

Literature Review of HOV Lane Schemes

by C Dixon and K Alexander

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LITERATURE REVIEW OF HOV LANE SCHEMES

ISSUE 2

by C Dixon and K Alexander (TRL Limited)

Prepared for: Project Record: 3/326 Task 45: Development of Monitoring Requirements for M1 HOV Pilot

**Client: SSR Division, Highways Agency
(Mr R Stewart)**

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LITERATURE REVIEW OF HOV LANE SCHEMES

EXECUTIVE SUMMARY

To date, High Occupancy Vehicle (HOV) lanes have only been implemented in the UK on short sections of dual carriageway (in Leeds and South Gloucestershire). The Highways Agency is looking to pilot an HOV lane on the strategic road network. HOV lanes have been used successfully in other countries (primarily in the USA, but also in Spain and Australia).

A number of potential UK sites were identified including the southbound section of the M1 between Junctions 10 and 7. It has subsequently been decided that an HOV lane should be implemented on both carriageways of the M1 between Junctions 7 and 10 because of the favourable business case. The HOV lane will be implemented as part of the planned widening of this section of motorway, which is scheduled to commence in November 2005.

This report reviews existing schemes, both within the UK and overseas. The objective of the review is to identify areas where previous experience could be relevant to the design, operation and monitoring of the M1 HOV scheme. Examples of these areas are:

- The position of the lane on the road, lane markings and signing.
- The types of vehicles allowed in the lane and the times of operation.
- Enforcement policies and techniques.
- Details of any monitoring carried out, including the types and quantity of data collected and the methodology for analysing the data.
- Publicity for and marketing of the schemes.

DESIGN OF SCHEMES

It was found that there is no standard design for the layout of HOV lanes or their operation. The type of layout, either concurrent, contra-flow or separated, and whether the HOV lane is an additional lane or uses an existing lane, depends on the amount of road space available. The times of operation depend on the traffic patterns including the direction of peak flows. The types of vehicles allowed in the lane depend on the vehicle composition, and the minimum occupancy of a vehicle depends on the amount of peak traffic. However, for all schemes identified, buses are always allowed to use the HOV lane, and HGVs are consistently banned from the HOV lane. Integration with the surrounding network through the implementation of public transport systems is considered key for the success of HOV schemes.

SAFETY

The safety of American concurrent HOV lanes has been studied. Results showed that an eight foot buffer¹ raised by six inches was the safest layout of those evaluated. Narrower buffers (not raised) typically cause an increase in accident rates as did wider buffer lanes. Wide

¹ Separated flow HOV lanes are separated from the general purpose (GP) lanes by either a physical barrier or a wide, painted strip of road, known as a buffer.

buffers can substantially separate traffic flows but may be mistaken for running lanes. Therefore, the USA research does not recommend wide (non-raised) buffers.

EVALUATION

If the purposes of the scheme are not clearly defined at the outset, there is a risk that inadequate data will be collected. Therefore meaningful conclusions cannot be made, and it will not be possible to prove whether the goals have been met. It is also important to consider the surrounding network and general purpose (GP) lanes when assessing the impact of an HOV lane.

There were no standard methods for evaluating HOV schemes. However, ongoing monitoring and assessment is vital for continuing successful operation of HOV lanes as congestion increases. Knowing the effectiveness of a HOV lane will help with future policies, e.g. increasing the minimum number of passengers, imposing time restrictions or implementing HOV schemes on other roads. Public opinion surveys after the opening of a scheme may highlight ways in which the number of users can be increased.

No information on cost benefit analysis has been found for the schemes reviewed.

ENFORCEMENT

HOV lanes must be enforced for them to be successful. Enforcement techniques include automated and manual video surveillance, automatic vehicle identification, infrared technology and patrols as well as self-enforcement. Many areas have set up the HERO programme where motorists are encouraged to report misuse of the HOV lanes.

The penalties should be high enough to discourage violation. In Georgia, USA, fines increase from \$75, for the first offence, to \$150 plus one point on the driver's licence, for the fourth offence. Fines for HOV lane violations in Austria are €21.

MARKETING AND PUBLIC PERCEPTION

Public awareness and understanding of HOV lanes and their purposes is key for their acceptance and continued legal use. It is vital that proposed HOV schemes be extensively marketed and the public are aware of how to use the lanes and also what changes in traffic behaviour are expected. It is important that the public be given a complete picture of any benefits or disbenefits.

Ideally marketing should begin well in advance of a scheme's opening. Aims of marketing campaigns have been to gain support from stakeholders and to encourage potential HOV users. Marketing campaigns for those schemes reviewed in the literature have included poster, newspaper, radio and television advertising campaigns. Information was also sent to local residents.

LITERATURE REVIEW OF HOV LANE SCHEMES

1. INTRODUCTION

To date, High Occupancy Vehicle (HOV) lanes have only been implemented in the UK on short sections of dual carriageway (in Leeds and South Gloucestershire). The Highways Agency is looking to pilot an HOV lane on the strategic road network. HOV lanes have been used successfully in other countries (primarily in the USA, but also in Spain and Australia).

A preliminary study into suitable locations for HOV lanes in the UK identified a number of potential sites including the southbound section of the M1 between Junctions 10 and 7. It has subsequently been decided that an HOV lane should be implemented on both carriageways of the M1 between Junctions 7 and 10 because of the favourable business case. The HOV lane will be implemented as part of the planned widening of this section of motorway, which is scheduled to commence in November 2005.

A work package has been established to review the objectives of installing the HOV lane, to determine a potential assessment strategy for the HOV Pilot scheme, to produce a draft specification describing the recommended monitoring requirements, and to carry out a systematic review of existing HOV schemes.

This report presents the findings of the review of existing schemes, both within the UK and overseas. During the feasibility study for the HOV Pilot scheme, information was obtained on several existing HOV schemes (Kellogg, Brown and Root (KBR), 2004). Additional information on these schemes has been obtained and further schemes, not identified during the feasibility study, have been discovered.

An international literature review has been carried out into previous work that has been undertaken on the implementation and evaluation of HOV lanes. The objective of the review is to identify areas where previous experience could be relevant to the design, operation and monitoring of the M1 HOV scheme. Examples of these areas are:

- The position of the lane on the road, lane markings and signing.
- The types of vehicles allowed in the lane and the times of operation.
- Enforcement policies and techniques.
- Details of any monitoring carried out, including the types and quantity of data collected and the methodology for analysing the data.
- Publicity for and marketing of the schemes.

The literature for this study has been collected via the TRL Information Centre, which contains bibliographic references and abstracts of English and foreign language articles from journals, books and research reports. It is the English language version of the world-wide International Transport Research Documentation (ITRD) database and therefore regularly receives material from the USA, Australia, Scandinavia, the Netherlands, Canada and other countries in addition to the UK input. The internet has also been used to find articles containing key phrases relating to the field. The amount of literature found on issues relating to HOV lanes has been huge, and much of the research is American based. Much of the information found is general HOV information from local transportation authority websites and online magazine articles. However, a large proportion of research has been done by the

Federal Highway Administration (FHWA) and various universities and these are the reports this literature review has largely focused on.

The majority of the information found is research of American HOV schemes. Section 2 focuses on the design, safety, evaluation, enforcement, marketing, public perception and environmental affects of various American schemes. This section also considers recommendations for the integration of American HOV schemes.

The UK schemes, including the M4 bus lane, are discussed in Section 3.

Other schemes in the rest of Europe and worldwide are discussed in Sections 4 and 5.

The conclusions and summary of the literature review are given in Section 6.

