack of access to choice in relation to travel. Work carried out by the SMART (Sustainable Mobility and Accessibility in Rural Transport) research programme at the Transport Studies Unit (TSU) at Oxford focused on the concept of public transport increasing choice, particularly for rural dwellers where walking and cycling are not an option due to mobility problems, hilly terrain or travel distance (Root, 1996). Rural dwellers who are without access to private transport are finding themselves increasingly isolated as facilities such as schools, hospitals and shops become more dispersed. As more village shops and smaller local hospitals close people must travel further to out-of-town shopping centres and regional hospitals.

National Road Traffic Forecasts (NRTF)
The 1989 NRTF predicted that between 1988 and 2025 the amount of traffic on Britain's roads would increase by between 82% and 142% (the difference between the forecasts being related to the rate of economic growth). The latest revision to these forecasts has reduced the growth rate (from 1996) considerably to a range of 24-51% by 2016 and 36-84% by 2031 (DETR, 1997). Such a growth rate would still result in significant increases on already congested roads. The implications for rural areas have been explored in two detailed

reports: one at the national level by the TSU (1992), the other in Norfolk by the Metropolitan Transport Research Unit (MTRU, 1994). The TSU study, more relevant to this report, found that traffic would grow in rural areas almost twice as fast as the average, producing an increase of between 127% and 267% by 2025. For rural dwellers the main impacts are a reduction in the environmental quality of the villages and hamlets due to increased noise, street lighting and danger. The enjoyment of walking and cycling is reduced when there is more traffic – indeed walkers and cyclists may feel unsafe when increasing amounts of traffic are speeding through the village. In addition the character of the countryside is gradually lost as windy roads are straightened and signposts and street lighting are added. The recent growth in traffic calming policies through villages has met with opposition from some rural residents who say that excessive humps, stripes and speed restrictive signposting ruin the character of the village.

Pollution

Emissions from motorised transport which contribute to global atmospheric pollution have generally been portrayed as an urban problem but a study of rural transport in Wiltshire by Friends of the Earth found high levels of ground level ozone in the South West of England (FoE Wiltshire, 1997). Ozone peaks between 3 p.m. and 4 p.m. as polluted air masses drift out from the cities on thermals, before falling off again in the evening. High ozone levels in rural areas may affect people's health, dissuade people from spending time outside on hot sunny days and may create poor visibility thereby affecting their enjoyment of the countryside.

Freight

There has been a steady and substantial growth in traffic from heavy goods vehicles (HGVs) since the 1950s and these have become much larger and heavier. Much of this growth is because goods are moving further, not because more goods are being produced. The number of goods moved by rail has declined by more than half the amount carried 40 years ago (Plowden and Buchanan, 1995). Most of the goods now carried by rail are bulk goods such as fuel and building materials. Freight transport by road has large external costs that are not fully reflected in pricing and taxation structures. External costs of road freight transport include damage to road infrastructure, fatalities and injuries in crashes, air pollution, noise and other damage such as damage to street furniture, roadside buildings, banks, verges and hedges. This is particularly relevant to rural

areas where sometimes walkers and cyclists must share narrow roads, not designed for heavy lorries, with road freight traffic.

Research for the Department of Transport has indicated that 4.5 billion tonne km of road freight (about 3.3%) could conceivably be switched to shipping (Mawhinney, 1995). Half of that would involve a complete switch from road onto coastal transport. About half would be re-routed to ports nearer to their destination. In rural areas with working ports and harbours, such as South West England, there is some potential to move freight off the road in this way. Rural areas would also benefit considerably from reduction rather than increases in lorry weights and sizes.

Funding

Local transport schemes for public transport, walking and cycling are notoriously underfunded. In the 1997/98 Local Transport Settlement, the Government allocated £746 million to local transport schemes, yet less than one in ten transport packages tackled the problems of rural areas (CPRE, 1996). Of this amount £110 million was allocated to bridge strengthening but only £79 million on 'greener packages'. The guidance on Transport Policies and Programme (TPP) submissions fails to encourage authorities to submit packages for rural areas (Transport 2000 et al., 1996). As a result highway authorities are presently using their minor works budget to improve conditions in small towns and villages. Yet the minor works budget was cut by 38% in the 1996 settlement. Also, local authorities are only permitted to bid for package funding for one year – yet other schemes can be presented as longer-term schemes. Planning ahead for a scheme is difficult if it is not known what funds will be available the following year. However the package system can introduce a workable and sustainable local transport system – working examples include the STAR project in rural Surrey and the package for Dartmoor National Park (Swiderska, 1997).

Tourism

Many rural areas are renowned for their peace and beauty and may be covered by some form of environmental designation such as Area of Outstanding Natural Beauty, Heritage Coast, and Sites of Special Scientific Interest or be in a National Park (such as the Dartmoor National Park). Due to the lack of public transport, roads into these areas become congested with tourist traffic during the summer season. The appeal of such tourist destinations may become threatened by the increase in the number of tourists travelling by car. The destinations

themselves may be sensitive areas, which cannot withstand the environmental impact of such increases and may suffer irreversible damage. It is clear that visitor traffic management strategies must be adopted and this is already happening in the Lake District and in parts of South Devon.

Case study of North Devon

Why North Devon?

The Council for the Protection of Rural England (CPRE) has stated that there are only three areas of extensive rural tranquillity now left in England and one of these is North Devon (CPRE, 1995; *The Independent*, 1998). Figure 1 illustrates its location. Nevertheless, it is representative of other rural areas of Britain which suffer the transport problems outlined above, namely travel poverty, approximately 50% increase in traffic during the tourist season, and an increasing number and weight of freight lorries on small rural roads. Through a variety of projects there has been some progress in meeting the needs of the travel poor. The county is renowned for its innovative solutions which include a transport co-ordination centre run by the County Council which has led to better use of resources and considerable financial savings. However many villages have

Figure 1: Location of North Devon

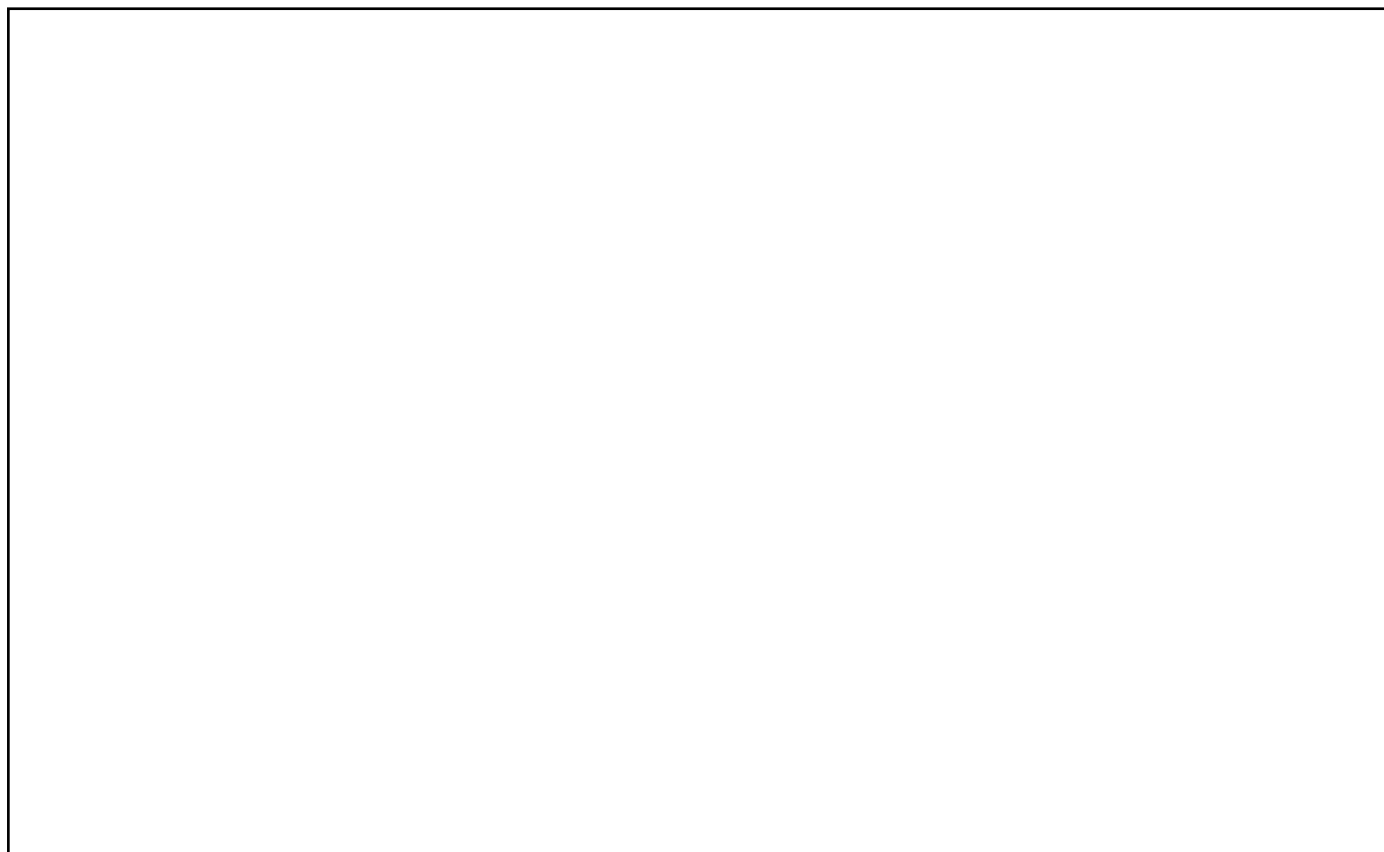


only one bus service per week (see Figure 2) and many tourist destinations are ruined by congestion.

Bus and train services

There is only one railway branch line in North Devon. It is known as the Tarka line and has received wide recognition for its achievements most notably by helping to regenerate local interest in rural rail, and by promoting green

Figure 2: Map of Rural Bus Services in North Devon.



tourism in the area. However locals complain that the service is too infrequent (one service per hour in the day and none at night) and too expensive (it is cheaper to drive from Barnstaple to Exeter for the day if it is just the cost of petrol that is considered).

Approximately one third of the population of North Devon do not have a car (8,000 households). The public transport system that they rely on has many problems:

- *The cost of public transport:* it is prohibitive for some people, such as the unemployed / those on low income
- *Timetabling and connections:* bus services are infrequent; there are no late services (often the last bus is at 5.30 p.m.), and there are poor connections with school times; the train service does not connect with the London and other long distance trains; the Ring and Ride service for disabled people is weekly in some areas and only fortnightly in other areas; there is a lack of bus/rail integration making multi modal journeys more difficult and costly. Finally, there is no facility for taking bicycles on the bus and no safe cycle storage at train stations.
- *Community transport:* resources are often underused due to poor communication between commercial and subsidised or voluntary operators. Current operating licenses are restrictive, for example Ring and Ride vehicles cannot pick up young able-bodied people.
- *Ticketing:* there is no through-ticketing

(separate tickets must be bought for different bus companies and trains).

- *Travel awareness:* many remote villages lack access to valuable travel information.

Visitor management

North Devon has both popular coastal resorts such as Ilfracombe and picturesque river valleys and villages inland. The number of cars swells by 50% during the holiday season, causing congestion on roads into these areas. Narrow roads are often blocked by caravans. In the past, many places have responded by building more car parks (e.g. Ilfracombe now has 8 car parks). However since the adoption of Local Agenda 21, community partnerships are being built, albeit slowly, and parish councils, in recognition that their appeal as tourist destinations may be threatened, are beginning to draw up and implement their own traffic management strategies. Although additional bus services are put on in the summer, it seems that tourist needs are not met in terms of comfort, accessibility and frequency of service. There is simply not enough incentive (financial or other) to leave the car at home or at tourist accommodation. At the regional level the West Country Tourist Board transport strategy hinders any pursuit of sustainable tourism initiatives by persistently lobbying for the upgrading of the road network. However some sustainable tourism initiatives have been successful in encouraging a modal switch, the most successful being the Tarka Trail. This is a branch rail line running through the picturesque 'Tarka country' between Exeter and Barnstaple with cycle hire available at many interim stops together with route maps of the extensive cycleways in the area.

Stakeholder survey of policy scenarios

In order to propose a mix of sustainable policy solutions, a consultative approach was chosen. Case studies of rural transport initiatives such as the Lake District Traffic Management Initiative have shown that unless there is widespread agreement and co-operation among both resident and business interests, even proposals with the best intentions will not work. A list of organisations in North Devon was drawn up which fairly represented the interests of residents, tourism and business. This included policy makers, transport operators, non-governmental organisations, businesses and residents. Twenty two out of the thirty people who were originally contacted responded (see Table 1).

Given that one of the greatest long term threats to rural areas is the ever increasing traffic on rural roads, the NRTF and their

Table 1: Organisations which responded to the stakeholder survey

• Devon and Cornwall Railway Partnership	• Braunton Parish Council
• Transport 2000 local group	• CPRE local group
• Gregory Distribution Ltd (road haulage company)	• Transport Action and Information Network (IRAN)
• North Devon District Council	• Ramblers Association
• West Country Tourist Board	• Devonshire Dales Development Trust
• Devon Wildlife Trust	• North Devon Transport Forum
• Barnstaple Parish Council	• Ilfracombe Partnership
• Cyclists Touring Club local group	• National Trust
• North Devon Rail Users Group	• Devon County Council, Transport
• A local Activist	• Co-ordination Team
• Local Agenda 21 local group	• Red Bus North Devon Ltd
• Combe Martin Community Partnership	

Table 2: Three Scenarios

I Accept traffic forecasts as inevitable	cater for the growth - policies would include road building, suburban development etc.
II Damage limitation strategies	try to deter the worst effects of traffic growth - policies would include fiscal measures, such as road pricing
III Trend reversing strategies	try to ensure the forecasts do not come true - policies include improving public transport and provisions for cyclists and walkers

implications for the case study area were chosen as a focus for discussion. Three scenarios were selected which presented a picture of what North Devon would look like given particular traffic conditions (see Table 2).

Full details of the scenarios can be found in Swiderska (1997). In summary, the first two scenarios used an interpretation of the NRTF which predict the increases in traffic to 2025 – high growth for scenario I and low growth for scenario II. The third scenario asked respondents to consider a situation whereby traffic levels dropped by 20% over the period, a figure not inconceivable given that the Road Traffic Reduction (UK Targets) Bill going through Parliament was aiming to introduce a national target to reduce 2010 traffic to 90% of 1990 levels. A brief summary is given below in Table 3. Alongside predicted traffic levels in each scenario were the associated transport

conditions in the following areas: travel trends and land use, public transport, walking and cycling, tourism, road freight and travel awareness. These areas were chosen in order that the concerns of a broad range of interest groups could be addressed ranging from freight transport to the tourism industry and local passenger transport. Policy solutions were proposed in each of these areas and examples are given in Table 3 while Table 4 shows suggested policy solutions in relation to traffic for the three different scenarios. Further problems and solutions in each scenario were given in the remaining categories.

Table 3: Summary of three local transport policy scenarios

Problem	Proposed policy solution
Scenario I: accept traffic forecasts as inevitable	
<ul style="list-style-type: none"> road traffic levels rising by more than 2.5x current levels travel trends public transport cycling and walking tourism freight transport travel awareness 	<p>accept the forecasts and cater for the growth. Policies would include road building, suburban development, etc.</p> <p>encourage near universal car ownership largely maintained by voluntary schemes</p> <p>some encouragement as part of national policy accommodate tourist demands for faster road links to North Devon and its resorts</p> <p>encourage road freight as cheapest mode</p> <p>little need for awareness campaign as majority already prefer the car</p>
Scenario II: damage limitation strategies	
<ul style="list-style-type: none"> road traffic levels - steady rise travel trends public transport cycling and walking tourism freight transport travel awareness 	<p>damage limitation strategies - manage existing road network</p> <p>gradually introduce environmental pricing</p> <p>some rural rail lines open; bus services operating where socially necessary</p> <p>promoted as alternative to private car; some building of cycleways and walkways</p> <p>promote use of public transport and cycling</p> <p>greater use of rail network and shipping encouraged</p> <p>expansion of <i>TravelWise</i> campaign</p>
Scenario III: trend-reversing strategies	
<ul style="list-style-type: none"> road traffic levels travel trends public transport cycling and walking tourism freight transport travel awareness 	<p>target of reducing road traffic by 20% by 2025</p> <p>reduction in the need to travel through land use policies</p> <p>all road investment diverted into public transport - significant improvements: choice of mode increased</p> <p>large transfer to this mode for journeys under 2 miles</p> <p>create visitor management plan; relieve pressure points using road hierarchy and access only roads</p> <p>road freight restricted to strategic lorry routes; all future investment in rail and shipping freight</p> <p>wider publicity to raise awareness among both rural dwellers and tourist trade</p>

Results

A summary of the results of the survey are given in Table 5. Some immediate conclusions can be drawn from the table:

- no respondent chose Scenario I although two respondents did choose a combination of Scenario I and II;
- the majority chose Scenario II or III with over 72% selecting a combination of II/III or III alone;
- 50% chose Scenario III, which proposed trend-reversing strategies.