2. USA

The first HOV lanes were opened in Washington, D.C., and Virginia in 1969 (Jasek, 2002). The FHWA website (FHWA, 2005a) shows that there are 136 HOV schemes in the USA, in 19 different states, covering 1139 miles (1256 lane miles), and a further 105 proposed sites covering 966 miles (1970 lane miles).

2.1 DESIGN OF SCHEMES

There are three designs of HOV lanes used in the USA (Jasek, 2002). These are separated flow, contra-flow and concurrent flow lanes.

2.1.1 Separated flow HOV lanes

Separated flow HOV lanes are separated from the general purpose (GP) lanes by either a physical barrier or a very wide, painted strip of road, known as a buffer. These HOV lanes are most commonly reversible flow lanes to help ease the morning traffic into, and the evening traffic out of an area. They are also used for two-way traffic, and often have their own merge/ diverge ramps.

2.1.2 Contra-flow HOV lanes

Contra-flow HOV lanes use an existing lane on the off-peak carriageway for traffic in the peak direction. This is usually the offside lane. A moveable barrier is used to separate the contra-flow and GP lanes during peak hours. This type of lane is generally a bus only lane, however, HOV versions exist in several locations including Honolulu, New Jersey and Boston. Contra-flow lanes generally operate in peak hours only. Often overhead signals on gantries are used to indicate that the lane is in operation. Signs carrying information on the operating times are located at merge points to the road and also reminders are placed along the carriageway.

2.1.3 Concurrent flow HOV lanes

The most common design of HOV lane is a concurrent flow lane. This is a lane in the same direction of travel as the GP lanes on the same carriageway. Like the contra-flow lanes, it is usually the offside lane. It is not physically separated from the GP lanes, but rather there is a narrow buffer, or markings on the road. Concurrent flow lanes are often referred to as diamond lanes because of the markings on the road (see Figure 1).



Figure 1. A concurrent flow HOV lane in the offside lane (METRO, 2002a). This lane has no buffer.

Of the existing HOV lanes in the USA approximately 15% are separated flow, 5% contra-flow and 80% concurrent flow lanes. Approximately 30% operate 24 hours a day (these are mainly concurrent lanes) and 70% are operational in either the morning peak or the evening peak period, or both. These details are summarised in Table 1. Full details of all the USA and Canadian sites can be found on the FHWA website (FHWA, 2005a).

Table 1. Types of HOV lanes in the USA

Type of HOV lane	Percentage of USA schemes (approximate)	Type of HOV lane	Percentage of USA schemes (approximate)
Separated flow	15%	24 hours a day	30%
Contra-flow	5%	Peak hours only	70%
Concurrent flow	80%		

2.1.4 Signing

The signing of HOV lanes should be made as consistent as possible to avoid confusion. Sign legibility is important; they should be recognisable and easy to understand. The Georgia Department of Transportation (GDOT) recommend that HOV signs are placed overhead where possible (GDOT, 2003a).

2.1.5 Vehicles allowed

Depending on the level of congestion experienced on the road, HOV lanes have different minimum occupancy requirements. Approximately 86% of HOV lanes are 2+ occupants per

vehicle lanes and the rest are for 3+ occupants only. Also, the type of vehicles allowed in the HOV lane varies. All the schemes allow buses and approximately 20% of the USA's HOV lanes are bus only lanes. Most HOV lanes do not allow HGVs regardless of occupancy. Other HOV lanes allow under-occupied, ecologically friendly cars, such as electric vehicles, whilst other schemes insist that a vehicle must always meet the minimum occupancy requirement regardless of the vehicle type.

In 1986, the FHWA carried out a survey of HOV lanes (Jasek, 2002). The main reasons for implementing restrictions on types of vehicle and minimum occupancy included:

- To improve highway operations;
- To reduce accidents.

2.1.6 Managed HOV lanes

Managed HOV lanes are those with, for example, restrictions on minimum vehicle occupancy dependent on time of day. The I-10W Katy Transitway in Houston is restricted to 3+ vehicles during peak hours and 2+ at all other times. When the number of occupants required for an HOV vehicle is increased from 2+ to 3+ this causes 80% of original HOVs to return to the GP lanes (Martin *et al.*, 2004).

Some HOV lanes include tolls (known as Higher Occupancy Toll or HOT lanes) for vehicles under the minimum occupancy that wish to use the lane. Some bridges in San Francisco waive tolls for HOVs in peak hours. The idea of a HOT lane is to improve lane utilization by selling any unused capacity. To be successful they should be implemented along with an existing HOV lane as a HOT lane is not self-supporting. Dynamic tolls ensure that the extra traffic paying to use the HOV lane will not exceed the excess capacity. As the traffic flow on the HOV lane increases, the toll will also increase thus reducing the number of drivers willing to pay. Dynamic tolls can vary as often as every five minutes. Concerns of legality (legislation is needed to criminalise non-payment), equity and public acceptance (users may feel they are being taxed twice to use a road) are associated with HOT lanes (Jasek, 2002).

It is not recommended that HGVs be allowed to use the excess capacity on the HOV lanes (Jasek, 2002).

2.2 SAFETY

The safety of several concurrent HOV lanes was investigated on behalf of the FHWA (Case, 1995). The purpose of the study was to determine the safety effects of HOV implementations and to recommend the safest measures to be used to separate HOV lanes from general purpose traffic. The different layouts considered were:

- 0-2 foot buffer (Figure 2).
- 3-8 foot buffer (Figure 3).
- 8 foot buffer. The buffer is raised by 6 inches from the adjacent lanes.
- 13 foot (full) buffer.



Figure 2. HOV lane with 0-2 foot buffer (Case, 1995).



Figure 3. HOV lane with 4 foot buffer (Case, 1995).

It should be noted that the results for the last three layout designs (not including the 0-2 foot buffer) are based on only one freeway each.

It was concluded that only the 8 foot buffer, with a buffer height of 6 inches, (Alameda 580, San Francisco) resulted in a drop in accident rates similar in magnitude to that associated with the addition of a GP lane. (The construction of an extra GP lane, by narrowing the shoulder or existing lanes, is reported in the USA to cause the accident rate to drop by 29% on average.) The traditional 0 to 2 foot buffer did not result in a drop in accident rates. Moreover, this type of HOV layout typically caused an increase in accident rates. This was

also evident in the evening peak period for the 13 foot buffer (I-10, San Bernardino Freeway, LA). The 3 to 8 foot buffer (I-405, LA area, Orange County) results were inconclusive due to problems inherent in the use of the control sections.

The Texas Transport Institute (TTI) (Jasek, 2002) suggested that an HOV lane should not increase the accident rate and, furthermore, the accident rate should be lower on such lanes. However, if the HOV lane is constructed from an existing lane it may not be realistic to assume that the accidents rate will drop.

Wide buffers can substantially separate traffic flows and provided refuge areas for breakdowns. However, buffers greater than four feet are not recommended as enforcement may prove a problem; motorists may mistake it for a running lane (Fuhs, 1990).

A 25mph difference between the traffic speeds in consecutive lanes may pose problems for vehicles entering the HOV lane (Stokes *et al.*, 1984). “When undue deceleration or acceleration by leaving or entering traffic takes place directly on the highway... it disrupts the flow of through traffic, and often is hazardous” (American Association of State and Transportation Officials, 1990). Also the ability to continuously merge and diverge to and from an HOV lane can increase the accident rate and may create enforcement problems (Fuhs, 1990 and Stokes *et al.*, 1984).

It is often noted that HOV traffic does not operate at the high speeds expected relative to the volume of traffic. Free flowing HOV traffic next to a congested GP lane is usually travelling at less than the speed limit. This is known as a “sympathy speed” (Martin *et al.*, 2004). The HOV driver is unwilling to drive faster because of the uncomfortable difference in speeds. On concurrent HOV lanes with a narrow buffer, a car from the GP lane may enter the HOV lane at any time. The drivers in the HOV lane may drive at a reduced speed in order to account for any sudden merging from the GP lane. The greater the separation between the GP and HOV lanes, the less likely HOV vehicles are to reduce their speed ‘sympathetically’.

2.3 EVALUATION

The methodology used to assess and evaluate HOV lanes in the USA is often not reported in the literature. In particular, the quantities of data collected are not specified, nor is the method of analysing the data. However, traffic volume, vehicle occupancy, speeds, travel times and their reliability, throughput of HOV lanes versus GP lanes, violations and public attitudes towards the scheme are typically assessed.

Several schemes were analysed by Martin *et al.* (2004). These are outlined below.

In May 2001, 16 miles of 24-hour HOV lane were opened on the I-15 in the Salt Lake City Valley, Utah. Both northbound and southbound carriageways included a single-lane HOV lane separated from four GP lanes by striping. HOVs (with 2+ occupants) are allowed continuous entrance and exit from the GP lanes, with one HOV-only merge/ diverge ramp on the southbound carriageway.

Martin *et al.* (2004) undertook a two year study evaluating the HOV lane performance. Their findings indicated that the number of people using the HOV lane during the afternoon peak period was equal to that of a GP lane, but the HOV lanes carried 66% less vehicles. However, for the rest of the day, the GP lanes carried more people than the HOV lanes. During the first year of the scheme the average vehicle occupancy on the surrounding network (the I-215), and on non-HOV sections of the I-15, remained the same as before the opening of the HOV lane. In the HOV lane sections of the I-15, the overall vehicle occupancy increased by 17%,

from 1.1 to 1.3 people per vehicle. This indicated that the HOV lane had encouraged people to car share.

The HOV lanes showed a 13% travel time saving in the morning peak period and a 30% saving during the afternoon peak period. Moreover, the HOV lane travel times were more consistent and reliable than those associated with GP lane travel.

National HOV violation rates are between 5% and 10%. After an initial reduction in violation rates the HOV lanes on the I-15 stabilised at 5% to 13%, with 20% violation rates at the HOV-only merge/ diverge ramp.

There are over 1060 miles of HOV lane in California carrying an average of 2500 people per hour in peak hours. However, in terms of number of vehicles, this is only two thirds of the capacity of the HOV lanes. State wide car sharing information is unavailable but regional data shows that HOV lanes do encourage car sharing.

The I-10W Katy Transitway in Houston originally opened a HOV 2+ lane, which, after monitoring, was increased to 3+ during peak hours. Conversely the HOV lane on the I-66 in North Virginia was originally opened as a 3+ lane but was later relaxed to 2+ after very few motorists took advantage of the lane. This increased the vehicles in the HOV lane by 60% (1,700 veh/lane/hr).

In Oregon, the I-5 was evaluated before and after the introduction of an HOV lane. This concluded that HOV users saved eight to ten minutes along the entire length of the scheme. The HOV lane carried 2,600 people per hour compared to 1,700 carried by a GP lane. Violation rates were 8%, which is within the national average.

Seattle's Puget Sound area has more than 200 miles of HOV lanes. Over 800 miles are planned by 2030. Congestion in this area occurs for 14 hours a day. Around midday the HOV lanes carry the same number of people as the GP lanes in, on average, 700 to 900 vehicles per hour.

In November 1998, two HOV schemes in New Jersey were decommissioned due to opposition. The I-287 HOV lane was under-used (400 vehicles per hour) and thus did not solve the congestion problem in the area. Although the I-80 HOV lane was heavily used (more than 1000 vehicles per hour), it was also closed due to the heightened political opposition. The percentage of traffic that these figures represent are not given. There are several other reasons why an HOV lane fails to produce time savings. For example, the HOV lane demand may be too high, thus the lane becomes congested (in this case the minimum vehicle occupancy might be raised), or the merge/diverge area becomes congested causing tailbacks along the HOV lane (METRO, 2002).

The above schemes are summarised in Table 2.

Table 2. Summary of the USA HOV Schemes.

Scheme	Design	Results of Scheme
I-15 Salt Lake City	Separated HOV lane 2+ occupants 24 hours operation	<ul style="list-style-type: none"> • In PM HOV lane carried same number of people as GP lane by 66% less vehicles; • Vehicle occupancy on I-15 increased by 17% and remained constant on surrounding network during 1st year; • 13% travel time saving in AM and 30% in PM; • Resulting travel times were more reliable.
I-10W Katy Transitway	2+ outside peak hours 3+ during peak hours	<ul style="list-style-type: none"> • 45% of people using the Transitway are bus users.
I-66 North Virginia	2+ occupants	<ul style="list-style-type: none"> • The change from 3+ to 2+ increased usage of the HOV lane by 60% (1,700 veh/lane/hr).
I-5 Oregon	(no details given)	<ul style="list-style-type: none"> • Drivers save 8-10 minutes along the length of the scheme; • HOV lane carries 65% more people than a GP lane; • Low violation rates.
I-287 New Jersey	No longer in use	<ul style="list-style-type: none"> • Decommissioned as lane use by only 400veh/hour.
I-80 New Jersey	No longer in use	<ul style="list-style-type: none"> • Lane used by 1000veh/hr but decommissioned due to public disillusionment after I-287 failure.

The Texas Transport Institute (TTI) conducted a survey of HOV lane projects. Turnbull *et al.* (1991) reviewed the current before and after evaluation methods in order to provide an overview of commonly used measures and techniques. However, no standard methods were apparent. HOV lane evaluation methods were extremely varied with adequate before and after data not always being collected. Initial evaluations may have been carried out shortly after a scheme had opened, yet ongoing monitoring may not have been done. On many HOV schemes formal evaluations have never been done, nor are they likely to be in the future.

If the purposes of the scheme are not clearly defined at the outset there is a risk that inadequate data will be collected, the goals will be unachievable and meaningful conclusions cannot be made. It is also important to consider the surrounding network and GP lanes when assessing the impact of an HOV lane. Turnbull *et al.* (1991) suggest that a comparison between what the effect of adding an extra lane would have been, rather than the HOV lane, may be useful.

Many factors such as which vehicles are allowed to use the HOV lane, the vehicle occupancy required, hours of operation, enforcement techniques, incident management and ingress/ egress points all need to be considered. In addition to flows, times, speeds etc (see above)

measured, the schemes reviewed by Turnbull *et al.* (1991) used the following methods to evaluate HOV lanes:

- Monitoring of bus schedule adherence;
- Monthly bus data (including passenger levels, operating statistics, revenues and costs);
- Park and ride counts;
- Changes in commuter behaviour and reasons;
- Changes in public perceptions;
- Vehicle occupancy counts;
- Accidents;
- Classification of types of vehicles;
- Licence plate surveys;
- Violation rates (whether these are repeat offences);
- Safety;
- User and non user surveys.

Turnbull *et al.*, suggest the following approach to evaluating HOV lanes:

- Clear articulation of project goals and objectives;
- Identification of measures of effectiveness;
- Identification of information needed;
- Development of the study design;
- Conduct “before” data collection;
- Conduct “after” data collection and evaluation;
- Ongoing monitoring and evaluation.

More details can be found in *Suggested Procedures for Evaluating the Effectiveness of Freeway HOV Facilities* (Turnbull *et al.*, 1991).