Given the mix of stakeholders interviewed, the results indicate that the desire for a different approach to transport was not confined solely to the 'green' groups, but was widely shared across the interests consulted.

Lessons from the scenario survey

Funding

Currently, the main way a local authority can move towards a more sustainable transport policy is through its annual bid for funds in the TPP. Such a trend is inhibited by large capital road projects which will be built at the expense of many more schemes to encourage travel on public transport, bicycle and on foot. Although there has been a slight upward trend in package bid money by Devon County Council, its TPP still contains large sums for major roads including in the case of North Devon, a bid for the Western Bypass and the Downstream Bridge through Barnstaple. Through its TPP submission Devon Co. Co. could press for reallocation of funds to more sustainable modes and this is supported by the survey results.

Land use planning

The scope of the package bid could be widened to include projects that would reduce the need to travel, such as reopening and reforming village shops. The new rate relief scheme

announced recently by the Department of the Environment, Transport and the Regions which will enable some village shops which may otherwise have closed to remain open, is a small step in the right direction. This scheme will provide 50% rate relief to post offices and general stores, with a ratable value of less than £5000, in rural settlements with less than 3000 people. With regard to freight, land use planning could play a much bigger role in securing distribution points, particularly for agricultural produce in the area. For instance there are no Milk Marque distribution depots in North Devon. Milk produced in the area is roadfreighted to Somerset for processing and packaging before returning by road for consumption in North Devon.

Public Transport

Often in rural areas it is not the number of vehicles and drivers that is the problem but the lack of co-ordination and communication

between commercial and volunteer organisations which can lead to severe underutilisation of resources. Second, improved timetabling and connections would attract more people onto buses and trains. To achieve this, detailed research needs to be carried out to establish the most appropriate route network and service provision which must include early start times to serve journeys to work and schools, and evening timings to facilitate leisure and visits to friends and relatives. There will obviously be different requirements for different rural areas but the principle is the same. Third, many respondents identified the lack of bus/rail integration as being a major disincentive to taking public transport. One respondent felt that bus deregulation and rail privatisation may be an opportunity to improve services since co-operation between bus and rail operators working together on a commercial basis could serve to complement each other rather than to increase competition. Perhaps the lowest cost initiative would be to display taxi information, together with a telephone link at the bus stop which would enable travellers to reach their final destination on public transport in relative safety rather than risk being stranded at a remote rural bus stop. The Government's recent allocation of an extra £41.7 million to local authorities for rural bus services (including £1.42 million to Devon), may help to get some new initiatives off the ground (DETR, 1998).

Table 4: Example policy solutions for three scenarios of road traffic levels

Scenario I: Dramatic rise in traffic on rural roads.	
<i>Traffic in rural areas forecast to rise by 267% (high growth scenario); will be most noticeable on most strategic routes such as the A361 link road, the Barnstaple urban relief roads, proposed Western bypass and Downstream bridge and tourist destinations on the coast</i>	<p><i>Accept the forecasts as inevitable; carry out measures to allow for growth:</i></p> <ul style="list-style-type: none"> • aim to accommodate predicted growth in traffic • build Western Bypass and Downstream Bridge without further delay • build further urban relief roads around Barnstaple • widen Link road to dual carriage way • build by-passes to all villages congested in summer
Scenario II: Road traffic levels rising	
<i>Traffic in rural areas is forecast to rise by 127% (low growth scenario), while traffic noise and road lighting extend far into the countryside</i>	<p><i>Damage limitation strategies:</i></p> <ul style="list-style-type: none"> • manage existing network: new roads will be built only where there is no alternative. • build Western Bypass and Downstream Bridge, which will bypass Barnstaple on the western side (currently largest capital item in the TPP (£23 million) despite Devon Co. Co. accepting the SACTRA (1994) conclusions that new roads induce new traffic). • gradually introduce policies to discourage car ownership • use of fiscal measures such as road pricing, environmental pricing
Scenario III: Road traffic levels gradually dropping	
<p><i>Making sure the NRTF do not come true</i></p> <ul style="list-style-type: none"> • traffic levels will drop by 20% over the period • use of selected road closures in sensitive areas (as proposed in the Lake District) • traffic management: use of speed restrictions and traffic calming in villages 	<p><i>Trend reversing strategies:</i></p> <ul style="list-style-type: none"> • increase petrol costs; increase the fixed costs of motoring (national policy) • increase parking charges particularly at tourist destinations and for car based commuters in towns such as Barnstaple. • congestion road pricing at popular tourist destinations: revenues to be reinvested in public transport systems. • charging to enter North Devon by car; incentives to enter North Devon by public transport (cheap return tickets, etc.). • traffic calming and speed restrictions

Table 5: Favoured scenarios

<i>Scenario chosen</i>	<i>Number who chose this scenario</i>
Scenario I	0
Scenario I and II	2
Scenario II	4
Scenario II and III	5
Scenario III	11
Total	22

Freight

Contrary to the opinion of some respondents in this survey, there are measures which county councils can take to both reduce the physical impact of HGVs on the countryside and to reduce HGV traffic overall. CPRE's Losing Lanes to Lorries Campaign has identified these as follows (CPRE 1997):

- effective planning policies which reduce the need to move freight long distances and which discourage developments which rely on long distance freight movements by road as opposed to rail (currently industry in Barnstaple is largely located in two industrial estates, Roundswell and Pottington but there is no freight depot or rail service);
- the creation of more local markets for food retailing in which locally produced food is

sold in the vicinity of where it has been grown, reducing the need to transport it long distances, (Barnstaple has a regular Pannier Market selling local produce and crafts which could be replicated in other small towns);

- to identify strategic routes for lorries which are best suited for HGV traffic and to sign them appropriately;
- to make greater use of weight, height and width restrictions in order to reduce the physical impact of lorries on villages and the countryside;
- to introduce lower speed limits, such as 20 mph through villages, thereby reducing the impact of lorries in the countryside and improving safety.

Such constraints also serve to help shift the balance towards alternatives to car and lorry-based transport. In addition local authorities can lobby national and EU policy makers to introduce legislation that will enforce the above measures. Local authorities can also establish voluntary agreements with freight companies and the Road Haulage Association, to achieve the above and also to find other means to pay for structural maintenance and bridge strengthening, a major part of the Devon TPP.

In North Devon, the existing rail line between Barnstaple and Exeter is underutilised. There is only one service each way per hour and no services at night. There is considerable potential to introduce freight trains on this route and to provide connections to InterCity trains at Exeter to London (via the Great Western and South West Trains routes), the South Coast, Bristol, Plymouth and Cornwall.

Tourism

With the exception of the Tarka Trail initiative, there has been a clear reluctance to tackle the problem of tourist traffic congestion in North Devon. There have been successful schemes in other parts of the country, for example the Lake District Traffic Management Initiative which has introduced policy measures such as access-only roads, which make it easier for the tourist to use public transport to reach the most sensitive beauty spots. Once again, thorough consultation is vital and could be initiated and managed by Local Agenda 21 branches.

Travel awareness

Computer hardware and links can be installed to enable an area controller to access centrally held information and distribute it to neighbouring parishes, information boards or household distribution. Also, the TPP consultation process could be extended to include the general public. The travel

awareness campaign, *TravelWise*, currently used in urban areas could be extended to rural areas.

National change

Changes at the local level would be more effective if they were accompanied by a change of direction at the national level. Even if only some of the policy recommendations were carried out, local authorities throughout the country would immediately be better equipped to introduce a sustainable transport system that people would want to use. Briefly, such changes should include the following measures:

- *Internalise externalities* - increase the cost of vehicle use so that the full environmental costs of motorised transport are accounted for (the revenue to be reinvested in public transport);
 - *Change TPP funding* - alter the system to allow for revenue projects (rather than just capital projects) and for long term spending (three years instead of one year); give clear guidance to encourage local authorities to bid for entire rural areas;
 - *Freight* - enforce lorry operations and regulations, and restructure lorry taxes so that the biggest lorries travelling the furthest pay the most tax;
 - *Public transport* - create a strategic rail authority to ensure co-ordination and co-operation between rail operators; reform the 1985 Transport Act to make special provision for rural bus services; introduce a national travel awareness campaign to encourage more use of public transport.
-

Conclusions

This article has attempted to identify sustainable, cost effective and feasible solutions to address the specific and complex nature of rural transport. Interviews with key stakeholders in the case study area revealed that the majority would like to see not only a fundamental change in approach to rural transport planning at the local level but also recognition of the need for a well defined rural transport strategy at the national level. The case study of North Devon has shown that in virtually every policy area, from the promotion of public transport to tourism initiatives, feasible policy alternatives do exist. Many are low cost measures that can be initiated locally, either by the local authority or by community groups. While some may affect existing and future traffic levels only at the margins, the benefits to communities and individuals in rural areas could be highly significant. However

these measures would be greatly strengthened by a recognition of rural transport policy issues at the national level. The Government White Paper on an integrated transport policy is an opportunity to make special provision for rural areas and to ensure that rural projects are allocated a significantly greater share of the local transport allocation.

Most importantly, a new national integrated transport policy could provide the effective framework within which local change and action could be facilitated, enabling some of the rural initiatives discussed above to be implemented more quickly and more easily. The solution to the rural transport dilemma, however, lies not only in transport policy, but

also in those other sectors which have affected transport trends over recent decades: housing, health, agriculture, economy, tourism, land use, etc. All activities have transport implications, and it has been changes in those other activities, as much as in transport itself, which have brought about the current rural transport dilemma. Just as it took several decades for the current problems to become self-evident, so it may take many years to bring about a significant reversal of past transport trends. There has been a significant shift in attitude over just the last five years. This brings some hope that new initiatives can be put in place in rural areas and may ultimately succeed in providing real benefits to those who live there.

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Children's Perceptions of Transport Modes: car culture in the classroom?

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Abstract

Children learn at a very early age how to identify between different modes of transport and which are preferable. Breaking the cycle of car dependency among future generations will not be easy.

Keywords

Advertising, Children, Social conditioning, United Kingdom

Introduction

Most planners, academics, and even politicians now agree that there is an urgent need to encourage people to reduce their use of cars and to persuade them to travel by alternative means (Royal Commission on Environmental Pollution, 1994). Unfortunately almost all research conducted in this area concludes that this is almost impossible to achieve (Anderson and Meaton, 1994a; Stokes and Hallett, 1992; Lex, 1995). People with cars are highly resistant to giving them up or even reducing their use. They offer a whole range of reasons for this but these are often excuses to justify their use of a highly convenient and flexible mode of transport. There have been several attempts to persuade car users to use greener modes of transport with the use of publicity and education campaigns (Anderson and Meaton, 1994b; BBC, 1994; Ciaburro, 1994; Curtis and Headcar, 1997), and such campaigns are often recommended as imperative in order to change car culture (Meaton and Morrice, 1996; Anderson *et al.*, 1998). However, recent evidence suggests that such campaigns can be at best, only marginally effective, and at worst, counterproductive. For example researchers in the Netherlands attempted to find out the effectiveness of different types of information in stimulating car users to be more selective in their car use (Tertoolen, 1994). The research found that while information concerning environmental effects helped raise individuals awareness of the need for environmental policy, the information did not lead to a change in the respondents behaviour. Information about financial implications of travel behaviour was

similarly ineffective in changing behaviour and actually led to greater criticism of alternative modes. Combined information had no discernible effect. The researchers were left to conclude that displacement mechanisms were being used whereby increased knowledge of the environment leads the individual to pass the responsibility on to others and increased awareness of financial costs were dealt with by criticising alternatives and a reassertion of the necessity of using the car.

Another problem with publicity campaigns concerning the environment is that to try and persuade people that it is important for them to change their behaviour, they have to use information that can convey the urgency of the situation. This can mean that the publicity is either shocking or full of dire warnings of the consequences if people don't do something. This again can also be counterproductive in that typical responses to gloom and doom information is to feel completely overwhelmed by it so that it induces feelings of helplessness and despair amongst the target audience.

One of the problems is that car use appears to be addictive (Vlek *et al.*, 1993; RAC, 1995). Once a person has a car they travel more often, over longer distances, and cannot contemplate life without their vehicle. If this is the case, policies should be formulated that are designed to deal with habits. Although there are various approaches to dealing with habits, most experts agree that the best way of dealing with a habit is never to pick it up.

Using this argument the best way of dealing with unnecessary car use is never to start it in the first place. Lex (1995) conducted a survey of children aged between 13 and 16 in order to find out their attitudes towards cars and motoring. The results found that youngsters are already as dependent on the car as their parents with 90% of girls and 75% of boys saying that they would find it difficult to adjust their lifestyles without a car. Most of the respondents expected to be driving their own cars by the time they are 19 with over half wanting to own a sports car. When the boys were asked what sort of things they would look for in a car the general look of the car and speed were the most important factors. Girls were more concerned

about its colour and whether it had a good stereo. For both genders, the environmental friendliness of the car was the least important factor.

The evidence suggests that children are already hooked on cars at a very early age. This has the potential to manifest itself in the 'car culture' and the excessive car use which is so difficult to reverse in later life. If attempts are to be made to prevent the continuation of this culture and to prevent future generations becoming addicted to the car, it is important to target children who have yet to assimilate the pro-car propaganda. The Lex study suggests that by the time children reach the age of 13 it is already too late, and that by then children have already been absorbed into the car culture. This is unsurprising given the amount of social conditioning they are subjected to. Babies are frequently given squashy car toys to play with, 'car' is one of the first words many children speak. Children learn from their parent's behaviour that cars are something to be admired (Stokes and Hallett, 1992) and children unable to walk are given dummy driving wheels so they can mimic their parents while they drive. Recent advertising for the Vauxhall Astra has shown babies 'demanding' certain qualities from cars. As they grow up society and even some government ministers inform them of the car's superiority to public transport and they begin to appreciate the different images associated with different makes of cars. For example, few people are ignorant of the run of Skoda and Lada jokes that were around in the late 1980s. Such image association is widespread in society and it is undeniable that certain modes of transport and certain types of car are associated with certain types of people. Porsche drivers are typically regarded as 'loathsome, stripe-shirted youthful city slickers' (*Independent on Sunday* 3rd April 1994) and the image of a Skoda driver is of 'an extremely old man hunched over a steering wheel' (*The Times* 16th December 1995). Research in Norway based on focus groups identified a range of images of transport users including the following; a car driver was perceived as 'a man, earning more and having a higher position than the average, and is a successful person'; a train passenger was 'well dressed, effective commuter living in residential areas and having a relatively high position in society'; and bus passengers were 'women, old or very young, belonging to the working classes or working as a functionary, and who cannot afford to have a car'.

The question is when does this social conditioning begin to register with the child? Since Lex has found that many children aged 13 have already absorbed the car culture, it was

decided that a study of younger children should be conducted in order to identify the age at which children consciously become aware of the various images and lifestyles associated with different modes of transport.

Method

Gleaning information from children as young as five can be problematic and using conventional questionnaires is often inappropriate. A new methodology was required that would not be too demanding for the children and which did not require them to read or write. Show cards have been used extensively with children (Kirklees Metropolitan Council, 1995) and have been found useful in extracting information from children on their attitudes and understanding of a wide range of issues. It was therefore decided that the methodology would use two sets of show cards. One set would show nine different types of transport including a variety of different types of cars, and the other set would show nine different types or groups of people. The children would then be asked to match up the two sets of cards putting the people together with the transport mode they thought they would be most likely to use. Table 1 shows the mode and the people types shown on the cards and suggests the 'correct' pairings.

Table 1: Mode and people show cards and 'correct' pairings.

<i>Mode Show cards</i>	<i>People Show Cards</i>
Family estate car	Family of five
Landrover	Lady in country clothes with dog
Train	Businessman wearing bowler hat
Motorbike	Denim-clad biker
Bus	Old lady
Bicycle	Sporty young man
Porsche	Flashy looking young man
Lada	Old man
BMW	Professional couple

In addition the children were asked to rank the modes of transport in order of preference. They were also asked what their normal mode of transport was, whether their family had a car and what type of car it was. Any relevant comments made by the children were also noted. The survey was conducted at two primary schools in Huddersfield, West Yorkshire. 140 children were interviewed, 70 at each school. Each age group (5-11) was represented by 20 children, and both genders were represented equally in each age group.

Results

66% of the children were in families that owned a car, and almost the same number stated that the car was their normal mode of transport. 31% said that the bus was how they normally travelled, while two children used their bicycles and one child mentioned the train as their main mode.

The favourite mode of transport for all children was the motorbike, with the two performance cars, the BMW and the Porsche coming in at second and third respectively. The bicycle and the family car were joint fourth favourites and the Landrover fifth. The train and the bus each had one admirer but the Lada was not mentioned by any respondent. These results suggest that there is a certain amount of brand awareness between car models, and that already public transport is unpopular. Some gender differences were evident. 50% more boys than girls preferred the motorbike and the Porsche, while twice as many girls preferred the family car, bicycle and Landrover.

There are also variations evident in mode preference according to age. The numbers of children favouring the motorbike declines with increasing age, as do those favouring the bicycle, while those favouring the Porsche increase in number.