Ongoing monitoring and assessment is vital for continuing successful operation of HOV lanes as congestion increases. Knowing the effectiveness of a HOV lane will help with future policies, e.g. increasing the minimum number of passengers, imposing time restrictions or implementing HOV schemes on other roads (Turnbull *et al.*, 1991).

2.4 ENFORCEMENT

Violation rates increase where GP and HOV lanes merge and at HOV-only diverge/merge areas. Getting into the desired lane a little too early is not perceived by drivers to be a true violation. Concurrent flow HOV lanes generally have the highest violation rates and therefore need greater levels of enforcement (Jasek, 2002).

Low violation rates are a good reflection of the public’s acceptance of a scheme. Also a high rate of violations may discourage legal users, if they feel the benefits of an HOV lane have

been reduced. However, proper use of HOV lanes, particularly concurrent lanes with continuous ingress and egress for HOVs, is difficult to enforce. A visible enforcement presence must be maintained. Where practical (i.e. for separated flow lanes), enforcement officers should be located at terminal points.

The TTI (Jasek, 2002) lists the elements critical for enforcement to be successful:

- The agency responsible for enforcement must have legal authority to do so.
- The penalties associated with violation must be appropriate.
- Any penalties should be high enough to discourage violation.

If the penalties are not high enough, repeat violations might not be deterred, and in effect drivers could use a low fine as a toll.

The Department of Motor Vehicle Safety (DMVS) is one agency responsible for enforcing the HOV lane restrictions in Georgia (Department of Motor Vehicle Safety, 2004). Fines and penalties for HOV violations are:

- First Offence: \$75 maximum (plus court fees);
- Second Offence: \$100 maximum (plus court fees);
- Third Offence: \$150 maximum (plus court fees);
- Fourth Offence: \$150 maximum (plus court fees), and one point on driver's licence.

Enforcement techniques include automated and manual video surveillance, automatic vehicle identification, infrared technology and patrols as well as self-enforcement. Often local police have other duties to perform and so HOV violation may not be a high priority. Video surveillance can have added advantages when it comes to the prosecution of violators. Also video evidence can be sent to first time violators in order to deter repeat offences.

Many areas (including Washington, D.C., Houston and Seattle) have set up the HERO programme where motorists are encouraged to report misuse of the HOV lanes. First time offenders are usually sent educational information on how to use the lanes properly. Further offences result in personalised letters recording the location and time of the violation. The aim of the HERO programme is not to prosecute the violators, but rather to educate them in the proper use of HOV lanes and to reduce the likelihood of repeat offences.

During 2000, there was a 49% increase in violations citations on the HOV lanes in Puget Sound, Seattle. The HERO programme also saw an increase in the amount of reported violations. The decrease in repeat offenders is attributed to this programme. Exact figures are not reported.

2.5 MARKETING AND PUBLIC PERCEPTION

Public awareness and understanding of HOV lanes and their purposes is key for their acceptance and continued legal use. Many schemes in the USA have come under criticism from the public. This may be due to confusion caused by lack of education on HOV use, or limited knowledge of the scheme's purpose. Therefore it is vital that proposed HOV schemes be extensively marketed and the public are aware of how to use the lanes and also what changes in traffic behaviour are expected.

It is important that the public be given a complete picture of any benefits or disbenefits as, in the past, incorrect conclusions have been drawn from published articles where incomplete data has been given. This lack of data has been interpreted as a cover-up by the local authorities who may be thought of as trying to hide disbenefits of a scheme.

Szoboszlay (1998 and 2000) criticised local transportation authorities for not publishing single occupancy vehicle (SOV) statistics. Szoboszlay reported that, on the Montague Highway, the number of SOVs per day increased by 4562 whereas the HOVs increased by 1207. The number of SOVs was not included in the Santa Clara County Transportation Agency (SCCTA) general plan for transportation (report T2010), thus giving the impression that the HOV increase was greater. Szoboszlay acknowledged that an increase in all types of vehicles would be expected after the adding of the extra (HOV) lane, but criticised the SCCTA for not giving all the information. In such cases, public opinion of a scheme may fall if it is felt that statistics are being manipulated.

Several HOV lanes have been criticised for “empty-lane syndrome”, or perceived under-utilisation where local road users saw the lanes as wasted road space (Martin *et al.*, 2004). In November 1998, two HOV schemes in New Jersey were decommissioned. The I-287 closure was attributed to the lack of congestion in other lanes, thus there was no incentive to use the HOV lane. Although the I-80 HOV lane was heavily used, it was also closed due to the heightened political opposition. The public was not sufficiently prepared for the opening of these lanes, therefore an adequate market did not exist. After the failure of these HOV lanes, New Jersey started a large marketing campaign, through the media, to promote a new HOV lane. The idea was to increase public awareness and confidence in the HOV lane purpose, to publicise accurate expectations and to encourage car sharing. Television, radio, press conferences, mailings, fliers left on windscreens and information accompanying licence renewal forms were used in the campaign.

Marketing for the Long Island Expressway HOV lane started far before the 1994 opening. The two aims of the marketing campaign were to gain support from stakeholders and to encourage potential HOV users. Both private and public interests were taken into account during the early planning stages in order to maximise support for the scheme.

The opening of an HOV lane in Tennessee in 1993 was preceded by a successful poster, newspaper, radio and television advertising campaign. Information was also sent to the local residents.

A public survey of the HOV lanes in Puget Sound, Seattle showed that 95% of HOV users thought the scheme was “a good idea” and 72% agreed with the introduction of the scheme. The survey identified key areas where the public wanted to see improvements. These included better enforcement and increased bus services (Martin *et al.*, 2004).

The marketing of HOV lanes is best presented to the public in terms of time saved, reliability of journey times and safety. Violation rates are a good reflection of the public’s acceptance of a scheme. However, these are often overestimated and as such the public feel that acceptance of the scheme is low. Commuters must be made aware of the purpose and expectations of the scheme in order to dismiss any misconceptions. They must also understand that violators will be prosecuted.

Public surveys after the opening of a scheme will draw attention to why people are not using the HOV lanes, and may highlight ways in which the number of users can be increased. Ongoing monitoring and assessment of the HOV lanes is essential as it will aid continuous public acceptance of the scheme.

2.6 ENVIRONMENTAL ISSUES

HOV lanes are thought to show benefits for the environment because car sharing reduces fuel consumption and emissions. However, there may also be opposition against land use for the construction of extra lanes. In the mid 1990s several groups opposed the construction of an HOV lane in New York arguing that the widening of the road would encourage a greater dependence on vehicles and not be an efficient use of land. A media campaign against the HOV lane saw the Department of Transport being ordered to stop the project (Jasek, 2002). This opposition may have been avoided if a stronger, more sophisticated, marketing campaign had been in place.

2.7 INTEGRATION

The intention of HOV facilities is not to force individuals into making changes against their will. Rather, the objective is to provide a cost-effective travel alternative that a significant volume of commuters will find attractive enough to change from SOVs to HOVs (Turnbull, 1992). Successful HOV lanes must not simply divert existing HOVs from GP lanes to the HOV lanes, but must also encourage people to switch from SOVs to HOVs, resulting in a higher occupancy.

Integration of alternative transport system, such as comprehensive bus services, may encourage people into the HOV lanes. "HOV lanes are most successful when complementary services... are incorporated into the network" (GDOT, 2003b). Park and ride facilities are convenient meeting points for car sharers. In America it has become quite common for people to 'slug' (Slug-Lines, 2004). This describes a form of casual car sharing much like hitch-hiking. People queue at designated spots (often known through word of mouth) to wait for a driver, wishing to use the HOV lane, also travelling in the same direction. This service is free to the passengers as the driver benefits from the use of the HOV lane.

3. UK

In the UK there are only two HOV lane schemes currently in use, both of which are on A-class roads. Although not specifically an HOV lane, there is also a bus lane on the eastbound M4 between Heathrow and London.

3.1 A647, LEEDS

In Leeds, a GP lane in the nearside lane of the A647 (see Figure 4) has been redesignated an HOV 2+ lane (including buses, coaches, motorcycles, pedal cycles and 2+ vehicles, but not HGVs over 7.5Tonnes) and is in operation at peak periods only (between 07:00 to 10:00 and 16:00 to 19:00) (Department for Transport (DfT), 2005). The initiative was from Leeds City Council. This scheme is 1.5km long (in two lengths of inbound lane) on a 2km length dual carriageway. The scheme was opened in 1998.



Figure 4. The start of the Leeds HOV lane (Leeds City Council (LCC), 2002).

Advance signing is provided at the approach to the HOV lanes (see Figure 5). Traffic signal control is provided at the end of the HOV lane to manage merging traffic from both lanes.



Figure 5. Leeds' HOV lane signing (LCC, 2002).

The objectives of the scheme were to increase car occupancy by encouraging car sharing and to demonstrate the feasibility of such a scheme. Police enforcement lay-bys and speed cameras are in operation. Extensive monitoring has taken place in the form of flow measurements, vehicle occupancy, journey times, accident rates, enforcement, public attitudes and air quality.

The results of monitoring have shown a reduction in inbound journey times for buses and other high occupancy vehicles of 4 minutes in the morning peak. A reduction in the inbound journey times for the GP lane of 1.5 minutes is reported. Increases have occurred, in bus patronage and average car occupancy, from 1.35 in May 1997, to 1.43 in June 1999 and to 1.51 in 2002 (DfT, 2005). There has also been a reduction in the number of accident casualties and a reported low level of violation (less than 6%). In the light of these results, the scheme has been deemed a success.

3.2 A4174, BRISTOL

Another scheme exists in the nearside lane of the A4174 Avon Ring Road at Hambrook, on the northern fringe of Bristol (see Figure 6). This 2+ HOV lane is approximately 1.75km in length (MRC, 2005). Opened in 1998, and later expanded in 2000, it reassigned a lane to HOVs from an existing dual carriageway road and operates during morning peak hours. This scheme allows buses and coaches, motorcycles and cycles in addition to high occupancy cars and vans, but not HGVs over 7.5 Tonnes.



Figure 6. Signing on the A4172 (2carshare, 2005)

3.2.1 Evaluation

The peak hour average vehicle occupancy (AVO) has increased since the scheme was introduced, as shown in Table 3.

Table 3. Average vehicle occupancy increase.

	3+ occupants	2 occupants	SOV
Before	3%	17%	80%
After	2%	28%	70%

Traffic flows have increased by 40% since the scheme's opening. Time saving benefits were approximately 30% in 1999 and 50% in 2000 and violations were approximately 7% in 2000 (MRC, 2005). Times and flows are not given; only percentages.

3.2.2 Marketing

A three-year marketing plan to increase car sharing has included roadside and media advertising, road-shows and employer incentives. South Gloucestershire Council have actively promoted their on-line car sharing scheme, www.2Carshare.com, along with the HOV marketing exercise. This has reportedly led to a marked increase of use of the web site. Enforcement is carried out by the police, and compliance is reported as good.

3.3 M4 BUS LANE

In June 1999, 6km of bus lane on the M4 began operation in the offside lane (see Figure 7). The scheme's main objectives were to encourage the use of public transport, to reduce journey times of buses and increase safety on the M4 section. The scheme operates between junctions 3 and 2 on the M4 eastbound carriageway (into London) with speed restrictions of 50mph (40mph where the bus lane merges with the general purpose lanes). The bus lane is reserved for buses, coaches and taxis only.

In July 2002, the speed restriction was raised from 50mph to 60mph (the 40mph limit at the merge area was retained). In addition, motorcycles were permitted to use the bus lane.



Figure 7. The M4 bus lane (Rees *et al.*, 2000)

3.3.1 Signing

The bus lane is distinguished by a red road surface, with the words “BUS LANE” at regular intervals (see Figure 7). There are also signs showing a picture of a bus, together with the word “Taxi” (in 2002, a picture of a motorcycle was added).

For the first few weeks after the bus lane was first opened, EMS messages were displayed informing drivers that the bus lane was operational.

3.3.2 Evaluation

The first year of the scheme was monitored by Rees *et al.* (2000) using before and after data from the M4 and adjoining network. For each vehicle type the occupancy, flow and journey times were analysed. The main results were:

- Average journey times during peak periods have decreased by 3 minutes for buses and 1 minute for cars.
- Journey times in off-peak periods have increased because of the speed restrictions.
- Journey times are more reliable.
- There is an overall benefit of 200 person-hours per weekday.
- There is a disbenefit of 350 person-hours per weekend day because of the speed restrictions.
- The new road layout has eased the bottleneck where three lanes of traffic merged to two. Instead of queuing, traffic is now stop-start.

- The surrounding network has not been adversely affected.
- On average, 3700 vehicles a day use the bus lane. Of these, 3100 are taxis, 500 are buses or coaches and 100 are minibuses.
- On average, 7% of vehicles in the bus lane contain 21% of the people.
- The general public perceives that too few vehicles are using the bus lane.

Any benefits were expressed in person hours and no cost benefit analysis was done.

“Lane friction” was observed during times of congestion. Traffic in the bus lane would travel slower than necessary, at a sympathy speed (see Section 2.2), while traffic in the GP lanes was stationary.

The performance of the scheme was reassessed after four years of operation (Rees, 2003). The bus lane scheme continued to meet most of the objectives set out before the scheme was installed. The saving in journey times during peak periods was still present, although it varied considerably from year to year.

The increase in the speed limit from 50mph to 60mph had only a small impact during off-peak periods, as traffic speeds between Junctions 4 and 2 were already close to 60mph. During peak periods, it was not expected that journey times would benefit from the increase in speed limits, as drivers cannot usually travel in excess of 50mph.

Following the opening of the bus lane to motorcycles, 100 motorcycles per day were detected using the bus lane. The presence of the motorcycles had no impact on the operation of the bus lane.

3.4 PROPOSED SCHEMES

Other UK Authorities are considering HOV schemes, including Sandwich in Kent. An HOV lane is being introduced northbound on the A370 Long Ashton Bypass in North Somerset. This HOV lane will operate during the morning peak.

Further information might be obtained on the UK schemes by visiting the sites. At the current time, site visits are not felt necessary, as the sites are both on A-class roads. Any required information should be available via phone or email from the person responsible for each site.

4. THE REST OF EUROPE

4.1 SPAIN

From mid-1970 in Madrid, the number of cars on the roads has increased yet few facilities existed to deal with the extra flow. An HOV lane has been operational since 1994. The lane is divided by physical barriers and covers a distance of 40km (Institut für Landes- und Stadtentwicklungsforschung und Bauwesen (ILS), 2000).

The results from this scheme have been positive. The travel times were drastically reduced for the HOV lane and as a result the percentage of 2+ vehicles increased from 30% to 40% in the first year. The average vehicle occupancy increased from 1.36 to 1.47 after implementation. Also public transport use increased by 40% in the morning peak period in the first year (ILS, 2000). These results are summarised in Table 4. No information on the percentage of SOVs is given.

Table 4. Summary of Spanish improvements.