An alternative way of assessing preference of mode is to compare the ranking given to each mode by the children. The frequencies of rankings of children's preference for transport mode were calculated. Except for first preferences for the Lada, all modes are ranked everywhere from first to last. The BMW, motorbike, family car and Porsche all appear to have higher ranks; Landrover and bicycle seem more evenly spread, and train, bus and Lada seem to lean more towards lower ranks. To assess the rankings further, the mean ranks for each mode were also calculated. The BMW has the highest mean rank (3.72) followed by the motorbike and the family car. Although the motorbike is the most preferred mode by the children, there are also a number of children (18) who rate it as their least or second least preferred, resulting in a less favourable mean rank than the BMW. The Porsche, Landrover and bicycle all have mean ranks of between 4.3 and 4.7. The train, bus and Lada are the least favoured, with mean ranks over 6. This may not be surprising for the 'unfashionable' Lada, but is worrying for the two modes of public transport.

Table 1 suggested the 'correct' pairings. When the data was analysed it was found that for all modes, it was these hypothesised pairings that got the highest score. However, there were great differences in the percentage of

children making the correct match, ranging from 75% to 27%.

The mode/person match that appeared to have the most significant image association was the motorbike and the biker. 75% of the children put these two showcards together. A further 7% thought that the rather flash young man might drive a motorbike. The remaining percentage was made up of a mixture of responses with three children thinking that the old lady might drive a motorbike.

The family and the family car gained the second best score but with 55% of children getting it correct. This represents a much vaguer image association than for the motorbike. The professional couple were associated with the family car by 16% of the children and 9% and 8% linked it with the sporty young man and the country looking woman respectively.

The only other pairing that was correctly identified by over 50% of the children was the Landrover and country woman. 52% of the children placed these two showcards together, 9% thought the family might use it and 8% suggested the old lady as the most appropriate user. Interestingly 6% thought that the professional looking couple might use it, possibly reflecting the current fashionability of 4x4s and their recent manifestation as prestige symbols.

The idea of buses being associated with women was evident amongst the sample with 48% of children linking the old lady with the bus. A further 21% thought that the old man would be likely to use this form of transport. No other people groups were strongly associated with the bus.

The bicycle was linked with the sporty looking young man by 47% of the sample and the only other people types showing any significant association were the flash looking man and the commuter (14% and 11% respectively). Interestingly no women people types were associated with this mode of transport.

The Lada has long been regarded as an inferior model of car and this image appears to have been assimilated by our sample. It was the only form of transport not mentioned by anyone as their favourite mode and it seems that it is largely associated with older people. 41% of the pupils linked it to the old man and 16% thought the old lady might be the most obvious user.

The BMW had similar levels of image association but this time 37% linked it to the professional couple and 15% with the sporty young man. Both the flashy looking young man and the commuter were linked to the BMW by 13% of the children. The Porsche, while being

the third most popular mode of transport caused some confusion amongst the children as to who would be most likely to drive it. Some 27% thought that the flash young man would be the most obvious user, a further 19% thought it would be driven by the professional couple and 16% thought the commuter might use it. Interestingly no child linked the old lady and the old man with the Porsche or the BMW. The children in this sample appear to recognise that the Porsche and the BMW are rather upmarket modes of transport, but are less able to distinguish between the types of people most likely to use them. However, they do appear to believe that old people are unlikely to drive such vehicles and have identified the more successful looking people (young men, professional couple, commuter) as being the most likely users.

The train was associated with the commuter by 27% of the children, although 16% thought that the flash young man might travel by train. This would seem encouraging in that the train as a mode of transport doesn't appear to be beset with the negative imagery associated with buses. However, since 15% of the children linked the old man with the train and 11% the old lady, it would still appear that public transport is still largely associated with older, poorer sections of society even by children of primary age.

This research aimed to find out at what age children begin to notice different forms of transport and when they begin to associate different modes with different types of people. The results so far clearly show that this image association is well and truly established by the time they reach the age of eleven. In order to be more precise about the actual age when they start to differentiate and absorb society's values further analysis was conducted.

The age children were starting to accurately match pairs was compared. The results suggest that the older the children, the greater the

number of correctly matched pairs. To ascertain whether this is statistically significant chi-square analysis was done for each separate mode pair to see whether the ability to accurately match the pairs was related to the children's age.

The ability to match the pairs for bicycle, bus, family car, Landrover, motorbike and Porsche are all significantly related to age ($p < 0.05$), with older children being more able to correctly match the pairs. The pair matching for the Lada and BMW are not significantly related to age while for the train there is a weak relationship. For those modes where there was a significant relationship with age, the age at which the children correctly matched more pairs than was expected, varied around ages 7, 8 and 9. For bicycle and bus it was at age 7, for Landrover it was 8, and for family car and Porsche it was 9. The picture is less clear for the motorbike as the observed number of children correctly matching the pairs was almost the same as the expected number for 7, 8 and 9 year olds.

A total score of between zero and nine was calculated for each child on the basis of how many of the pairings they had got correct. A score of nine indicates the child got all nine pairings correct, a score of zero indicates a child got no pairings correct. There was little difference between the mean number of pairs correctly matched for boys and girls (4.07 and 4.13 respectively). Using a Mann Whitney U test we were able to confirm there was no statistically significant difference between the total pairing scores for boys and girls ($p = 0.989$).

The number of correct pairings, subdivided by age can be seen in Table 2. There appears to be a difference in pairing ability according to age, with the older children correctly matching more pairs. The mean number of pairs correctly matched, according to age seems to confirm this. A Kruskal-Wallis test proved this was correct ($p < 0.00001$), the older children being more able to correctly match pairs than the younger children.

Table 2: The number of children that correctly matched numbers of pairs, by age.

No. of pairs	Age													
	5		6		7		8		9		10		11	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
0			1	5	2	10	1	5						
1	8	40	5	25	1	5			1	5	1	5		
2	2	10	4	20	3	15	5	25	1	5	1	5		
3	5	25	7	35	4	20	2	10	1	5	2	10	2	10
4	4	20	2	10	2	10	4	20	2	10	4	20	2	10
5			1	5	3	15	4	20	5	25	3	15	4	20
6	1	5			4	20	2	10	4	20	5	25	5	25
7							2	10	2	10	4	20	6	30
8									1	5				
9					1	5			3	15			1	5
Mean no. of pairs	2.45		2.35		3.75		3.90		5.60		4.90		5.75	

Discussion and Conclusions

The results of this survey are worrying. They indicate that image association between modes of transport and different sections of society are evident in the minds of children as young as seven. This suggests that the origins of the car culture so pervasive in adult society, are nurtured at the very early stages of a child's development. Car culture, as a result, is almost seamlessly perpetuated between generations, and it appears likely that the next generation will be even more wedded to their cars than

previous ones. If we are to break this cycle of admiration, aspiration, acquisition and consequent addiction, we must act at all levels of society.

It has been argued that young people are often overlooked in the transport debate (Turner and Pilling, 1998). This research suggests that young children also need to be brought into the discussion. The next real issue is how to go about it. The problem is that although there are recognised forums for teaching and influencing children on values, rights and wrongs, etc., (schools, television, parents) these all represent and sanction the values that are being questioned. School teachers, for example, frequently

drive cars to work, many parents own, use and preen their vehicles, and society in general continues to applaud the motor car. It is therefore unlikely that campaigns undertaken in any of these single spheres will be successful. What is required is a complete package of innovative campaigns, targeted at all sections of society, in different ways. We cannot change the attitude of the children without changing the attitudes of their parents, and we cannot change the attitudes of parents without changing the values in society. Once it is accepted that this radical action is required, more research will be necessary to identify the optimum means of achieving it.

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Transport Policy in the EU: A strategy for sustainable development?

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Abstract

This paper seeks to analyse the European Union's approach to transport policymaking and the programme of Trans-European Networks. The strategic considerations at the heart of this programme bear little relation to the Union's stated commitments to sustainable development in all policy areas. Sustainable development can only be implemented on a strategic level in policy formulation and not, as seems to be the case with TENs, as an afterthought. The paper concludes by identifying the issue of transport for 'need' as a guiding principle in the formulation of 'sustainable mobility'.

Keywords

Policy formulation, Trans-European Networks

Introduction

This paper examines the confusion generated by the failure to clarify the conceptual distinctiveness of 'sustainability' and 'sustainable development'. Both terms are essentially contested but it is argued that the substitution of 'sustainable development' for 'sustainability' results in what McManus calls a '... marginalised sustainability discourse'. (1996, p. 54).

This divergence is examined with reference to the issues of transport and mobility. The consideration of the issue of sustainability in this policy area must begin by questioning the notion of the need to travel. A more radical notion of sustainable development is proposed which entails the incremental application of a long term sustainability strategy.

This is contrasted with the current sustainable development agenda, where the basis of a sustainable transport policy has been only partially worked out. Questions continue to be raised about what sustainable development means with regard to transportation and mobility. The available policy documents often contradict each other. This is demonstrated in the discussion of the 'Trans-European Networks' (TENs).

The Process of Sustainable Development

"... any process of 'sustainable development' must be based upon the principle it is trying to achieve - that is, sustainability. [...] As such, 'sustainability' becomes a goal which may be unattainable given the need to start from current ecological, political, economic and social realities, but still one that should be pursued as an appropriately positioned yardstick against which 'sustainable development' can be measured." McManus (1996, p. 69)

If we treat development here as 'process' and sustainability as 'end', at least we have something to work with, as McManus says, a 'yardstick'. Doubtless this rather simple measure will fare no better than many other attempts for clarity on this issue. Arguments over absolutes in regard to sustainability will no doubt continue *ad infinitum*, in the evaluation of policy as well as in more theoretical realms. This 'yardstick' approach can however be informative in terms of assessing the general direction of policy making. This is what we shall attempt in the following analysis of European transport policy and sustainable development.

In practice, much of what passes for policy on 'sustainable development' has a much narrower remit. The chief focus of much policy claiming to be 'sustainable' is on issues more usefully placed under the category of 'quality of life'. Clearly there is a distinct overlap between 'sustainable development' and 'quality of life' agenda, but it would be foolhardy to equate them. Sustainable development goes beyond a shallow environmental approach or short term concern for living standards. This paper is implicitly concerned with *sustainability* which may in general underpin debates over quality of life, but which addresses a global concern with limited resources and capacities. The differences are in matters of scope, in that sustainable development deals with a broader range of issues, not all necessarily linked to questions of human welfare. In addition, the concept of futurity is crucial to sustainable *development* as a move in the direction of greater sustainability and is thus concerned

with intergenerational and intragenerational justice. Concern with quality of life can be and often is more limited in terms of the populations who are deemed to matter.

Conceiving of sustainable development as a process which refers to the originating notion of sustainability is a reminder of the implicitly radical content of both terms, regardless of the extent to which they have been watered down in practice. This may be an inevitable feature of being '... (arguably) the dominant global discourse of ecological concern' (Dryzek, 1997, p. 123). Being central in discourse over the environment, sustainable development retains an important resonance which requires frequent re-iteration in terms rather less equivocal than those of governments and bureaucrats. In order to progress the debate on sustainable development, we may not insist on consensus, which would surely only be wishful thinking anyway, but we should insist on reflection. Indeed, there is an urgent need to re-state if not a detailed definition (or even a 'shopping list of sustainable goods'), what the purpose of sustainable development is in the broadest sense.

"Sustainable development, therefore, amounts to a strategy for environmental sustainability because of the belief that a particular form of development will provide the conditions within which environmental sustainability can be guaranteed" Dobson (1996, p. 422).

No doubt there will be continued disagreement over what sustainability and sustainable development entail. The problem then hinges on equally contested notions of sustainability, for which there are already over 300 definitions available (Dobson, 1996). Sustainability in the broadest possible (anthropocentric) interpretation is concerned with maintaining the present natural capacities of the biosphere whilst satisfying the needs of the human population. Numerous interpretations of this underlying principle seek to elaborate this basic starting point, in bewildering directions at times.

This paper examines one aspect of the debate on sustainable development within the context of the European Union. The treatment of different dimensions of political economy in terms of policy sectors does tend to mitigate against the overall strategic essence of the sustainability issue. In treating the issue of transport in this distinct fashion we are paying necessary attention to this problem as far as possible. It is certainly the case however that one cannot hope to engage with real political debates and the business of policy making without taking these issues to some extent on

their own terms. The issue of sustainable transport is therefore not seen as entirely separate from other considerations despite the fact that this often appears to be the outcome of such a focused approach.

'Sustainable Transport'?

A lack of commitment to a *strategic* notion of sustainable development would justify a pessimistic conclusion that, at best, sustainable transport policy has rhetorical value, but is largely subordinated to issues of 'economic growth'. This seems to be the current approach taken to the issue of transport in the European Union. The sheer quantity of resources consumed combined with the negative externalities which result make transport a particularly urgent issue for those concerned with the social and natural environments.

Maddison, *et al.* (1996, p. 221) examine the 'Main Factors in Transport Social Cost' and conclude that work undertaken indicates four key factors of concern. These are: road accidents; noise nuisance; air pollution and climate change. The emphasis is on the identification of economic costs related to these four areas, which a number of studies repeatedly show to be most problematic. The measurement of 'quality of life' has become synonymous with the practical approaches to measuring sustainable development. In this approach, identification of 'sustainability indicators' is rather more to do with the quality of life agenda than evolving a strategic, *cross-sectoral* response to the need for sustainable development.

The campaign to develop sustainable transport policies within a European context poses great challenges to the Community and its members. In the face of growing transport liberalisation the Union has a commitment to its current and prospective members, to provide transport policies which meet the needs of its citizens. Such requirements range from increasing transport safety; protection of the environment and investing in the quality and effectiveness of transport infrastructure by using new and innovative means. The European Commission accepts that it is necessary to act quickly to prevent damage to the environment, as well as to the economies of member states and their citizens. The Commission has also expressed the hope that member countries will adopt its plans for developing a series of integrated transport projects in order to attempt to reduce the growing levels of international traffic. The traditional 'predict and provide' and 'business as usual' approaches to resolving transport grievances can no longer be used as

remedies to the Union's growing transport problems.

The development of European transport policies, commonly referred to as the 'Trans-European Network', is a priority project for the European Commission, avowedly as an attempt to establish social and economic cohesion and sustainable mobility. Before such projects can be developed there is a requirement to reconcile two fundamental objectives; on the one hand mobility, and on the other, the wellbeing of the environment. The TENs programme, based on the complementarity and interoperability of modes of transport, has many roles to fulfil in an ever growing Union. The central objectives of the TENs are:

- to support trade and economic activity;
- prevent further infrastructure inadequacies;
- act to bind Europe together;
- and remove obstacles which prevent further enhancement of the Single European Market.

A key concern will be to eliminate any difficulties in the general implementation of the common market which arise from transport regulations. For example, in having cross border passageways without passport or customs controls.

According to the Commission, the proposed network will

- 'take advantage of synergies and offer passengers and freight operators greater choice. This will stimulate efficiency, improve services, enhance safety and provide an optimal network from an environmental point of view' (Johnson and Turner, 1997, p. 48).

Environmentalists however do not agree with the Commission's sentiments. The proposed series of projects, it is feared, will cause huge disruption to natural environments, split communities, create 'improvements' which will result in greater road usage, thus conflicting with its other priority commitment stressed in the Maastricht Treaty - sustainable mobility. Transport Commissioner Neil Kinnock refuses to accept that the network will be inherently damaging to the environment (June 1995). He has put forward three arguments to defend the projects. First, that a vast majority of the road network has already been constructed and some projects will consist of upgrading low quality existing roads. The majority of new construction will take place in the peripheral and poorer parts of the Community, namely Ireland, Greece, Spain and Portugal. The aim is to bring their road networks up to the same standard as the rest of the EU. Environmentalists would argue the days of basing road developments on the perceived need to accommodate increased mobility are over. Policies should be aimed at

reducing the need to travel by private car and provide incentives to use alternative, environmentally less damaging modes.

Secondly, Kinnock has used the budget allocation as proof of his commitment to re-orienting modal priorities. Of the 90 billion ECU destined to be spent on the first 14 priority projects 80% will go to rail, 9% to road/rail links and 10% to roads. Johnson and Turner dispute this claim, for they argue the criticism concerning the assessment of TENs depends on the number of projects rather than the size of investment. They state:

'68 North-South road links and 60 West-East road links are included in the guidelines compared to only 11 links in total for rail, whereas 80% of the spending on the Christophersen priority projects by 2010 is destined for rail, which accounts for only 6% of passenger and 15% of freight traffic. Roads, the dominant mode, will receive about 20% of the investment' (1997, p. 61).

The essential point therefore is that the varying levels of expenditure reflect the previous priorities which favoured road construction in the majority of cases, in the UK particularly. As such, the higher figures for rail reflect the rather parlous state of many parts of the European railway network and are not due to privileging rail over road.

Finally, Kinnock argues in addition to the existing environmental impact assessment requirements, the Commission is developing a methodology for carrying out a 'Strategic Environmental Assessment' (SEA) of the entire network. The methodology for this SEA will be tested in 1999 when the projects are subject to the five year review. Assessment of individual projects have now been completed. Questions are raised as to how sustainable the network actually is, bearing in mind the SEA of the entire network was conducted after the programme was completed and the plans were in place. In addition, Johnson and Turner have expressed concern about the validity of the methodology used in conducting the SEA in the first place (1997, p. 90).

The Commission has also developed plans to assist economic regeneration projects. In turn such developments automatically lead to increased traffic levels if they are not subjected to careful and progressive planning. Prevention of rising traffic levels requires adopting new and innovative approaches to transport policies, such as investing in transport telematics; eliminating barriers to administration and cross-border traffic flows; improvements in multi-modal links and investing in the quality and attractiveness of public transport. (Kinnock, 1997)

Commitments to sustainable development declared in the Maastricht Treaty and the Fifth Environmental Action Programme (5EAP) cannot be maintained with the current TENs policy. The priority projects favour long distance mobility, gained at the expense of shorter distance transport. As previously mentioned, the TENs will result not only in adverse social effects, but also has major implications for the environment by damaging the landscape, fuelling the growth in demand for transport and contributing to the growth in greenhouse gases. Whitelegg has estimated that there will be 'an increase in carbon dioxide emissions of 15-18% above the existing forecast, which threatens to undermine attempts to meet greenhouse gas reduction targets' (Whitelegg, 1995). Even a fairly basic appreciation of the notion of sustainable development would surely involve a commitment to reducing the need to travel.

The reason for the TENs programme and the retreat from Maastricht, Rio and 5EAP is not difficult to identify. No matter how hard the EU tries to create 'environmentally friendly' policies, it still retains economic prosperity as its major objective. As Johnson and Turner argue, the 'accelerated establishment' of the TENs programme is part of a wider strategy to enhance Europe's economic competitiveness. (1997, 14). Job creation and a competitive economy are therefore seen as a necessary requirement for the long term advantage of the Community. The objectives of sustainable development rather than being a part of this strategic overview, appear to be an afterthought.

The primacy of economic considerations over environmental concerns is illustrated by Neil Kinnock's opening speech for the European Commission Conference on Fair and Efficient Road Pricing. Kinnock cited the UK Royal Commission on Environmental Pollution report and its recommendation for an increase in fuel duties as an incentive to limit distances travelled in private cars. He stated that the report advocated these fuel cost increases to be phased in across the EU. However, the report recommended that this measure should be used in conjunction with other policies, such as public/private partnership investments in public transport. Kinnock's justification for not encouraging the widespread use of increased fuel duties across the EU was purely financial: 'apart from the fact that such a proposal would get no support from the Council of Economic and Finance Ministers, an incentive which relied on fuel price rises would simply increase costs without offering any certainty of durable improvement or real reduction in most of the significant and costly problems of transport' (CEC, 1997). This emphasis on lower costs is directly

contrary to EU environmental policy based on the Polluter-Pays Principle and its commitment to internalise the external cost of transport. The failure to appreciate the necessity for finding alternatives and compensating for losses as far as practicable is not really considered by Kinnock. The increased costs in duties would potentially be available at least as a contribution to improving parts of the public and commercial transport infrastructure in line with the principle of sustainable mobility.

Denial of the use of taxation is inconsistent with the Directorate-General XI views on environmental approximation. DGXI is in favour of using environmental taxes and charges as supplementary policy instruments so long as they do not interfere with EU principles concerning competition and the internal market. Economic incentives could encourage pollution producers to look for alternative, cleaner methods of mobility. Economic instruments have the double advantage in that they help deliver both a cleaner environment and a stronger economy.

The European Federation for Transport and Environment (T&E) believe the EU's transport policy is heading in the right direction, even if the TENs plans leave a lot to be desired. The EU has a firm commitment to stabilise CO₂ emissions, but fails to reach this target mainly due to traffic growth. The Commission believe this is not a long term problem as there are a number of ongoing research and development programmes investigating new technology which will be geared towards users' demands and respect for the environment. The 'Auto-Oil' programme is one such example, the Commission is investigating economically efficient measures including vehicle technology, fuel quality, enhanced inspection and maintenance to reduce vehicle emissions throughout the Union. Significant differences exist between member states with regards to air quality and socioeconomic conditions. The strategic nature of the problems require that a number of different instruments need to be implemented simultaneously if policy is to be effective. Solutions cannot be applied without the full co-operation of national as well as regional and local authorities. The complexity of problems arising from the principle of subsidiarity in strategic implementation of all aspects of sustainable transport are themselves worthy of discussion, but cannot be assessed here.

The idea of 'sustainable mobility'
Finding a formula that works in transport is a concern for those involved in all aspects of the move to a more sustainable society. The issues

relating to land use, planning, urban design and social equity are fundamentally important. Success in any one sector can all too easily be undone by a failure to co-ordinate practice or share principles with those working in other areas.

Disentangling the various reasons for travel and the priorities these might have in a sustainable transport policy is itself problematic. Concentrating on modes that are responsible for the greatest amount of damage or loss in terms of externalities is one method of approaching this. According to Maddison *et al.* 92% of transportation's external costs come from road transport. Of this figure, 60% is due to cars and approximately 20% from freight. Priorities can thus be set reactively in regard to this figure by addressing those modes which generate the greatest external cost.

In the debate over sustainable transport, the need for agenda setting which reflects social as well as environmental priorities is evident. An emphasis on 'mobility' contains more than the traditional transport agenda. Implicit is a recognition of the issue of 'travel for need' based on the notion of access and social inclusion. If there is to be a more sustainable set of practices advocated which is progressive in both social and environmental terms it must surely lie in this direction. Decreasing travel by unacceptable modes, whilst attempting to reduce the structural causes of much travel, can be consistently applied with this emphasis on equity of access.

'Sustainable mobility' can thus be defined in such a way that it encompasses a hierarchy of travel of favoured modes and favoured purposes, privileging in both cases the more environmentally benign (whilst being cognizant that this is a matter of degree) and the socially inclusive. The consequences of development of out of town shopping demonstrate that a failure to consider issues of access and inclusion have other structural disadvantages such as desertion of town centres by customers and ultimately traders.

Skinner (1997) has utilised Maslow's 'Hierarchy of Needs' to illustrate how mobility ties in to the consideration of human choices and quality of life. The challenge of a coherent notion of sustainable mobility is undeniably complex. To have an operational notion of welfare needs is a precondition of establishing distinct quality of life goals. These require scrutiny in turn with regard to the broader issues presented by sustainable development. Doyal and Gough (1991) refer to the intergenerational dimension in any assessment of 'needs' and their attempt to categorise needs shows clearly that the temporal dimension, whilst problematic is unavoidable. In examining differing accounts of needs (see for example Doyal and Gough, p. 220) it is clear that mobility is a facilitator of needs, not a need in itself. It may involve facilitation of other needs such as social contact (or indeed inclusion) and access to facilities e.g. hospitals and schools. That these are currently provided to a large extent on the basis of extensive individual travel hardly needs pointing out. It is also clear that this is by no means an inevitability, but that the only solutions are both strategic and long term in nature.

Conclusion

Less transport-intensive economic development will not only give us a better environment, it can also give us greater economic efficiency and better communities, creating more jobs and (potentially) spreading wealth more fairly. The challenge of sustainable development can only be met by a strategic approach which crosses policy sectors and is inter-disciplinary in nature. Economic and environmental objectives must be integrated as far as possible if the strategic imperatives of one sector are not to result in the neglect of the other. As long as economic issues are dealt with strategically and environmental ones reactively the outlook for sustainable development in Europe is bleak.

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The Comparative Pollution Exposure of Road Users - A Summary

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*This paper is a summary of Road user exposure to air pollution published by the Environmental Transport Association on behalf of the Department of the Environment, Transport and the Regions. Environmental Transport Association
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Abstract

Levels of vehicle-derived pollutants found inside and immediately outside motor vehicles are a cause of concern. It is now generally recognised that car drivers, in particular during rush hour, are travelling through a 'tunnel of pollutants' and are exposed to significantly higher levels of pollution than background readings would suggest.

Keywords

Air pollution, Exhaust gases, Health impacts, Literature review

Introduction

In response to the London smog of 1952, when over 4,000 additional deaths occurred in a matter of days, the air quality in Britain's major cities was dramatically improved through legislative action and a switch from coal to town gas as a source of fuel. In more recent years however, developing scientific knowledge has drawn attention to the human health impacts of other, less discernible, forms of air pollution. Many of the most important problems result from vehicle exhaust emissions, especially in urban areas, and have become more pressing as traffic levels have steadily risen. Major efforts are now being made to monitor and evaluate this pollution, and to cut emissions.

Most studies of air pollution from vehicle traffic have concentrated on urban background air quality and its effects on people outside vehicles. Equally, 'ambient' levels are often equated with values measured at background monitoring sites, intentionally positioned at some distance from major roads. However, experimental evidence suggests that road users (including pedestrians, cyclists, drivers and passengers in all kinds of vehicle) are exposed to higher levels of air pollution than the background data might suggest. Furthermore, the evidence indicates marked differences in the exposure levels of travellers by different modes.

Scope and Definitions

Pollutants Covered

The main pollutants examined are volatile organic compounds (VOCs, including benzene and other hydrocarbons), carbon monoxide (CO), nitrogen dioxide (NO₂) and respirable particulates (PM₁₀). Of these, benzene and CO are primary by-products of the combustion of petrol, and particulates from diesel combustion. NO₂ is mainly a secondary pollutant, formed when nitric oxide (NO), another primary by-product of the internal combustion engine, is oxidised in air.

Evidence on pollution from particulates, various oxides of nitrogen (NO_x), VOCs and CO is extensive and these are amongst the pollutants addressed in the *UK National Air Quality Strategy*.

Some other pollutants such as ozone and 1,3-butadiene are excluded, either because there is little relevant information, or because they are of lesser relevance to the subject of the review. Tropospheric ozone is not covered because, although it is an important secondary pollutant formed by complex chemical reactions in the atmosphere, concentrations are not particularly elevated in the presence of traffic-generated pollution. Indeed, ozone levels can be reduced by the presence of other pollutants, so one would not expect to find the highest concentrations of ozone in or near vehicles. 1,3-butadiene is not included owing to a shortage of specific data on this chemical. However, findings on other VOCs may well be of relevance to 1,3-butadiene.

Primary and Secondary Pollutants

Primary pollutants, such as CO and VOCs, are emitted directly from vehicle engines or exhaust systems. As such, they are likely to be at their highest concentrations in or near traffic, with levels falling off rapidly as one moves away from the source of pollution owing to dispersal into the surrounding air. Secondary pollutants are those which are created from primary pollutants through chemical reactions in the air. NO₂ is the most important secondary pollutant considered in this study. As the chemical reactions which generate secondary pollutants can take some time to occur, some

dispersion of the pollutants is also likely to take place while they are being formed. As a result, secondary pollutants may not be so heavily concentrated around emission sources as are primary pollutants, and clear patterns of pollution may be more difficult to detect.

Factors Influencing Pollution Levels experienced by Road Users
Patterns of pollution vary greatly from city to city, and also over time. These can make monitoring results difficult to assess, and limit the applicability of information from one source to other times and places. A wide range of factors will influence the level of pollution experienced, including the following:

Vehicle technology, vehicle mix and condition
Various characteristics of the vehicles which make up traffic influence emission rates and, therefore, the characteristics of local air pollution. The combustion and emissions technology of new vehicles in the developed world has progressed rapidly during the last twenty years. The most significant step for cars has been the introduction of 3-way catalytic converters which can reduce emissions of most pollutants greatly. The penetration of such vehicles and the overall mix of vehicle technology within the fleet varies from country to country. Clearly, the make-up of vehicle technologies will have a bearing upon the overall levels of various pollutants in and around the roadway. Similarly, the overall traffic mix in terms of cars/trucks/buses/motorcycles can be characteristic of particular parts of the world or even specific cities and this too will tend to dictate the nature of local air pollution, especially where it affects the petrol/diesel split or the balance of heavy and light duty vehicles. The condition and level of maintenance of the vehicles making up the

traffic will also influence the emission rates and ultimately the levels of pollution.

Fuel quality
Just as vehicle characteristics influence emission rates, the standard of fuel used in those vehicles also impacts upon emission rates. The simplest demonstration of the importance of fuel is found in the direct relationship between the amount of leaded fuel used and the levels of lead pollution in the air. Other fuel characteristics which influence emission rates include benzene concentrations in petrol and sulphur levels in diesel. Beyond these single components, there are some more complex relationships between aspects of fuel quality and emission rates of various pollutants. Some European countries and states in the USA have introduced reformulated petrol and diesel fuels which can reduce emissions of some pollutants by up to 20%.

Traffic and the effects of preceding vehicles
For many pollutants, there is a clear link between traffic levels and the concentration of pollution in the roadway air. There are two components to this relationship: firstly, each extra car on a given stretch of road contributes to exhaust emissions. Secondly, as levels build up, traffic speed tends to decline. This in turn tends to increase the emission rate of some pollutants: stop-start traffic is perhaps the most polluting. In general, air quality can be considered likely to worsen as traffic levels increase and congestion develops.

A separate but related issue is the influence of vehicles in the immediate vicinity of road users' exposure. Recent research seems to indicate that the level of pollutants inside cars may depend in particular upon the emission rates of the vehicle immediately in front of the vehicle being monitored. This phenomenon has implications for the peak concentrations which may be reached when travelling behind highly polluting vehicles and, to some extent, the transferability of results.

Dispersion of Pollutants Across the Roadway
Research carried out in street canyons shows the importance of position on the roadway: the concentration of pollutants from vehicles tends to fall as one moves from the centre of the roadway to the pavement. Figure 1 shows this relationship for three pollutants, derived from research in Frankfurt roadways. The gradient is greatest for the primary pollutants, CO and NO, while secondary pollutants such as NO₂ show less difference between roadway and kerbside concentrations. A similar relationship can be established for vertical distance above the road -

Figure 1: Comparison of differences in CO, NO AND NO₂ concentrations on the sidewalk and inside the car (Rudolf, 1994)

concentrations of primary pollutants tend to fall away quite rapidly with increased height while NO₂ levels show a slower fall and ozone concentrations actually increase with height due to the reaction with NO in the lower parts of the street.

In general, those road users in the centre of the roadway are likely to be travelling through a tunnel of the most polluted air and this is the principal reason for their raised relative exposures to pollutants.

Weather: temperature, wind and rain

The weather can influence air quality in numerous ways. In general, high winds and rain tend to clear pollution from the air. Direct sunshine tends to exacerbate pollution problems by enabling reactions involving primary pollutants that contribute to the formation of secondary pollutants and smog. The importance of temperature is more difficult to define simply - both high and low temperatures can be associated with poor air quality. Higher temperatures increase evaporative emissions of VOCs. Lower temperatures increase cold-start emissions (emissions occurring in the first few miles of driving, before the engine and any emissions equipment have warmed up enough to operate efficiently). The most dramatic influence of weather conditions upon air quality is when a temperature inversion occurs over a city (warm, still, polluted air is trapped by a layer of colder air above) and such incidents tend to be responsible for the most elevated levels of pollution in many cities.

Ventilation of Vehicles

The state of ventilation of a vehicle is likely to affect the level of pollution inside. Fans and heaters often raise levels (in particular, of VOCs) by drawing in air heavily laden with pollutants, while air conditioning may reduce levels of certain pollutants, presumably by condensing out the compounds from the intake air. It also appears that air filters offer only limited protection from particulates, especially the smaller sub-micron (PM_{1.0}) particles, and that ventilation increases particulate levels.

Duration of Exposure

To fully assess the health significance of the pollutant concentrations experienced by road users, account has to be taken of the duration of the individual's exposure in different locations. In general, for members of the public, exposure will range from a few minutes to a few hours on any one occasion. For commuters, and other daily road users, this enhanced exposure will typically be repeated twice daily for most of the

days in a year. This may well be an important element in total pollutant exposure, but a full consideration of this matter is beyond the scope of the present review.

A further factor to be taken into account is the different timescales of significance for the different pollutants. Thus for NO₂, effects are related to short durations of exposure, typically one hour, and the higher concentrations experienced by road users will therefore be of direct relevance. For carcinogens, such as benzene and 1,3-butadiene, it is the longer-term exposure that matters, hence the air quality standards are expressed as annual means. In this case, the short periods of exposure to higher concentrations experienced by road users will not be of direct relevance, but will only be significant in so far as they increase long-term exposure. For PM₁₀ the time period considered to be of significance is 24 hours, and this will also diminish the importance of the short periods of high concentrations experienced by road users.

Monitoring Points

A number of different practical approaches to monitoring concentrations and exposures are employed in various studies. Clearly, monitoring the level of pollution as close as possible to an individual is likely to give the best indication of their exposure to pollution at that particular point in time. This however, is only a 'snapshot' and may not give a reliable indication of their worst (peak) exposure or their average exposure over time. It will also not be a reliable guide to their exposure in a range of different circumstances, or to the levels of pollution affecting the population at large. For these and other reasons, a range of measures are used in monitoring pollution levels in order to assess possible effects on human health.