Benefits/ Disbenefits	Result
2+ vehicles	From 30% (before) to 40% (after)
AVO	From 1.36 persons (before) to 1.47 persons (after)
Public transport usage	Increase of 40%

Due to this scheme there was an increase in commercial bus speed and service regularity, a decrease in travel time, a decrease of space use, congestion, energy consumption, pollution and accidents.

No information has been found on how this scheme has been monitored, or on enforcement.

4.2 NORWAY

Norway has one HOV lane scheme, located in Trondheim (see Figure 8). The nearside lane of a four-lane arterial road was used to create the carpool lane and it was opened in May 2001. The scheme applies all day (24 hours) and is available to buses, taxis and carpools with 2 or more occupants. The total distance is 0.8 km and this HOV lane has been a low cost measure, \$80,000 USD set aside for signage, markings, information and marketing (Nordic Road and Transport Research (TN&TR), 2001).

Selection of the scheme was determined by using the American CORSIM Model, which is a microscopic traffic simulation model (NT&TR, 2001 and FHWA, 2005b). The vehicle use, occupancy requirement and the geographical extent of the HOV lane was analysed by the model.



Figure 8. The Trondheim HOV scheme

The congestion on this section was quite light, lasting for only half an hour, with delays of 5 minutes for individual vehicles (TN&TR, 2001). The primary objective was to provide more reliable and predictable travel times for carpoolers and buses. The reduction of the number of SOVs was a secondary objective.

Table 5 summarises the changes due to the HOV lane's implementation.

Table 5. Summary of Norwegian scheme.

Benefits/ Disbenefits	Result
Change in average speed (in HOV lane)	From 20km/hr (before) to 30km/hr (after)
Travel time	Reduction of 5%
Total traffic (all vehicles)	Reduction of 5% (just as many persons are transported as before)
2+ vehicles	Increased by 4%
Congestion periods	Increased by 15 minutes on GP lanes (journey times remain stable in HOV lane)
Public Perception	64% in favour (74% of bus users, 59% of car users)
Violations	8-10%

Studies to date have shown that travel times for the users of the carpool lane are short and stable throughout the day (NT&TR, 2001). For the general lane, congested periods have extended from 30 minutes to 45 minutes. The share of 2+ cars has increased from 30% to 34%. The total traffic on this arterial seems unchanged, however, it is not possible to determine whether carpoolers have been attracted from other roads. On the basis of these results the carpool lane has been deemed a success.

Attitudes to the scheme were measured and 64% of the respondents were in favour, however, this number varied when broken down by transportation mode. For instance bus passengers (74%) were more favourable than car drivers (59%) (NT&TR, 2001).

The number of violators was quite high on the first day after the opening: 23% of the vehicles in the HOV lane did not have a passenger and drove there illegally (NT&TR, 2001). By mid June the number of violators was reduced to 16% of the vehicles in the HOV-lane and one month later it was only 8%. Pavement markings introduced in July (BUS, TAXI and 2+) have

significantly contributed to the last reduction. The share of violators has stabilized on 8%-10% in the carpool lane (this is similar to the USA national average). This was achieved with no police control issuing fines for illegal driving.

A political decision was made to increase the 2+ requirement to 3+ for the scheme in November 2001. No information has been found on the effects of this change.

4.3 AUSTRIA

Austria opened an HOV 3+ lane in Linz in October 1998. This scheme was a conversion from a bus lane. The scheme is in operation 24 hours a day. Typical usage of this 2.9km section was 25 buses in the AM peak, 70 vehicles with 4+ occupants, 225 vehicles with 3 occupants and 96 violators (i.e. vehicles with less than 3 occupants). No information is given as to what percentage of the total flow these figures represent. 26% of the HOV lane users were new carpools due to the lane (MRC, 2004). This scheme uses a continuous solid white line to segregate this 'right inbound' HOV lane. There is no official sign to designate an HOV lane in Austria, therefore a bus sign is used with additional text for qualifying vehicles. The cost of this scheme was minimal as it was a bus lane conversion. This is the only HOV scheme in Austria.

Compliance was poor (MRC, 2004). Enforcement was limited due to the inability of being able to stop the vehicles as no stopping areas or hard shoulders are available. The penalty for violation is €21 (about £15).

The HOV vehicles travel the section in less than 7 minutes, whereas vehicles in the GP lane take 25-30 minutes (MRC, 2004). Buses have not experienced a reduction in travel time as a result of conversion of the bus lane to a HOV lane. The MRC report (2004) does not indicate if bus travel times have increased. HOV users save 60,000 person-hours per year and reduce CO₂ emissions by 125lt/yr.

Table 6 summarises the affects of Austrian HOV scheme.

Table 6. Summary of Austrian scheme.

Benefits/ Disbenefits	Result
Average daily violations	96
Increase in carpools	26%
Time saved by HOV users	60,000 person hours per year
CO ₂ emissions	Reduced by 125 litres per year

No specifics on the method of monitoring have been found on this scheme. However, a strong and effective media campaign was launched on the opening of the scheme.

5. OTHER SCHEMES

5.1 CANADA

Canada has a total of 23 HOV sites, in four different provinces. The Canadian sites are listed in Table 7. These sites vary in length from 0.4 km to 18 km and typically are 3+ HOV lanes, in operation during peak periods. The first HOV lane was opened in May 1991.

Table 7. Canadian HOV schemes (Schijns, 2003)

**Transportation Research Board
High Occupancy Vehicle Systems Committee – Arterial Applications Sub-Committee
Signalized Arterial Road HOV Lane Database
Part 2 – Canada**

#	Location	Prov	Road	Type ¹	Length ²	HOV ³	Hours	Open
C1	Burnaby-Vancouver	BC	Barnet-Hastings	4 lane hwy – 6 lane arterial	18 km	2+	Peak pd/ peak dir	Sep-96
C2	Burnaby	BC	Willington Ave	6 lane arterial	1.3 km	6+	24h	Sep-00
C3	Delta	BC	Highway 99 NB	Queue jump		3+	Peaks	Fall-95
C4	Delta	BC	Highway 99 SB	Queue jump		3+	Peaks	Fall-95
C5	Delta	BC	Highway 17			3+	Peaks	
C6	Pitt Meadows	BC	Pitt River Bridge			3+	Peaks	
C7	Vancouver	BC	Lions Gate Bridge	Queue jump		3+	Peaks	
C8	Vancouver	BC	Granville St	6 lane arterial		3+	Peaks	
C9	Vancouver	BC	Georgia St			3+	Peaks	
C10	Calgary	AB	Centre St	Tidal flow 4 lane arterial		2+	Peaks	Sep-00
C11	Mississauga – Toronto	ON	Dundas St	6 lane arterial	5 km	3+	Peaks	Jan-92
C12	Toronto - York	ON	Yonge St	6 lane arterial	2.8 km	3+	Peaks	Aug-93/ 1999
C13	Toronto	ON	Don Mills Rd – Overlea Blvd	6 lane arterial	11.5 km	3+	Peaks	Nov-93/ Dec-94
C14	Toronto	ON	Eglinton Ave East	6 lane arterial	11.3 km	3+	Peaks	Nov-93/ Dec-93
C15	Toronto	ON	Dufferin St / Allen Rd	6 lane arterial	3.3 km	3+	Peaks	Aug-93
C16	Toronto	ON	Pape Ave	4 lane arterial	2.1 km	3+	Peaks	Nov-93
C17	Ottawa-Gatineau	ON-PQ	Champlain Bridge	Reversible median lane on 3 lane bridge	~ 1 km	2+	12h/dir'n	Jul-02
C18	Ottawa-Gatineau	ON-PQ	Portage Bridge	Median lane SB, curb NB on 6 lane bridge	0.5 km	3+	Peaks	Nov-95
C19	Gatineau	PQ	Bldv Maisonneuve	6 lane arterial	1.1 km	3+	Peaks	May-91
C20	Gatineau	PQ	Bldv Fournier	6 lane arterial	0.6 km S 1.0 km N	3+	Peaks	Aug-96
C21	Gatineau	PQ	Bldv Alexandre-Tache	4 lane arterial	1.1 km E	3+	24h	Nov-94
C22	Gatineau	PQ	Ch d'Aylmer	4 lane arterial	4.8 km	3+	Peaks	Oct-97
C23	Gatineau	PQ	Bldv Greber	6 lane arterial	0.4 km S	3+	AM Peak	Jul-96
Total	4 areas	4	23 sites		— km	1: 6+ 19: 3+ 3: 2+	2: 24h 1: 12h 20: peaks	

1) HOV lanes are right curb lanes unless otherwise noted

2) length is per direction for two directions, unless otherwise specified

3) current operational HOV eligibility level. Some facilities have changed eligibility rules since opening.