Typically, 'background' levels of pollution have been assessed by monitoring equipment at a distance of 50 to 100 metres from the roadside. Many authors also recorded the levels of pollution within vehicles. For cars and other small vehicles, it can generally be assumed that the exposure levels of drivers and passengers will be similar. This may not be the case for larger (mainly public transport) vehicles.

A general point should be made about monitoring technology: the performance of portable monitors is not always good, and some caution should be exercised when comparing concentrations from portable and fixed site monitors which employ different methods.

Transferability and Robustness of Results

The study drew on analysis conducted by scientists in many parts of the world, and in a

wide range of situations. As such, some of it is of obvious relevance to the UK or European urban environment, and some less so. In general, this can be determined through some comparison of the factors listed above that influence in-vehicle concentrations of pollutants. Equally, some studies are based on a large number of measurements and a high quality of sampling and analysis, while others appear less reliable for various reasons. There has in general been a marked improvement in the quality and reliability of results obtained in recent years, compared for example to those reported in Jefferiss *et al.* (1992).

Miscellaneous Findings

A study by Rudolf (1990), of motorway driving around Frankfurt in the summer of 1989 found that levels of in-vehicle pollution in passenger cars was 10% - 40% higher than that of trucks. This in general supports similar findings from buses, suggesting that larger vehicles, somewhat more removed from the level of most exhaust pipes, experience lower levels of pollution than do cars.

Rudolf also noted that pollution concentrations fell rapidly away from roads. Findings from most other studies, and for most pollutants, strongly support this interpretation.

Beyond this general tunnel of high pollutant concentration, a number of studies point to the direct effects of individual vehicles on the level of exposure. For car drivers their own car can be an important source of pollution, especially if the technology is faulty or less advanced, while in slow-moving traffic, the vehicle in front can be a major source. Similarly, and to perhaps a greater extent, a nearby vehicle can strongly affect the pollution exposure of cyclists and pedestrians.

Other transport-related microenvironments can also have distinctive pollution characteristics. Open-air car parks generally have relatively low levels of pollution, comparable to background levels, as the number of vehicle movements is typically quite low. However, enclosed car parks appear to retain the pollution caused by vehicles, and high levels of pollution have been recorded. Vehicle filling stations also expose drivers to high levels of VOC emissions.

Health Impacts

There are a number of health-related studies which have used epidemiological techniques to detect health effects in certain occupational groups. Results suggest that elevated levels of exposure to air pollution may have contributed

to some health effects.

For example, Raaschou-Nielsen *et al.* (1995) found not only that street cleaners in Copenhagen were exposed to higher levels of pollution than cemetery workers, but that there were clear differences in health as a result. Chronic bronchitis in the study sample was associated as much with pollution levels as with smoking, and asthma was linked to job type but not affected by individuals' level of smoking. Reports of coughs, phlegm and irritation of the mucous membranes were also more common amongst street cleaners than in cemetery workers.

Forastiere *et al.* (1994) studied the incidence of cardiovascular disease and cancers amongst urban police in Rome. They found that the likelihood of bladder cancer was significantly increased amongst car drivers, and motorcyclists showed increased risks of non-Hodgkin's lymphoma. They concluded that vehicle exhausts and (for motorcyclists) inhaling fumes from fuel tanks were key factors in explaining their results.

Conclusions

The studies reviewed indicate that cars in particular offer little or no protection against the pollutants generated by vehicle traffic. Indeed, by virtue of their position in the road, road users can be exposed to significantly elevated levels of pollutants when driving and they are, in effect, driving in a 'tunnel of pollutants'. In short, more recent studies have served to confirm the general conclusions set out in Jefferiss *et al.*

Studies from Britain, continental Europe and the United States agree that in-vehicle levels of the vehicle-derived pollutants benzene (and other hydrocarbons), carbon monoxide, and nitrogen dioxide are substantially elevated above the levels of these pollutants found in air at a distance of around 50-100 metres from the vehicle, whereas levels of non-vehicle derived pollutants vary far less. Although commuting journeys may take up an hour or two of the day, car commuters may receive more than 20% of their total exposure to some pollutants from these journeys. Typical indicative values for average concentrations relative to background levels are shown in Table 1.

Most of the studies indicate that drivers and passengers in motor vehicles are exposed to higher levels of these pollutants than pedestrians and cyclists. Larger public transport vehicles appear to exhibit lower pollutant levels for primary pollutants than do cars. Cyclists are subject to higher personal exposure because of their elevated respiration rates, but nonetheless

Table 1: Typical Ratios of Average Concentrations to Background Levels by Mode

Pollutant	Pedestrians/Cyclists	Bus Users	Car Users
VOCs	2	3-4	4-6
Carbon monoxide	2-2.5	3-4	4-5
Nitrogen dioxide	1.5-2	2	3
Particulates	some elevation - figures uncertain		

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appear to suffer similar or lower exposures than motorists owing to their usually travelling close to the kerbside. Contrary to popular belief, pedestrians generally experience the lowest exposures of any road users. Table 1 also demonstrates that the issue of road-user exposure to particulate pollution is one worthy of further research efforts, especially given the general and growing concerns over the health effects of this pollutant.

Some time series data from Europe have failed to detect any marked improvement in levels of in-vehicle pollution in spite of the introduction of catalytic converters, while others do indicate a downward trend, especially for VOCs. Some data from the US, where the majority of vehicles now use catalytic converters, do suggest some improvement. It may as yet be too early to draw firm conclusions as to the likely impact of catalytic converters in Europe, but it is possible that catalysts alone are not sufficient to solve the problems identified, and this matter should be kept under review.

It should also be noted that the ratios set out in Table 1 seem likely to persist even if background pollution levels fall, especially for the primary pollutants. This conclusion is supported by the fact that similar ratios are found in various parts of the world, in spite of differing absolute levels of pollution and variations in traffic levels and conditions, fleet composition and mix of technologies.

Not surprisingly, the factors exacerbating the interior levels of VOCs and CO in cars seem to be dense, slow-moving traffic, stable air, vehicle age, and a faulty exhaust system. The in-vehicle levels of NO_x, on the other hand, seem to be

worse during motorway driving, and levels of NO₂ in particular seem to rise later in the day. Interestingly, in most studies the level of ventilation did not significantly alter interior concentrations, although conditions tended to be worse with the heater or ventilation on and sometimes better (for VOCs) with air conditioning in use.

Clearly, the levels reported by background, fixed-site monitoring and road-user concentrations do not correspond closely to one another. There appears to be a strong argument for increasing the number of monitors in kerbside positions, on central reservations and at road junctions, so as to establish more accurately the exposure of road user groups.

Given the apparent dependency of peak concentrations in road users' microenvironments upon emissions from individual vehicles in the immediate vicinity, governments should consider to what extent advanced inspection and maintenance procedures could help to reduce short-term exposures of road users.

In the *UK National Air Quality Strategy* it is stated that 'the Government considers that the objectives should apply in non-occupational near-ground level outdoor locations where a person might reasonably be expected to be exposed over the relevant averaging period'. It is clear from this report that measurements from background monitoring are likely to underestimate the exposures of road users significantly.

Beyond the exposure of the general public, the findings may also have implications for guidelines on occupational exposures. Traffic wardens along with drivers of taxis, buses and delivery vehicles are all likely to be subject to raised concentrations of vehicle-derived pollutants for much of their working day. Some European studies reviewed suggest that occupational exposure limits for these groups may be exceeded and this area also should be re-examined.

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In total 77 papers were reviewed in Road user exposure to air pollution. This included 45 new papers and some previously analysed in Jefferiss et al. (1992).

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Mortality from vehicular particulate emissions in Tel-Aviv-Jafo

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We wish to acknowledge the assistance of Dr. Leonid Tartakovski (Technion University, Haifa) and Mr Joe Basis (Tel Aviv Municipality) regarding Israeli vehicular emission factors. In addition, thanks to Mr. Moshe Tenne (Ministry of Infrastructure) for modelling advice.

Abstract

The present level of emissions due to motor vehicles in Israel's second largest city, based on kilometres travelled by vehicle and fuel type, was estimated. By applying co-efficients relating changes in mortality levels with changes in ambient PM₁₀ levels, it is estimated that tailpipe emissions annually cause around 293 premature deaths, primarily among the elderly. This annual toll is in excess of the combined total of deaths whose primary underlying causes were falls, homicides, infectious diseases, suicides, traffic and non-traffic accidents.

Keywords

Air pollution, Deaths, Tel-Aviv-Jafo

Introduction

Israel has one of the highest densities of motor vehicles per square kilometre in the world causing ever-increasing problems of traffic congestion (Fletcher, 1998). There are around 550 motor vehicle accident fatalities a year in a population of only 5.8 million (CBS, 1996). In contrast to the huge publicity given to these road fatalities, little or no attention has been given to fatalities caused in a more indirect manner as a result of motor vehicles emissions.

This paper aims to quantify the present level of mortality and morbidity as a result of motor vehicle emissions in Israel's second largest city, Tel-Aviv-Jafo, which has a population 353,100.

Methods

Tailpipe Emissions

Data as to the number of vehicles by type (car, taxis, vans less than four tonnes, motorcycles, buses and trucks) and fuel used (petrol or diesel) were collected for the city of Tel-Aviv-Jafo. Data on the annual average number of kilometres by vehicle type travelled within the city was also obtained (CBS, 1996), enabling a calculation of total vehicle kilometres by

vehicle type and fuel used.

Next, in conjunction with the Technion University, Haifa, we collected data on urban cycle emission factors (g/km) by type of emission (NO_x, CO, etc.) for cars by year of manufacture and the presence of a catalytic converter (Tartakovsky *et al.*, 1997). SPM (suspended particulate matter) emissions estimates were obtained from fleet-weighted data from Holland (Ministry of Housing, Spatial Planning and the Environment, 1997) for petrol driven cars adjusted to Israeli fuel consumption and emissions data (0.026 g/km). Emissions from petrol-fuelled taxis, since the average age of taxis is around two years old, were assumed to be the same as cars with catalytic converters (0.020 g/km) based on English fleet data (UK Emission Factors Internet Database).

Emissions from diesel taxis were based on Dutch data for diesel cars adjusted to Israeli fuel consumption and usage data, with a level of 0.259 g/km for SPM. Similar adjustments gave diesel fuelled van, bus and truck SPM emissions of 0.288, 1.795 and 1.133 g/km. Motorcycle SPM emissions of 0.09 g/km were also based on UK data applied to the engine size and stroke parity characteristics of the Israeli motorcycle fleet (CBS, 1997a).

Data on total annual kilometrage by vehicle type was multiplied by the emission factor co-efficients in order to arrive at the total annual tailpipe emissions by type of vehicle. Data on SPM was converted to PM₁₀ (particulates < 10 µm) on the basis that PM_{10s} constitute approximately 99.4% and 96% of SPM from petrol and diesel motor vehicle emissions respectively (Small and Kazimi, 1995).

Refinery Emissions

Petrol refinery emissions based on Israeli data of 0.10 g per urban kilometre travelled for petrol fuelled cars and taxis (A. Kotler, Israel Electricity Corporation; personal communication) were used. An identical value of 0.10 g/km was used for refinery emissions for diesel-fuelled cars and taxis, since diesel and petrol fuel refinery emissions per kilometre are similar (Lewis and Gover, 1996). Diesel refinery

emissions of 0.29 g/km for buses and trucks were based on USA data (Kitchen and Damico, 1992) adjusted to Israeli refinery conditions. Motorcycle fuel refinery emissions of 0.009 g/km were based on the relative fuel consumption of motorcycles compared to cars.

Again total tonnes emitted at the refinery was calculated by multiplying kilometrage by emissions per kilometre. Since the refineries are based near coastal ports, we assumed that only 50% of their emissions would actually fall on Israel, the remainder falling into the Mediterranean sea. Based on nationwide data from the USA, we expect that 50.95% of SPM emitted from the fuel refineries were PM_{10s} (US-EPA, 1995).

Data from the Environmental Ministry's newly established air monitoring stations found the average ambient air level of PM_{10s} from three monitoring stations in Tel-Aviv-Jafo to be 56.8 µg/m³ in 1996 (Aaron Serry, Department of Environment; personal communication). The largest single source of these PM_{10s} (48.2%) is emissions from the Reading power station situated on the North-west seafront of the municipality, based on assumption that 40% of the 1377 annual tonnes of PM₁₀ emitted actually fall within the municipal boundaries (Dr. Ilan Setter, National Meteorological Centre, Beit Dagan; personal communication). Around 412.7 tonnes or 36.1% of the PM_{10s} (i.e. 20.51 µg/m³) are generated by motor vehicles, 14.4% coming from natural sources such as sand (Environmental Monitoring Unit, Tel-Aviv; personal communication) and 1.3% from industry and home heating. For each tonne of PM₁₀ emissions from vehicles, ambient PM₁₀ air levels will rise by 0.0497 µg/m³ (20.51/412.7 total tonnes of PM₁₀ emitted from motor vehicles).

Health Effects of Emissions

A 1.0 µg/m³ increase in ambient air levels of PM₁₀ will increase all cause non-accidental mortality in persons aged over 30 by around 0.381% (Pope *et al.*, 1995). There were 4048 non-accidental deaths in Tel-Aviv-Jafo among the over 30 population in 1997 (Tel-Aviv-Jafo Municipality, 1996). If there were no vehicular emissions, ambient air levels of PM_{10s} would be 20.52 µg/m³ lower and the number of deaths would be only 3755 (i.e. 4048/[1+20.52 * 0.381%]). Therefore each tonne of PM₁₀ emitted from vehicles contributes 0.711 deaths (i.e. [4048-3755]/412.7 tonnes). By multiplying this co-efficient of 0.711 deaths/tonne by the number of tonnes emitted by type of vehicle we arrive at the number of excess deaths attributable to PM_{10s} by type of vehicle.

We estimated that there would be an increase of 0.51% in the number of chronic bronchitis (including emphysema) cases annually per 1 µg/m³ increase in ambient PM₁₀ levels (Abbey *et al.*, 1993). One tonne of PM₁₀ is estimated to cause 0.58 extra cases of chronic bronchitis annually in the Tel-Aviv-Jafo municipality.

Increases in hospital use was based on co-efficients of 0.34% increase in all-age respiratory admissions excluding those for chronic bronchitis and emphysema, 0.21% increase in cerebrovascular admissions in persons over 65, 0.001% increase in Congestive Heart Failure and Ischaemic Heart Disease admissions in persons over 65 respectively per 1 µg/m³ increase in ambient PM₁₀ levels (Wordley *et al.*, 1997; Thurston *et al.*, 1994; Schwartz and Morris 1995). Baseline data was calculated from diagnosis specific hospital admissions (CBS, 1997b) adjusted by department specific lengths of hospital stays in the Tel-Aviv-Jafo municipality. Increases in emergency room visits are negligible and so were omitted from our calculations (WHO, 1996).

For every 1 µg/m³ increase in ambient levels of PM_{10s} we assumed a 0.0029% increase in lost work days, over and above a baseline of 1.51 days/person year (Ostro, 1987).

Life expectancy at the average age of a tailpipe death of 72.8 years (Pope *et al.*, 1995) is around 84.9 years (CBS, 1996) meaning that there were on average 12.1 potential years of life lost for each tailpipe death. These mortality effects of lost life years were valued using a 5% discount rate, according to the willingness to pay method of valuing human life, which assigned a value of \$222,450 per life year lost based on adjusting US data (Moore and Viscusi, 1988) to estimated Israeli GNP levels of \$16,857 per head in 1997 (CBS, 1996). Chronic bronchitis cases were similarly valued at \$197,396 per case (US-EPA, 1997). Each hospital day was valued at \$387 (Ministry Of Health, 1997) and each lost work day at \$97 per day (CBS, 1996).

Health effects of PM₁₀ emitted from refineries were similarly estimated based on a (population weighted) national ambient PM₁₀ level of 38.3 µg/m³, produced by 37,923 tonnes of PM₁₀. Based on 32,720 non-accidental deaths annually in the over 30 population (CBS, 1998), we estimate that each tonne of PM₁₀ emitted from refineries causes 0.126 deaths nationwide.

Results

Around 416,000 motor cars each travel an average of 6238 kilometres annually in the city, resulting in an annual total of 2595 million

kilometres or 83.8% of all vehicle kilometres travelled in the city. The 1100 buses of the Dan bus company, while representing less than 0.2% of all vehicles actually contribute to 2.8% of the total kilometrage since each bus travels an average of around 78,000 kilometres annually in the city. As a result of their high per kilometre emission rates, diesel buses account for nearly half of the 293 fatalities attributable to vehicular tailpipe emissions (see Table 1). Trucks, cars and diesel vans cause the majority of the remaining deaths. At present in Tel-Aviv-Jafo we estimate that cars account for 8.3 of the 10.2 annual deaths from refinery emissions.

In addition to the 303 expected deaths from tailpipe and refinery emissions, a further 134

new cases of chronic bronchitis will be induced annually. Together these account for 99.6% of the \$661 million costs of emissions to society caused by vehicles in Tel-Aviv-Jafo (Table 2). External health emission costs per kilometre travelled range from \$0.04 and \$0.05 for petrol fuelled taxis and cars respectively to \$1.77 and \$2.79 respectively for diesel trucks and buses (Table 3).

Discussion

Deaths from tailpipe emissions account for approximately 15.7% of mortality primarily caused by cardio-circulatory-pulmonary diseases in Tel-Aviv-Jafo. The estimated 293 annual deaths from tailpipe emissions exceed, by a tenfold factor, the annual average of 29 traffic accident fatalities in Tel-Aviv-Jafo over the past decade. The magnitude of the public health menace is also evidenced in that tailpipe emission mortality also exceeds the combined total of deaths in Tel-Aviv-Jafo whose primary underlying cause was falls, non-vehicle accidents and homicides (125 per year), infectious diseases (92 per year), suicides (43 per year) and motor vehicle fatalities (29 per year) (Tel-Aviv-Jafo Municipality, 1996). Mortality costs from tailpipe emissions amount to around \$610 million in addition to \$25 million morbidity costs, mainly from new cases of chronic bronchitis.

The costs induced by tailpipe emissions alone represent around 10.7% of Tel-Aviv-Jafo's contribution to Gross National Product. Most of these costs will never be realised but just represent the valuations that people theoretically are willing to pay to avoid death. Using a human capital method of valuing human life according to lost productivity will considerably lower the magnitude of costs, although this method is considered by welfare economists to be theoretically unsound.

As a result of car fuel usage in Tel-Aviv-Jafo, a further ten persons (mainly living elsewhere in Israel) are estimated to die annually from refinery generated emissions. Mortality costs from refinery emissions amount to around \$21 million in addition to \$3.5 million morbidity costs.

Our non-accidental mortality co-efficient of 0.381%/µg rise in ambient PM₁₀ levels was derived from a seven year prospective study of 151 metropolitan areas in the USA with over 550,000 adults. The study measured both acute and chronic effects of PM₁₀ emissions (Pope *et al.*, 1995) independent of the potential confounders of tobacco smoking and socio-economic status. This study has been used as the benchmark 'gold-standard' by both the

Table 1: Mortality from tailpipe and refinery emissions¹

Emission source	Number of vehicles	Estimated annual mileage (km)	Average tailpipe emissions of PM ₁₀ (g/km)	Annual emissions of PM ₁₀ (kg)	Annual deaths from tailpipe emissions	Annual deaths from refinery emissions	Total deaths
Diesel Bus ²	8083	110	205.6	1.795	1.1	140.3	141.4
Petrol Car	416,016	2595	67.5	0.026	8.3	47.7	56.0
Diesel Trucks	6000	64	75.7	1.133	0.6	51.6	52.2
Diesel Vans	9261	103	30.9	0.288	0.0	21.1	21.1
Diesel Taxi	1740	156	42.2	0.259	0.1	28.8	28.9
Motorcycles	15,529	59	5.3	0.089	0.1	3.7	3.8
Petrol Taxi	85	8	0.2	0.020	0.0	0.1	0.1
Total	456,714	3095	427	0.138³	10.2	293.3	303.5

Notes

- The numbers in the table have not been adjusted to account for rounding errors.
- 8083 inter-city diesel buses stop in Tel-Aviv-Jafo, 1100 operate exclusively within the municipality.
- Average tailpipe emissions of PM₁₀ for all vehicles is 0.138g/km

Table 2: Annual mortality and morbidity costs from refinery and tailpipe vehicle emissions in Tel-Aviv-Jafo (1997)

Emission source	Refinery Persons	Tailpipe Persons	Refinery \$ Million	Tailpipe \$ Million
Deaths	10	293	\$21.1	\$610.6
Chronic Bronchitis	17	117	\$3.4	\$23.2
Hospital Days	60	1649	\$0.0	\$0.6
Lost workdays	1286	19490	\$0.1	\$1.9
Total	1373	21549	\$24.7	\$636.3

Table 3: External costs (\$ per km) by vehicle type

Emission source	Refinery	Tailpipe	Total
Diesel Bus	0.023	2.768	2.791
Petrol Car	0.008	0.040	0.048
Trucks Total	0.023	1.747	1.770
Diesel Vans	0.001	0.444	0.445
Diesel Taxi	0.001	0.400	0.401
Motorcycles	0.004	0.138	0.142
Petrol Taxi	0.008	0.031	0.039
Total			\$5.636

World Health Organisation (WHO, 1996) and the Environmental Protection Agency in the USA (US-EPA, 1997). The above estimate can be considered conservative in that the only other study which captured both acute and chronic effects (Dockery *et al.*, 1993) reported a 0.784% rise in non-accidental mortality per 1 µg rise in ambient PM₁₀ levels in a sample based on fewer locations than Pope's study. In addition the estimate is downward biased since inter-city migration, which would tend to homogenise exposures of cohort members, was not considered by Dockery *et al.*

Many short-term exposure studies based on time series have reported on statistically significant relationships between PM₁₀ and mortality, reporting co-efficients in the range of 0.03% - 0.17%/µg rise in ambient PM₁₀ levels. (Wordley *et al.*, 1997; Ito and Thurston, 1996; Katsouyanni *et al.* 1997; Faiz *et al.*, 1996). Taking the mid-point of 0.105%/µg means that around 81 (of the 293) deaths can be attributed to short-term effects of exposure to ambient PM₁₀ levels. It is important to note that the studies found linear increases in risk occurring with no threshold at concentrations below current ambient air standards (Wordley *et al.*, 1997). Unlike the short-term nature of exposures to smogs, fogs, wood fires and industrial accidents, exposure to vehicle emissions by city dwellers is clearly of an everyday chronic nature.

The fleet average of 0.0258 g/km of PM₁₀ used in our model for petrol-fuelled motor car emissions, is almost identical to the 0.028 g/km reported in the UK for both urban and rural travel (UK Emission Factors Internet Database).

Because of their high kilometrage and the 1.8 g/km PM₁₀ emission factor, diesel buses account for almost half of the tailpipe mortality. The 1.8 g/km PM₁₀ emission factor represents the vintage of the bus fleet in Tel-Aviv-Jafo. However, this emission figure is lower than the 2.66 g/km reported in New York city (Faiz *et al.*, 1996) and the 2.50 g/km in Santiago, Chile (Escudero, 1991), but higher than the 1.40 g/km fleet urban cycle in the UK and 1.50 g/km fleet level in Holland (Ministry of Housing, Spatial Planning and the Environment, 1997).

The 6000 trucks 'by virtue' of their high kilometrage and 1.13 g/km PM₁₀ emission factor account for more fatalities than the 416,000 petrol fuelled cars. The emission factor for trucks is slightly higher than urban emissions from the British HGV fleet of 1.04 g/km and the 0.91 g/km overall emissions from trucks in Holland, but is lower than the 2.46 g/km, 1.60 g/km and 1.47 g/km emitted by New York city, urban European and Californian heavy duty trucks (Small and Kazimi, 1995).

The mortality data is sensitive to the percentage of PM₁₀ emissions from the Reading power station estimated to fall on Tel-Aviv-Jafo. Our calculations used a conservative estimate of 40%, (i.e. one that would minimise the relative impact of emissions from vehicles). However, if this was reduced to 30%, then tailpipe emission mortality would rise from 293 to 337 deaths.

We used a conservative estimate (with respect to prevailing winds) that only 50% of refinery emissions would fall on land, if this figure was 60% (as is possible due to the likely distribution of the prevailing winds) then estimated annual mortality from refinery emissions would rise only from 10 to 12 deaths.

A further conservative bias is that the daytime population of Tel-Aviv-Jafo is considerably higher than the residential population due to the presence of many commuters who work in Tel-Aviv-Jafo but live outside the municipality. These commuters will also be exposed to vehicle emissions but whose deaths (if any) will be recorded in districts outside of Tel-Aviv-Jafo and are hence not included in our baseline figure of 4048 non-accidental deaths in persons over 30 years of age.

Considerable attention has been given to generating (though not necessarily implementing) policy measures aimed at lowering the traffic accident fatalities (Richter, 1998). These should be supplemented with additional policy measures aimed at reducing the far greater magnitude of mortality caused by tailpipe and refinery emissions.

Immediate measures could include the substitution of oxidising catalysts to diesel engines or the use of alternative fuels such as LPG in diesel buses or trucks. Additional longer-term reductions in motor vehicle-generated emissions could be gained by the adoption of town planning and fuel pricing modalities that encourage the design and use of pedestrian routes, cycle paths and rail networks (Fletcher, 1998). In keeping with the Polluter Pays Principle, the external emission costs (Table 3) could be used to increase the cost of diesel fuel relative to petrol and hence encourage the use of substitutes for diesel fuel.

In direct contrast to the clear identification of the causality of motor vehicle fatalities, the identification of the vector-victim relationship from vehicle emissions is based on statistically - modelled relationships. This indirect mode of identification should not be an excuse for inaction, since such statistical relationships are now accepted worldwide with regard to the linkage of mortality to radiation and cigarette smoke exposures.

The biblical imperative 'though shalt not put

a stumbling block before the blind' (Leviticus 19:14) allied to the magnitude of the public health menace from vehicle emissions (and its associated high external costs), should provide sufficient incentive to overcome problems

arising from the interdisciplinary nature of potential solutions to vehicle emission deaths, involving multiple-ministerial co-operation (health, transport, environment, interior, energy).

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High Occupancy Vehicle (HOV) Lanes: Highway expansions in search of meaning

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Aspects of this paper are based in part upon an earlier 1994 collaboration with Christopher Leman and Kristin Pauly, "Rethinking HOV". The author takes full responsibility for current conclusions or analyses.

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Abstract

High Occupancy Vehicle lanes have been widely promoted and constructed in the USA in a belief that the provision of such facilities would improve transit performance, stimulate car and vanpool formation, and improve land use and air quality in urban areas. Critics, especially among environmentalists and alternative transportation advocates, assert that HOV lanes are merely highway expansions which promote more driving, weaken transit, increase air pollution, and facilitate suburban sprawl. This article demonstrates that, generally, HOV lanes are effective only to the extent that they are designed to fill transit and formal carpool program needs. Questions are also raised about the efficacy of HOV criteria, and the extent to which these programs are shaped by ideological and political considerations, rather than by careful analysis and planning.

Keywords

HOV lanes, Transport investment, USA.

Introduction

For several years, decades in some localities, over twenty urban regions in the United States of America have embarked upon programs of developing specially designated highway lanes to be shared by transit and carpool vehicles. These lanes almost always are within existing roadway rights-of-way, usually immediately adjacent to general lanes, and are called 'High Occupancy Vehicle (HOV) lanes'. A minority of these lanes are separated from general flow lanes by physical barriers. Most are simply demarcated by paint and signage, and occasionally a narrow buffer space separating them from general traffic. Almost all such lanes have been created by new construction or the opening of formerly transit-exclusive lanes to other vehicles. Many of these lanes have been built in bits and pieces, often do not connect well with other roadways, and often do not form a system of special lanes. The assumptions, sometimes explicit - often implicit - in these programs, are that such lanes

will provide improved flow for their users, increase reliability while decreasing duration of trips, and stimulate shifts of travel mode from Single Occupancy Vehicles (SOVs) to HOV transit and carpooling (Fuhs, 1993; Turnbull and Hubbard, 1994).

While no precise tabulation of HOV lane kilometres seems to exist, the extent of HOV lanes is enormous. In the Seattle (WA) area alone some 267 km of expressway HOV have been constructed. Another 210 km are planned or under construction (Parsons Brinckerhoff *et al.*, 1997). Many other Seattle area HOV lanes have been constructed or are planned on roads which are not expressways. In the Los Angeles metropolitan area approximately 1000 freeway HOV lane miles (1600 km) have been constructed or are in various stages of planning and development (Fuhs, 1993; Turnbull and Hubbard, 1994). It is likely that approximately 3200 HOV lane km are in continuous (24 hour) operation at present in the USA (Fuhs 1993, p. 16). Some additional HOV lanes exist only at peak traffic period times or in peak traffic period directions. Another 1600 lane km may be in one form or another of planning or development.

Depending on acquisition and construction issues the cost of HOV may range from \$6 million to \$60 million per km. HOV was introduced in the USA in the 1970s following the huge program of highway building in the 1950s and 1960s. After several years of experience it was found that such HOV highway treatments needed special access-egress ramp treatments as well as special interchanges at the intersections of two or more highways in order to function well. This has triggered costly programs of rebuilding ramps and interchanges. Not uncommonly, the construction costs of ramps and interchanges exceeds the construction costs of an entire HOV lane segment. One HOV interchange planned for downtown Bellevue, an 'Edge City' suburb of Seattle is estimated at \$126 million. Another HOV and general lane interchange for the Washington (DC) area is estimated at \$320 million (Rathbone, 1998).

Promoters of HOV lanes promise great benefits from them. Traffic congestion is

expected to lessen, transit ridership and carpool formation is expected to increase, energy efficiency is anticipated to improve while vehicular pollution decreases. Environmentally and transit-minded critics of HOV lanes refute such claims (Johnston, 1991; Leman, 1992; Replogle, 1993; Vuchic, 1994; Leman, Schiller and Pauly, 1994) while highway proponents criticise HOV lanes and wonder whether it wouldn't be better to build a general lane instead of an HOV lane? Or, better, two general lanes (Dahlgren, 1995) or simply convert existing HOV facilities for general traffic (*New Jersey Star-Ledger*). Advocates of deregulation and privatisation see underused HOV lanes as prime candidates for conversion to mixed High Occupancy/Toll facilities open to solo drivers with the ability to pay for greater privilege (Fielding and Klein, 1997).

This paper will address several of the key issues surrounding the spread of HOV lanes. Foremost among these are the policy basis, or lack thereof, for HOV lanes, their performance, and the extent to which they help or hinder proven high-occupancy modes, i.e. transit. The extent to which HOV promotion constitutes an ideological, rather than analytical, outlook will also be examined.

The history of HOV

The discussion of the history of HOV lanes needs to start with a distinction between ridesharing or group transport and the sorts of facilities intended to accommodate such activities. Transport in common has existed since the time of the two person litter, through the days of the horse-drawn omnibus, and into the modern era of trains and buses. Ridesharing in the form of 'carpooling', the deliberate sharing of a vehicle in order to increase occupancy and reduce the demand for extra vehicles, long predates the HOV lane - in fact, it predates by decades the invention of the term 'high occupancy vehicle'.

In the early years of the automobile, most vehicles were operated as high occupancy vehicles. In fact, the larger passenger capacity of many cars was designed to accommodate greater ridesharing. Economic necessity made carpooling a routine part of life for most families and individuals. Neighbours would share the ride to work, school, grocery shopping, and the movies. Wartime gasoline rationing encouraged ridesharing, as did explicit publicity campaigns. One World War II era advertisement of the U.S. Government portrays the grim message, "If you ride alone, you ride with Hitler!"

As the number of cars per household

increased, carpooling steadily declined. Average vehicle occupancy has been declining since the 1960s. According to the 1990 census, average vehicle occupancy for commuting has dropped to 1.09, the lowest level ever recorded. Between 1980 and 1990, the nation's daily carpools for commuting declined from 19 million to 15 million, with the largest drops occurring in carpools of three or more occupants (Pisarski).

Explicit government efforts during peacetime to promote ridesharing first began in the energy crises of the 1970s. Corresponding with this increase in governmental promotion of ridesharing was the emergence in the 1970s of the term 'high occupancy vehicle'. The term high occupancy vehicle is an attempt to encompass car pools, van pools, and buses in the same term; as discussed in later sections, it is an awkward fit on the road, just as it is in terminology. Initially the minimum number of occupants per high occupancy vehicle was defined as being three (or even four, as in the case of the Shirley Highway). However, this number has increasingly been defined as being a minimum of two.

Special facilities such as exclusive rights-of-way for transit, especially on roadways, begins with the nineteenth and twentieth centuries. Early urban and suburban rail systems, beginning with the horse-drawn tram of the nineteenth century, were accorded special rights-of-way, often in the middle of existing roadways in town. Roadway lanes set aside for the exclusive use of buses also have a long history in the United States. As rails were paved over to create more motor vehicle lanes, and as the buses that replaced the streetcars began to suffer from the growing traffic congestion, special transit lanes were developed. The earliest in the United States was in 1939, when more than a mile of lanes in each direction on Chicago's North Sheridan Road were converted to bus-only during peak traffic periods; local traffic was still allowed on the lanes. The number of bus-only lanes increased throughout the country in the 1960s and 1970s, with some on a 24-hour basis (Levinson *et al.*, 1973).

Freeway lanes and ramps also began to be set aside for buses. One of the first (1970) was a morning bus-only lane on the New Jersey Turnpike (I-495) approaching the Lincoln Tunnel into Manhattan. At the same time a bus lane (1970) and two carpool lanes (1971) were set aside on I-80 on the eastern approach to the San Francisco-Oakland Bay Bridge. The first U.S. freeway lane built solely for buses was probably the Shirley Highway Transit Lane on I-395 in northern Virginia (1969). In 1973, this lane was opened to carpools, apparently the

first U.S. instance in which buses and carpools officially shared a long-haul HOV lane (Fuhs, 1993). Thus commenced a long process of downgrading transit-only facilities to carpool, and even beyond to solo drivers.

community in highway planning and construction circles.