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The Calgary site experiences tidal flow. The carriageway is four lanes wide, with an HOV lane in the nearside lane (see Figure 9). The average vehicle occupancy has increased from 1.32 to 1.39. Bus ridership has increased by 56%, and total car volume is down 32% (McCormick Rankin Corporation (MRC), 2002).

This site is specified, by signing, for buses, cars with 2+ occupants and bicycles. Prior to enforcement there was a 20% to 35% violation rate. The enforcement used is conventional policing with 267 tickets issued between January and April 2001 (MRC, 2002).

The design features include a pavement diamond, plus dashed lane lines with overhead reversible signs. The scheme operates between 07:00-08:30 southbound and 15:30-18:00 northbound.

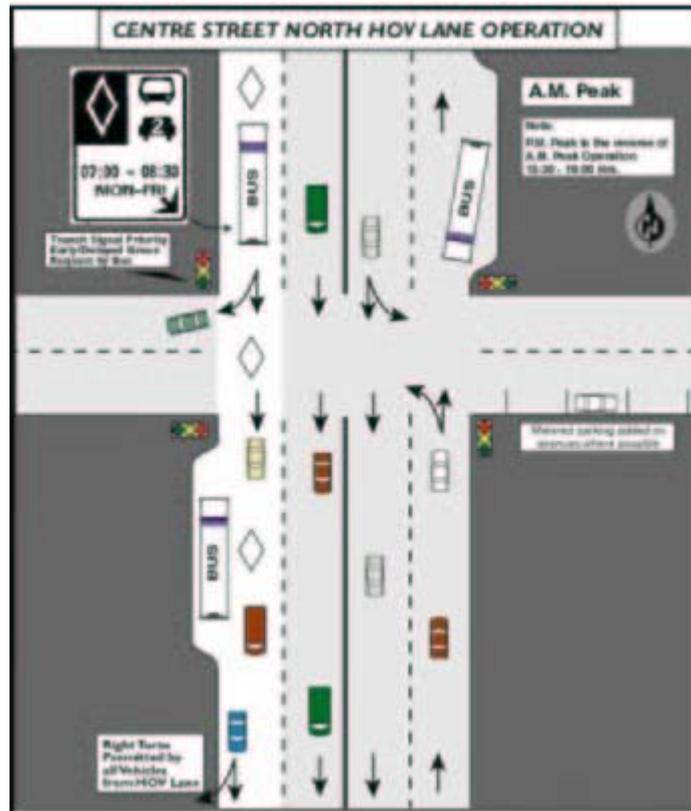


Figure 9. Calgary's HOV lane operation layout (MRC, 2002)

Publicity prior to the scheme was carried out by means of open house displays, posters on buses and shelters and adverts in newspapers. Every household received an “Escape the Rush – use the HOV lane” bumper sticker. A survey showed that the scheme was supported by 79% of the area’s residents (MRC, 2002).

No specifics have been found on monitoring of the Canadian schemes.

5.2 AUSTRALIA

Australia has 11 HOV lane schemes located in Brisbane, Melbourne and Sydney (see Table 8). The distance covered by the HOV lanes varies between inbound and outbound and, in some cases, the schemes operate inbound only into the cities. All schemes are for peak hours only with some being just for the AM peak period. The majority of schemes are for 3+ occupancy vehicles. The earliest of the schemes was implemented in 1992.

The South East Busway in Brisbane, progressively opened between September 2000 and June 2001, was the result of five years planning, design, construction and community liaison. In 1996 a market survey showed that 25% of the respondents already used the bus and another 61% would consider using the South East Busway assuming there would be improvements to convenience, frequency, reliability and safety. The decision to build the Busway system was found to cost less than the do-nothing alternative and, by the year 2011, the Busway is estimated to save taxpayers about \$62 million (Australian dollars). This scheme has also increased property values by 20% within the vicinity (Transport Research Board (TRB), 2002).

HOV and bus priority measures will significantly enhance the opportunity of success. These measures may include Road Infrastructure, Parking Facilities, Ride-Share Schemes, Information and Awareness, Marketing, Enforcement and Research and Evaluation.

According to the DPI, improved parking facilities can include reserved parking spaces, premium location or undercover parking, discounted parking fees, direct access to HOV facilities, and integration of HOV parking facilities with park and ride schemes. Information and awareness is essential for a successful scheme, it is important that key stakeholders support the need for and general principles of HOV and bus priorities prior to the introduction of specific projects. Marketing and promotion is important before, during and after the scheme's implementation to develop expectations, advertise the opening, educate and inform drivers and to promote immediate use of HOV lanes. Although voluntary compliance should be encouraged, effective enforcement is essential. Appropriate mechanisms should be in place for enforcement of HOV lanes prior to introduction of the scheme and infringement penalties should be sufficient for effective enforcement.

Ongoing research into HOV lanes is essential and up-to-date knowledge of experience elsewhere should be obtained. Ongoing evaluation of HOV lanes against scheme objectives is necessary to determine the operational success of the scheme. In addition, the results can be used in fine tuning the scheme and in marketing campaigns.

Early USA schemes on freeways typically involved expensive and extensive lane additions and physical barriers, whereas Australian HOV and bus priorities along arterials relied more on traffic management with less reliance on infrastructure and a stronger focus on shorter length schemes.

6. CONCLUSIONS

A comprehensive review of existing HOV schemes has been carried out. The review has obtained detailed information on schemes already identified during the M1 HOV Lane feasibility study, and has also discovered several additional schemes. Most of the HOV schemes are in the USA, but HOV schemes are operating in Canada, Spain, Australia, Norway and Austria, as well as two existing schemes in the UK.

The review has identified several areas where previous experience could be relevant to the design, operation and monitoring of the M1 HOV scheme. The previous experience is summarised in the following sections.

The intention of HOV facilities is not to force individuals into making changes against their will. Successful HOV lanes must not simply divert existing HOVs from GP lanes to the HOV lanes, but also provide a cost-effective travel alternative that a significant volume of commuters will find attractive enough to change from SOVs to HOVs, thus resulting in a higher occupancy and lower vehicle flows (Turnbull, 1992).

6.1 SCHEME DESIGN

There are three types of HOV lane designs:

- separated flow;
- concurrent flow and
- contra-flow lanes.

Most of the USA's HOV lanes are concurrent flow lanes separated from the GP lanes by a narrow, painted buffer. This design is similar to that planned for the M1. Over 80% of the USA's HOV lanes are 2+ lanes. All allow buses, but not HGVs. Most HOV lanes operate during peak flows only. Those operating for 24 hours are largely concurrent lane designs.