This friendship was generally not reciprocated, however, when new HOV lanes were planned or constructed. Many HOV lanes have been built without reference to the needs of transit services - or existing service patterns. Others have been designed in ways that create obstacles to use by buses. Some HOV lanes have been located alongside the medians of freeways which necessitates that buses entering from the other side of the expressway must weave across several general lanes in order to gain access to them. The dominance of the highway and car mentality in the design and construction of HOV lanes is quite unfortunate. Transit deserves foremost consideration because it is the workhorse of many urban freeway HOV lanes.

HOV versus transit

HOV lanes appear to have been the creature of the era of freeway and sprawled suburban development. They seem to be an afterthought, a late acknowledgment that it might be wise to maintain reliable bus schedules in the face of mounting traffic congestion. They also came of age in an era when transit agencies felt themselves to be under siege. Ridership was falling. Costs were rising, due in large part to the expense of orienting services to longer suburban commuter routes rather than more profitable in-city routes. More new jobs were locating in distant suburban office developments than in urban cores. Transit agencies began to think of ways which they might better service such a suburban clientele. One of these ways might be to assist in the promotion, if not formation, of car and vanpools. It seemed logical to such transit planning minds that bus lanes could be shared with carpools. It also won friends for the transit

Table 1 compares the performance of buses and carpools on selected North American HOV and bus-only facilities. These facilities were selected for comparison because almost all of them are considered successful by HOV standards; they move at least as many, or substantially more, persons than comparable general traffic lanes. The most impressive performance is on bus-only lanes which clearly outperform almost all the mixed bus and carpool HOV lanes. The nation's most productive road lane of any kind is the bus lane on New Jersey's Route 495, which in the morning peak carries more than 35,000 people into the Lincoln tunnel. The lane serves 30% of all trans-Hudson River commuters, more than the combined total of all 12 general purpose lanes next to it (Home and Quelch, 1991). Also impressive is the Ottawa-Carleton area's network of transitways, which help OC Transpo carry 30% of all vehicle-based travel and 70% of peak hour trips to downtown (Bonsall, 1987). Overall, buses carry 67% of the traffic of the HOV-Transit lanes depicted in Table 1. In lanes open to buses and carpools, buses still carry almost half (48%) of all passengers.

A few of the HOV lanes included in Table 1 serve carpooling populations well. Those in the Washington (DC) area specifically serve large employment facilities, such as the Pentagon military complex, where each weekday thousands of staff form orderly processions entering large vans at 15 minute intervals from mid-to-late afternoon. The apparently excellent performance of carpools on the San Francisco-Oakland Bay Bridge is due in part to the large numbers of commuters who are informally picked-up at bus stops by solo drivers seeking to qualify for the bridge's toll-free carpool lanes. Such arrangements, referred to derogatorily as 'slugging', should be viewed as a setback for

Table 1: Performance of Selected North American HOV-Transit lanes

Location	HOV/Bus Facility	AM Peak Hour Inbound Passengers (1988)			Bus (%)
		Bus	Van/Carpool	Total	
Union City, NJ/NY	Route 495	34,685	0	34,685	100
Ottawa, Ontario	O-C Transitway	11,000	0	11,000	100
Pittsburgh, PA	East Busway	5,892	0	5,892	100
Pittsburgh, PA	South Busway	2,098	0	2,098	100
Vancouver, BC	H-99	1,081	0	1,080	100
New York, NY	Gowanus Expressway	8,686	173	8,859	98
New York, NY	Long Island Expressway	7,838	214	8,052	97
Houston, TX	I-45N (pre-carpool)	2,810	416	3,226	87
Seattle, WA	SR520 (W)	3,140	498	3,638	86
Seattle, WA	I-90	1,250	229	1,479	85
Seattle, WA	I-5N (pre-2+)	2,605	1,105	3,710	70
Fort Lee, NJ/NY	I-95	1,800	919	2,719	66
San Francisco, CA	US101	1,995	1,490	3,485	57
Houston, TX	I-10 (Katy)	1,820	2,595	4,415	41
Los Angeles, CA	I-10 (San Bern.)	2,750	4,352	7,102	39
Washington, D.C.	I-395 (Shirley)	5,621	9,483	15,104	37
Wash./Fairfax Co., VA	I-95	1,226	5,336	6,562	19
San Francisco, CA	Oakland Bay Bridge	3,535	8,273	11,808	30
Houston, TX	US290 (NW)	600	3,248	3,848	16
Miami, FL	I-95 (1985 data)	350	2,460	2,810	12
San Diego, CA	I-15	350	2,686	3,036	12
L.A./Orange Co., CA	I-405	120	3,705	3,825	3
L.A./Orange Co., CA	Route 91	0	3,112	3,112	0
TOTAL (bus only)		54,756	—	—	100
TOTAL (all facilities):		101,252	50,294	151,546	67
TOTAL (facilities open to carpools):		46,496	50,294	96,790	48

(adapted from Leman, Schiller and Pauly, 1994)

transit agencies and the toll authority rather than a 'triumph of carpooling'. Other 'successful' carpool lanes where few, if any, buses fear to tread (towards bottom of Table 1) probably testify more to the difficulty of serving sprawled areas with transit - and the lack of coordination between highway construction interests and transit agencies - than to the power of carpool formation.

HOV criteria and travel behaviour: A date is not a carpool!

Carpools are generally defined as arrangements whereby two or more persons share a ride from one destination to another, ostensibly reducing the number of vehicles which might otherwise be used for such travel. The construction of HOV lanes is expected to increase the proportion of persons riding transit or carpooling by allowing better and more reliable travel times. As discussed above some of the earliest HOV lanes were originally transit-only lanes which were opened, or downgraded, to carpools. The criterion for carpools, in the early stages of HOV, was generally three or more persons ('3+') to a vehicle. Since many newly constructed HOV lanes were not necessarily built in areas where there were job concentrations or carpool programs, this criterion was generally lowered to 2+ in order to have any appreciable use made of the lanes. Because of political pressures, or lagging rates of carpool formation, some 3+ lanes have been downgraded to 2+ in recent years. In some cases a 2+ criterion was applied in the belief that it would be easier to stimulate carpool formation at this level and that the criterion could be easily raised to 3+ as the lane became crowded with 2+ vehicles.

There are several problems inherent in these assumptions about carpool criteria and motivation for ridesharing. First, the travel time savings while in a vehicle must be significant in order to overcome the time penalty paid by participants in carpools. That is, most carpoolers must either wait for the carpool to arrive, or must spend some time in travel (often by car) to a rendezvous location, which undermines the time saved travelling in the HOV lane. Secondly, just as there are some 'inconveniences' associated with transit travel, as compared to personal vehicular travel, there are inconveniences associated with carpooling: adhering to a fixed schedule when work hours may vary, inability to change plans or run errands, or even disdain for the type of music preferred by the driver have been cited as objections to carpooling.

The assumption that, given the right

environment and incentives, SOVs would evolve into 2 person carpools (HOVs) which would further evolve into 3 person carpools over time is a curious instance of Darwinian thought applied to urban transport. Upon examination it turns out that almost half (43%) of 2+ vehicles in general or HOV lanes are occupied by members of the same household. (Fielding and Klein, 1997) The extent to which these vehicles move out of a general lane into a newly provided HOV lane is merely a matter of rearranging the furniture on the freeway. It is not a triumph of shift from one modal status to another. That the designation 'High Occupancy Vehicle' is given to 2 person cars is yet another example of how far down the road past Orwell's 1984 double-think language American highway planners have gone. That a date is not a carpool is obvious to most casual observers of HOV lanes. The ultimate mixing of American transportation and political values occurred when a pregnant woman cited for driving solo in a 2+ HOV lane contested her Seattle area traffic citation. Asserting that a fetus is a human being she claimed status as a carpool. The court found otherwise.

More calling into question of the belief system underlying the highway HOV construction program occurred in 1991 when the Washington State Legislature pressured the State's Department of Transportation into downgrading the I-5(N) freeway HOV lane from 3+ to 2+ minimum carpool occupant criterion. Since there were still a few empty spaces left between buses and 3 person carpools (and the motorcycles which are also allowed in the lane, even though generally driven by just one person), policy makers evidently thought that a lowering to 2+ would stimulate some of the solo drivers in general lanes to mate and issue forth carpools — and reduce SOV traffic congestion in the general lanes.

The results of a careful evaluation by researchers at the University of Washington and the Texas Transportation Institute showed otherwise. The downshift from 3+ to 2+ resulted in a large increase in vehicles in the HOV lanes without a significant reduction of vehicles in the general purposes lanes. In fact, there was a decrease in the freeway's overall average vehicle occupancy and an increase in the proportion of SOVs. People left buses (now slowed by the traffic) for carpools, and left vanpools and larger carpools for 2+ carpools. They also shifted onto the freeway from parallel arterials, and travelled more at peak periods. And they took trips that formerly they would have not made at all (Ulberg *et al.*, 1992). There also appeared to be an increase in congestion-causing traffic incidents related to

the increase in the amount of traffic on the road.

Perhaps the most egregious harm done by HOV lanes is the extent to which they undercut transit performance. Except in those few instances (see Table 1) where transit exclusivity preceded HOV designation or where HOV lanes have been designed and operated with transit benefit in mind, the net effect of HOV lanes appears to have been to hinder transit performance, drain transit revenues, and reduce ridership. In 1995 the Virginia DOT downgraded an HOV lane from 3+ to 2+ on a highway (I-66) running adjacent to the Washington (DC) Metro Orange Line. As riders deserted transit for the newly accessible (and 'free') highway space, either as solo motorists or 2+ carpools, transit revenues plummeted. Virginia DOT has been requested to pay the transit service \$1.6 million annually to compensate for revenues lost to the highway (*Washington Post*, 1995).

HOV by conversion

One might ask of promoters of HOV lanes, 'if HOV is so good, why not just convert some existing general lanes to HOV - especially given the drawbacks and expense of constructing new HOV lanes?' In fact, most bus-only lanes now in existence - and there are hundreds, if not thousands, around the world - were conversions from traffic or parking lanes. A few freeway lanes, too, have been converted for bus or carpool use. But generally the planning of HOV lanes ignores the conversion alternative. Cost-benefit studies compare HOV construction with the construction of general purpose lanes, without analysing the alternative of converting an existing general purpose lane. Conversions are subject to some restrictions not faced by construction projects. A number of state highway departments in the USA prohibit conversion outright, or impose tighter preconditions and analytical requirements.

The rare analyses of HOV by conversion of existing lanes often use the alarming term 'take-a-lane', and sometimes even 'take-away a lane', as if general purpose were the highest and best use (Parsons Brinckerhoff *et al.*, 1992; Bechtel, Parsons Brinckerhoff, 1992, p. 27). Official use of the term take-a-lane is fostered by the (USA) Transportation Research Board's Committee on HOV Systems, whose glossary claims that the step is 'rarely applied' (reprinted in Fuhs, 1993). 'Optimize-a-lane' would be at least as fair a term. At the very least the more neutral term 'lane conversion' should be employed.

A few of the past conversions of general purpose lanes to HOV use were later reversed, but the wrong lessons have been drawn from

these cases. There was public outcry, but the conversions were not managed well or marketed to anticipate and address it. And the conversions that were cancelled did succeed at a number of their immediate goals. For example, the HOV lanes that were converted on the Santa Monica Freeway for 21 weeks in 1976 carried nearly as many people as the other lanes combined, and helped the freeway carry more people in fewer vehicles than it ever had before. Carpools and bus ridership both more than tripled and were increasing further, and they dropped when the lane was discontinued (UMTA, 1977).

The standard objection to conversion 'that congestion will be increased in the remaining general-purpose lanes' should not end discussion. Additional steps can mitigate or prevent the worsened congestion. Toronto's Department of Public Works and the Environment showed imagination in implementing the Bay Street Urban Clearway, an HOV lane shared by buses, taxis and bicycles. According to the Department's evaluation the addition of turn restrictions at a number of intersections and the prohibition of stopping at curbside actually increased the volume of general-purpose traffic and reduced the levels of congestion on Bay Street.

HOV versus the environment

Environmental benefits, such as reduced air pollution, improved transit performance, and better land use are often claimed by proponents of HOV lane construction. Federal funds for HOV lanes in the U.S. have been available even in cities not in attainment with the Clean Air Act through the Congestion Mitigation - Air Quality (CMAQ) program of the Intermodal Surface Transportation Efficiency Act - ISTEA 1991 (Schiller, 1997) and the recently passed Transportation Equity Act for the 21st Century - TEA-21.

Representatives of several environmental and alternative transportation organisations think otherwise. Their analyses points to the increases in roadway capacity and driving, especially longer commutes, stimulated by HOV lane construction. The time savings offered by HOV lane travel, or the temporary relief of general lane congestion, generally facilitate a longer commute which results in greater suburban sprawl. Areas of urban sprawl generate more motor vehicle trips than traditional cities, and are more difficult to serve by transit (Replogle, 1993).

Computer models analysing HOV lane construction in the Sacramento (CA) area demonstrated increased solo driving and

car-oriented land uses. By the year 2010 carbon monoxide levels would be little better, and oxides of nitrogen levels would actually be worse than if the freeways had not been expanded at all. In the longer run, the air quality results would almost certainly be much worse (Johnston, 1991). In the San Francisco Bay Area the Sierra Club challenged and delayed the construction of HOV lanes on part of I-80 when it demonstrated that the lanes would stimulate more solo driving, longer trips, more sprawled development and worse air quality (Holtzclaw and Lewis, 1996). In the New York City metropolitan area the group Transportation Alternatives has published criticisms asserting that 'HOV = HOAX', and the Environmental Defense Fund and the Tri-State Transportation Campaign have successfully challenged several regional HOV proposals, advocating instead a combination of improved transit and road tolls.

HOV as global highway ideology: from Amsterdam to Taipei to Toronto and Vancouver

Despite a lack of demonstrable value or effectiveness, HOV planning and construction spreads across the countryside of the USA. It appears to be gaining friends in other parts of North America and on other continents as well. Transit-rich Netherlands opened 'Europe's first HOV lane' for buses and carpools on Highway A-1 near Amsterdam in 1993 (Turnbull and Hubbard, 1994, pp.20-22). Taipei refers to its bus lanes as 'HOV' (Turnbull and Hubbard, pp.83-84) Can the inclusion of carpools and taxis in them be far behind? Canada's cities have resisted sprawl and maintained good transit services relative to their counterparts in

the USA (Schiller, 1994, 1996) Rates of transit ridership, and the quality of services and intermodal connections in Toronto and Montreal rival those of many European and Asian centres. Recent years have seen the growth of HOV lane construction in Canada, most notably in the Toronto and Vancouver regions (Turnbull and Hubbard, pp.23-24, 81-82).

Because the validity of the claims for greater transportation efficiency and transit and carpool improvements remain unproven or contested, one has to wonder whether such claims are based more on ideology and belief rather than upon analysis and experience. Because HOV lanes are neither 'fish nor fowl', i.e. neither true transit nor true automobile facilities, they attract a fair amount of political and media criticism (*New York Times*). Because discussions of transportation policy are often not very sophisticated in the USA, HOV has become a convenient target of media demagoguery (*New Jersey Courier News*, *New Jersey Star-Ledger*).

As this article and related environmental critiques have shown, transit accounts for most of the effectiveness the few successful HOV lanes in North America can claim. Overall, HOV by new construction seems to hinder rather than help urban areas in their goals of improving transit ridership, stimulating car and vanpool formation, decreasing air pollution, and optimising land use efficiency. The question needs to be asked if HOV is a belief desperately seeking validation, a highway expansion in search of meaning? Meanwhile the difficult details of improving transit and land use, and reducing pollution and global greenhouse gases are being overlooked in the rush to build more lanes to nowhere.

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Car Sharing and Mobility Management: Facing new challenges with technology and innovative business planning

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Abstract

More car sharing organisations are beginning to appear throughout Europe and North America. The use of existing and new technologies in an innovative way offers tremendous opportunities for this industry to grow.

Keywords

Business planning, Car sharing, Innovation

Introduction

During this century several transportation modes, including transit, personal automobiles, and aeroplanes, have competed for market share. Despite this competition, the personal vehicle has become the dominant form of mobility in many countries throughout Europe and North America. In turn, public transport has found it increasingly difficult to attract and retain passengers. This paper describes an important movement towards new 'Mobility Management' in which competition no longer favours a particular mode. Rather, this new mobility framework could be used to increase the demand for multimodal transportation by linking new transportation business models and incentives (e.g. convenience and cost savings) with advanced technologies (e.g. cell phones and smart cards that can facilitate intermodal transfers and payment). In the future, the integration of collective and private transportation modes could lead to energy savings and a more sustainable approach to mobility.

In this model, customers would construct a set of transportation tools to accomplish their mobility goals that reflect their individual set of mobility criteria, such as time and cost savings, convenience, and comfort. Mobility Management can be likened to a shopping centre that offers its customers a range of mobility services and options. This form of 'one-stop' transportation shopping can empower individuals by offering them a choice of modes that best fits their needs on a daily basis. On Monday, this might mean taking the train and a bike; car sharing on Tuesday; telecommuting Wednesday through Friday; and walking on weekends. Everyday is a new

choice, depending on the needs and goals of the individual.