6.1.1 Signing

Concurrent HOV lanes are commonly marked with a diamond (see Figure 10) with overhead and adjacent signing indicating minimum occupancy, authorised vehicles and hours of operation.



Figure 10. A concurrent flow HOV lane, marked by diamonds, in the offside lane (METRO, 2002)

6.2 SAFETY

The safest buffer design is the 8 foot buffer with a buffer height of 6 inches. Research shows that this design results in a drop in accident rates. Narrower buffers can lead to increased accident rates as can wider buffers which may also be mistaken for a running lane.

6.3 ENFORCEMENT

Low violation rates are a good reflection of the public's acceptance of a scheme. However, enforcement on concurrent HOV lanes is difficult.

For enforcement to be successful (Turnbull *et al.*, 1991):

- The agency responsible for enforcement must have legal authority to do so.
- The penalties associated with violation must be appropriate.
- Any penalties should be high enough to discourage violation.

Penalties should be high enough to deter violations and discourage the HOV lane being thought of as a toll lane by those willing to pay the fines. In Georgia, USA, fines increase from \$75, for the first offence, to \$150 plus one point on the driver's licence, for the fourth offence. Fines for HOV lane violations in Austria are €21.

Enforcement techniques include video surveillance, automatic vehicle identification, infrared technology and patrols as well as self-enforcement. Video surveillance can have added advantages when it comes to the prosecution of violators. Evidence can be sent to first time violators which may help to deter repeat offences. HOV violation should be a high priority with visible means of enforcement.

The aim of the HERO programme, where motorists are encouraged to report misuse of the HOV lanes, is not to prosecute the violators, but rather to educate them in the proper use of HOV lanes and to reduce the likelihood of repeat offences. This programme is credited with reducing violation rate in some areas.

6.4 EVALUATION

There is little information available about the methodology used to assess and evaluate the operation of HOV lanes. In particular, the quantities of data collected are not specified, nor is the method of analysing the data. No cost benefit analysis was identified for any of the schemes.

All schemes were monitored to some extent (as would be expected for schemes reported on the internet). Data was collected before and after the schemes were installed (although for how long is not usually specified). Typical items that were measured are:

- Vehicle occupancy. This was measured for almost all schemes. Occupancies were sometimes measured in the HOV lane and GP lane separately, and sometimes across the carriageway. In a few cases, occupancies were also measured away from the HOV site (to be used as a control site).
- Traffic volume. Flows in the HOV lanes were measured for almost all schemes. Often, the total flows across the carriageway were not mentioned. This is likely to yield to misleading results as the true value of HOV traffic may not be known.
- Travel times and their reliability. Journey times in the HOV lane and the GP lanes were compared. For a few schemes, there was a statement that journey time reliability for HOVs had improved, but this was not quantified.
- Violations. For most schemes, some figures were given on violations, i.e. rogue vehicles using the lane. It is not usually made clear whether the figures are from independent observations or from enforcement statistics.

The results are normally quoted as overall figures. They are not broken down by time of day or day of week, nor are seasonal variations mentioned.

The Texas Transport Institute (TTI) conducted a survey of HOV lane projects (Turnbull *et al.*, 1991). It reviewed the current before and after evaluation methods in order to provide an overview of commonly used measures and techniques. However, no standard methods were apparent. HOV lane evaluation methods were extremely varied with adequate before and after data not always being collected. Initial evaluations may have been carried out shortly after a scheme has opened yet ongoing monitoring may not have been done. On many HOV schemes formal evaluations have never been done, nor are they likely to be in the future.

If the purposes of the scheme are not clearly defined at the outset is a risk that inadequate data will be collected. Therefore meaningful conclusions cannot be made, and it will not be possible to prove whether the goals have been met. It is also important to consider the surrounding network and GP lanes when assessing the impact of an HOV lane. Turnbull *et al.* suggest that a comparison between what the effect of adding an extra lane would have been, rather than the HOV lane, may be useful.

The schemes reviewed by Turnbull *et al.* used the following methods to evaluate HOV lanes:

- Monitoring of bus schedule adherence and monthly bus data including park and ride counts;
- Changes in commuter behaviour and reasons;
- Changes in public perceptions through surveys of both users and non users;
- Occupancy counts;

- Accidents;
- Classification of types of vehicles;
- Licence plate surveys;
- Violation rates (whether these are repeat offences);
- Safety.

Turnbull *et al.* suggest the following approach to evaluating HOV lanes:

- Clear articulation of project goals and objectives;
- Identification of measures of effectiveness;
- Identification of information needed;
- Development of the study design;
- Conduct “before” data collection;
- Conduct “after” data collection and evaluation;
- Ongoing monitoring and evaluation.

Ongoing monitoring and assessment is vital for continuing successful operation of HOV lanes as congestion increases. Knowing the effectiveness of a HOV lane will help with future policies or the implementation of HOV schemes on other roads.

6.5 PUBLICITY AND MARKETING

Public awareness and understanding of HOV lanes and their purposes is key for their acceptance and continued legal use. Many schemes in the USA have come under criticism from the public. As such it is vital that proposed HOV schemes be extensively marketed and the public are aware of how to use the lanes and also what changes in traffic behaviour are expected.

It is important that the public be given a complete picture of any benefits or disbenefits as, in the past, incorrect conclusions have been drawn from published articles where incomplete data has been given. This lack of data has been interpreted as a cover-up by the local authorities who may be thought of as trying to hide disbenefits of a scheme.

A number of HOV lanes have been criticised for “empty-lane syndrome”, or perceived under-utilisation where local road users saw the lanes as wasted road space. Such HOV lanes are often decommissioned and the public lose faith in other schemes which may or may not be showing a benefit.

If the public are not sufficiently prepared for the opening of HOV lanes, an adequate market will not exist. Marketing campaigns, through the media increase public awareness and confidence in the HOV purpose, publicise accurate expectations and encourage car sharing. Television, radio, press conferences, mailings, fliers left on windscreens and information accompanying licence renewal forms are some of the marketing methods used.

The marketing of HOV lanes is best presented to the public in terms of time saved, reliability of journey times and safety. Commuters must be made aware of the purpose and expectations of the scheme in order to dismiss any misconceptions. They must also understand that violators will be prosecuted.

Public surveys after the opening of a scheme will draw attention to why people are not using the HOV lanes, and may highlight ways in which this number of users can be increased. Ongoing monitoring and assessment of the HOV lanes is essential as it will aid continuous public acceptance of the scheme.

Integration with the surrounding network through the implementation of public transport systems is considered key for the success of HOV schemes.

6.6 SUMMARY

The literature review has shown that:

- There is no standard design for the layout of HOV lanes or their operation.
- Signing for a HOV lane is usually placed at the start of the lane and at regular intervals along the scheme. However, there is no standard spacing for these signs. Overhead signing is preferable where possible.
- Signing gives details of minimum occupancy requirements and restrictions on times and vehicle types.
- Buses are always allowed to use the HOV lane, and HGVs are consistently banned from the HOV lane in the schemes reviewed.
- Integration with the surrounding network through the implementation of public transport systems is considered key for the success of HOV schemes.
- Public awareness and understanding of HOV lanes and their purposes is key for their acceptance and continued legal use.
- Advanced marketing of a scheme may help promote public acceptance and understanding.
- HOV lanes must be enforced for them to be successful. The penalties should be high enough to discourage violation.
- There were no standard methods for evaluating HOV schemes.
- No cost benefit analysis has been found for the schemes reviewed.
- Ongoing monitoring and assessment (including public opinion surveys) is vital for continuing successful operation of HOV lanes.

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