At present, advances in electronic and wireless communications are making innovations in transportation products and services possible. Due to these developments, as well as the congestion and air pollution associated with the automobile, the success of the personal vehicle may begin to diminish. In the future, personal vehicles are likely to play a significant role in transportation; however, their importance could shift. In contrast to their current status as a 'dominant' mode, automobiles might be viewed as just one alternative among a wide range of attractive mobility options. With the same enthusiasm that planners invested in personal automobiles in the past, transportation planners and policy makers now have an opportunity to 're-engineer' transportation into a diverse set of mobility services by employing advanced technologies. Car sharing is one important step in this process.

During the past decade, car sharing has experienced a successful pioneering stage in Europe. At present, car sharing has begun a transformation into a professional and profitable business framework, which includes mobility services, in a number of regions throughout Europe. Car sharing is offered as one service in a broader context of mobility services, such as car rentals and transit linkages. Car sharing offers an alternative to satisfying the demand for individual mobility, while encouraging collective transportation when it is convenient and cost effective for the individual. In Europe, many car sharing customers already rely upon intermodal transportation. With time and experience, many car sharing participants employ shared-use vehicles less and use other modes of transportation more often, such as transit and cycling.

Car sharing systems: The basics
Car sharing is a system where customers time-share vehicles located at car sharing lots or stations. Customers use car sharing vehicles by the hour or day and pay on an hourly and

kilometre basis each month. The principle of car sharing is simple. Individuals gain the benefits of private cars without the cost and responsibilities of ownership. Instead of owning one or more vehicles, a household has access to a fleet of vehicles on an as-needed basis. Car sharing may be thought of as organised short-term car rental. Car sharing is more successful when access is easy and assured, costs are low, payment is straightforward, and vehicle choices are plentiful. Individuals gain access to car sharing by joining organisations that maintain a fleet of cars and light trucks, which are often distributed throughout a network of vehicle locations.

There are many car sharing organisations (CSOs) in Europe and North America. In Switzerland and Germany, car sharing has offered a transportation service for over 10 years. At present, Mobility CarSharing Switzerland serves over 20,000 people at 600 stations in 300 cities and towns throughout Switzerland and manages a fleet of 900 cars.

Using a car sharing system involves three steps. First, customers place a reservation for a vehicle. Individuals can typically make a telephone reservation on a 24-hour basis by speaking directly with a car sharing operator or placing a computerised 'Interactive Voice Reservation System', using a touch-tone telephone. Recently, Mobility CarSharing introduced an Internet reservation system. Reservations can be made days or weeks in advance. For example, an individual can make a vehicle reservation for a doctor's appointment that he or she has in two weeks. In Europe, most reservations are made spontaneously at the immediate time the vehicle demand occurs. In Switzerland, each car sharing station usually maintains two to five vehicles. Stations are located in residential areas, work sites, train stations (i.e. for intermodal use), gas stations, car dealerships, and shopping areas.

During the second step, an individual travels to the car sharing station where his or her car has been reserved and accesses the vehicle key from a manually-operated key box. Every user has access to this box by a personal key. At the car sharing station, a customer takes the key for a specific car and drives off. In late 1998 or early 1999, this manual box system will be replaced by on-board computers that will be installed in every car and a smart card will be distributed to each user for accessing vehicles (i.e. opening the car door).

Advances in electronic and wireless technologies are helping to provide security, reliable access to vehicles, and data tracking. This automation makes sense for a high volume of shared-use vehicles. The quickly developing

market for navigational devices, such as global positioning systems (GPS), will likely have a significant impact on car sharing businesses and the market for Mobility Management.

However, car sharing is not the only product provided by new mobility services. As a consequence of technological advances and new demands of lifestyles, customers will be able to take advantage of a range of products and services that best satisfy their changing mobility demands. Already, some mobility services exist in Europe, such as Autodate in the Netherlands, which services over 85,000 customers. At present, many transit agencies, CSOs, and mobility centres are beginning to provide a variety of car sharing products and other mobility services based on smart cards and communication technology. Some examples include:

- Car sharing organisations, like Mobility CarSharing and several other organisations in Germany, Austria, and the Netherlands, that are expanding the scope of their services;
 - Traditional car rental companies that are also combining mobility packages with car sharing and transit;
 - Car-lease-sharing, for example 'CashCar' in Berlin;
 - Car pooling or van pooling; and
 - Taxi or collective taxi services.
- Finally, the third step in car sharing is the monthly billing of all customers. In Switzerland, hourly rates for a medium-sized car are 1.30 ECU/hour (11.00 pm - 7.00 am is free of charge) and kilometre rates are .25 ECU/km (rates are slightly cheaper for longer distances). All costs for the car are covered, including insurance, gasoline, maintenance, and depreciation. To use a shared-use vehicle, customers can choose from three options:
- 'Member': Deposit of 600- ECU (refundable when leaving the system) and an entrance fee of 120- ECU (non-refundable). The customer obtains the best rates per hour and kilometre with this package.
 - 'User': Annual fee of 60- ECU/year (non-refundable). The customer pays slightly higher rates per hour and kilometre.
 - 'User special': Annual fee of 40- ECU/year (non-refundable) in combination with an annual transit pass.

Car sharing in Europe and worldwide In 1987, Switzerland began car sharing. Based on a merger of existing companies in 1997, Mobility CarSharing Switzerland emerged as one nationwide car sharing company. The uniform standards and quality services

provided by Mobility CarSharing have helped this organisation grow significantly over the past ten years. At present, this organisation holds almost 50 percent of the market share for all car sharing users in Europe and is currently increasing its market share. Based on the principle of partnership management, Mobility CarSharing now serves over 20,000 customers and is expecting to grow by 100% within the next year. Partnership management is a business framework in which car sharing providers partner with other businesses, such as transit operators, gas stations, and car rental companies, to offer a combined mobility package that enhances their products and services.

Due to different standards and operations, German CSOs have experienced slower growth. In contrast, many German CSOs are still in a pioneering stage, which emphasises grassroots organisations, local strategies, and operations. Average growth in Germany is only about 10% - 20% per annum due to relatively high monthly fees and regular membership attrition. At present, there are approximately 25,000 car sharing participants in Germany. However, Germany may soon find its way to an increased market share due to the recent merger of two car sharing umbrella organisations (i.e. European Car Sharing Deutschland and Bund Organisierter Autoteiler), and the incorporation of StadtAuto Berlin and StadtAuto Hamburg in an effort to 'standardise' operations and services.

Other European countries providing professional car sharing services are the Netherlands and Austria. In addition, new car sharing businesses will soon be launched in Sweden, Denmark, Italy, and the UK. Furthermore, several interesting and advanced car sharing developments are taking place in the USA. Many of these operations are either researching or considering advanced car sharing technologies and services. In February 1998, CarSharing Portland began offering services. In the fall of 1998, the City of Seattle plans to launch a large car sharing operation. Later this year, the Institute of Transportation Studies of the University of California, Davis (in conjunction with its partners: the Bay Area Rapid Transit District (BART); American Honda Motor Company, Inc.; Lawrence Livermore National Laboratory (LLNL); Teletrac, Inc.; and INVERS) will launch the 'CarLink: Smart car sharing system' program. The purpose of this demonstration project is to implement and evaluate a smart car sharing program, emphasising advanced technologies (i.e. compressed natural gas Honda Civics, a smart car sharing management system, and an

automatic vehicle location unit), multiple car sharing stations, and reliability. In addition, several other US cities have proposed car sharing projects, mainly cities with populations above 500,000 people.

Car sharing: Success factors
Based on their experience and knowledge of technological developments, the authors recommend several important factors for implementing car sharing in the future. These factors include:

Complement Existing Transportation Systems and Services:

Mobility packages are based on a variety of traffic modes, which can be used by customers in conjunction with car sharing. Partnerships with existing transportation institutions (for example, gas stations, car rental companies and transit agencies) are an important success factor for car sharing operators and businesses. For instance, car sharing is complementary to car rental and can be used to supplement the demands of car sharing users when their travel needs exceed one to two days when car rental becomes more economical than car sharing. Car sharing services can be used for a few hours a day, and car rentals can be used for one or more days for special occasions like business trips or vacations.

Maintain a Balanced Mix of Users and Locations:

Maintaining a 'balanced' mix of users is important to car sharing success. For instance, neighbourhood users typically reserve vehicles for evenings and weekends. In contrast, business users generally reserve vehicles from Monday to Friday, during daytime hours. Hence, these two user groups complement each other.

Since car sharing has to compete with privately owned vehicles, car sharing vehicles must be distributed in a decentralised manner to satisfy a wide range of customer needs. In such a small country as Switzerland, providing over 600 stations has been a critical factor to the success of car sharing.

Design Smooth Interfaces and Multimodal Interchanges:

Modal interfaces (e.g. smart cards that allow customers to access vehicles and transit) should be designed to reduce intermodal switching times, so that modal transfer requirements do not exceed three minutes (e.g. returning vehicle keys and paying for a transit pass). The attractiveness of stations and locations to

facilitate modal interchanges can reduce a customer's perceived 'transaction' costs (i.e. the perceived time and hassle required in making a transfer) and increase his or her subjective perception of the service (e.g. comfort, prestige, and a wide range of services). Smart cards (i.e. an electronic purse that can be linked to a bank account and used to pay for multiple services throughout a day) can facilitate these intermodal changes and reduce the perceived transaction costs associated with renting and accessing a shared-use vehicle.

Consider Advanced Electronic and Wireless Technology:
 New technologies can provide real-time access to information, reservations, ticketing, and billing. Furthermore, these technologies can support operators in providing their products and services and satisfying the customers' demand for flexibility, spontaneity, and reliable access. Not surprisingly, new business challenges for car sharing and mobility services will grow from the added capabilities that advanced technologies can bring to service providers. Some new opportunities include 'instant vehicle access' without a reservation or conventional key, 'open-ended reservations', 'one-way rentals', and even 'virtual car stations'.

Market Standards and Marketing:
 In the future, national or even international standards for products and services will be increasingly important, so that customers can easily access mobility services in multiple locations (e.g. during a business trip or vacation).

New Lifestyles and Multimodal Mobility
 We define new Mobility Management as accessibility that not only incorporates the shared usage of cars, but also reflects the 'mixed usage' of various transportation modes. Based on a variety of travel options, individuals can

select different travel modes and integrate them to meet their variable mobility demands and goals. When needed, individuals can even consult with a mobility counsellor to determine the best mix of modes and services.

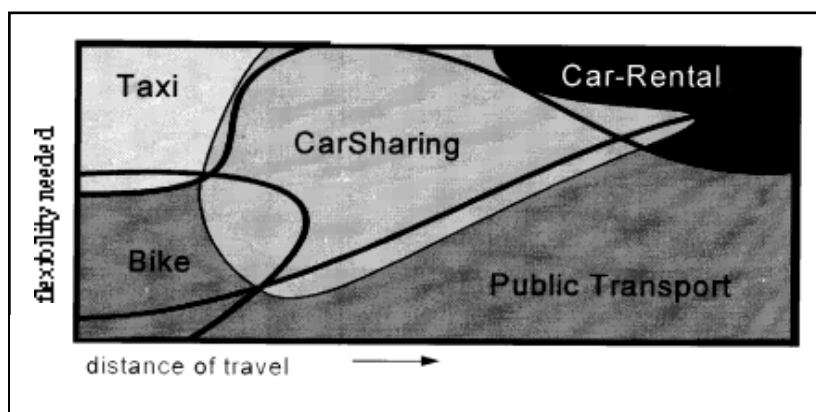
In a sense, each individual has his or her own 'mobility painting', which is based on their individual needs. 'Mobility Management' can also be thought of as 'travel blending', similar to a blend of tea, coffee, or tobacco. An individual's 'travel blend' would be characterised by its ability to reflect the values of each customer and to provide convenient options and more financial choices. Once mobility services are more widely available, these services will likely compete with the personal vehicle.

Mobility Packages: Some Examples from Switzerland
 In the future, various transportation options will be combined into mobility packages and services to satisfy customer needs for simpler, effective transportation. In Switzerland, Mobility CarSharing is already developing, testing, and evaluating several mobility package programs, including 'Fahrpass,' 'Zuri Mobil', 'Zuger Pass Plus', 'Auto auf Abruf', and 'MAX-Car'. Most of these projects are based on collaboration with transit organisations and are supported with start-up funding by governmental institutions. However, no subsidies are provided for their actual operation.

'Integration of use' is the innovative message linked to all of the programs listed above. One of the primary goals of these programs is to combine and integrate different travel modes to encourage intermodality. Between 1996 and 1997, 'Zuri Mobil' attracted over 3,000 individuals, who joined this Zurich-based program. At present, the population of Zurich is approximately 360,000 people. After paying an annual fee of 60- ECU to join, customers can take a second person along with them on public transport at no extra charge; access traditional rental cars at lower rates and preferred status; and gain access to over 150 shared-use vehicles at 80 stations in Zurich and an additional 900 shared-use cars at 600 stations managed throughout Switzerland. In Zurich, customers have access to car sharing on every third street, and most car sharing lots are closely linked to train and bus stations.

In comparison, the 'Zuger Pass Plus' (ZPP) program goes one step further. In addition to integrating a variety of mobility providers into one mobility package, ZPP includes other retailers, such as food distributors. ZPP offers a

Figure 1: The mobility gap: Car sharing completes the service



broader range of services and benefits to customers, particularly those that drive. By expanding the scope of partners beyond transportation providers, ZPP implements a strategy that bundles diverse businesses into a mobility service package. ZPP has helped Mobility CarSharing evaluate the concept of Mobility Management and further explore the idea of a mobility shopping centre, where customers can access a variety of products and services.

On 1st September 1998, Mobility CarSharing will launch a nationwide mobility package in collaboration with the Swiss National Railway System. Through this new program, rail passengers will gain easy access to car sharing and traditional rental car vehicles that are located throughout Switzerland. Approximately 1/2 of all 700 Swiss train stations will provide car sharing lots. Hence, intermodal vacation trips or travel blending will be possible from most Swiss cities and towns. As a result of this new program, Mobility CarSharing expects to attract 20,000 to 30,000 new customers, a growth of 100% in the company's car sharing market (i.e. a new customer base of at least 40,000 individuals).

A four-year project, known as 'MAX-Car' in Lucerne, also evaluates intermodal transportation. Soon it will begin testing new car concepts, such as electric and low emission vehicles, that can be used as shared-use cars. These vehicles will be deployed from the main train station located in Lucerne. It is hoped that the short walking distance from trains and buses to the shared-use vehicles will motivate businesses and households to shift to multimodal transportation.

Other collaborations might include partnerships with the car industry. In the future, car manufacturers and dealerships also enlarge their field of car sales by providing mobility services. For example, 'SMART', the small two-seater produced by a joint venture between Daimler-Chrysler and Swatch, already provides mobility services to select suburban areas in Europe.

Conclusion

Until the past decade, almost all efforts at organising car sharing organisations resulted in failure. For a variety of reasons, a new era began in the late 1980s in Europe. Several car sharing organisations are now firmly established and on steep growth trajectories. Experience from Europe has shown that car sharing programs are most successful where environmental consciousness is high; driving disincentives

such as high parking costs and traffic congestion are pervasive; car ownership costs are high; and alternative modes of transportation are easily accessible.

As car sharing takes root, an interesting growth dynamic can be observed. More business-oriented CSOs thrive by acquiring those that fail or lack strong leadership and developing a broader range of services. To retain customer loyalty, they continue to improve services and/or reduce costs. Two linked strategies are being followed: co-ordinate and link with other mobility services, and incorporate advanced communication, reservation, and billing technologies. But advanced technologies are expensive, and linking with other services is successful only if the customer base is large. Consequently, many CSOs either remain quite small or follow a spiralling growth trajectory.

Taking a longer view, CSOs may be the prototype of an entirely new business activity: mobility service companies. As vehicle ownership proliferates and vehicles become more modular and specialised, entrepreneurial companies may see an opportunity to assume the full care and servicing of a household's or an individual's mobility needs in neighbourhoods, work sites, transit stations, shopping centres, etc. These new mobility companies might handle insurance, registration, and maintenance, and could substitute vehicles as a household's situation changes. In the future, both the pioneering CSOs of Europe and North America could combine their knowledge of operations with advanced technology companies to create mobility services that contribute to our social, economic and environmental well being.

We conclude that car sharing will play a significant role in helping to redefine mobility patterns, modal decision making, and mobility behaviour. If mobility service companies guarantee vehicle accessibility and reliability, customers will likely follow this new trend. Nevertheless, it is important to keep the following points in mind. First, it is critical to educate and excite customers about new transportation options, such as car sharing and mobility services. Second, it is important to anticipate the need for future mobility products and services, such as those demanded by modern lifestyles. Finally, advanced electronic and wireless technologies should be considered thoughtfully as useful tools for improving the quality of transportation services, modifying current transportation options, and ultimately shaping travel behaviour.