High Occupancy Vehicle Lanes – Worldwide Lessons for European Practitioners

S. Schijns, P.Eng.
McCormick Rankin Corp., Mississauga, ON, Canada

Abstract

Europe has long provided bus lanes and on-street bus priority measures. High Occupancy Vehicle (HOV) programs expand that practice to include private shared-ride vehicles (carpools) and other priority vehicles. There are a few HOV lanes in operation in Europe, and interest is growing in their potential applicability in congested urban roadways. With over 200 HOV lane projects now in use on streets and highways around the world, there are useful lessons to be learned by those considering the HOV option in the European context.

A survey of HOV facilities reveals the scope of current practice, ranging from arterial queue-jumps to bus/carpool lanes to freeway HOV lanes and High Occupancy Toll facilities. HOV lane projects from nearly one dozen countries are highlighted.

The reasons for project successes and failures are outlined, with particular attention paid to the constraints and operational issues prevalent in the European environment. Critical issues such as enforcement, conversion from general purpose use, hours of operation, design, and underutilization are explored. The documented effectiveness of HOV facilities in influencing mode choice is summarized. The role of public transport and its interrelationship with private ridesharing (carpooling) in the HOV context is also dealt with.

Finally, the future of HOV priority within the urban transport system is discussed, touching on high-tech enforcement solutions, HOV priority within tolled facilities, and the integration of HOV initiatives within broader Transportation Demand Management programmes.

Keywords: High Occupancy Vehicle, HOV, carpools, High Occupancy Toll, HOT, priority, Transportation Demand Management, TDM, 2+, 3+

1 Introduction

High Occupancy Vehicle (HOV) lanes are lanes on streets and highways restricted to use by buses and multiple-occupant vehicles during all or part of the day. The aim is to provide HOVs with faster, more reliable travel than non-HOVs (primarily single occupant autos) during congested periods. This is intended to attract more travellers to bus and shared-ride travel rather than driving alone, thereby increasing the person-carrying capacity of the roadway, reducing per-capita emissions and energy consumption, and promoting a more sustainable urban transport situation.

Bus lanes aimed at improving the functionality and attractiveness of public transport are in common use in urban centres around the world. Many HOV lanes have begun as bus lanes or have bus priority as their primary goal. However, the HOV designation augments the public transport function and allows the priority measure to reach out to other forms of efficient shared-ride travel. This paper focuses on HOV lanes rather than bus-only lanes.

The presence of a significant number of carpools in the urban transport system, even in the absence of any direct incentive or priority measures, testifies to the significance of that mode. It is common for there to be more people travelling in private shared-ride vehicles than by public transport in an urban area, despite the attention and funding provided to structured public transport.

Many jurisdictions have therefore found a place for HOV lanes in the Transportation Demand Management component of their regional transportation plans.

HOV lanes have been implemented in a few places in Europe, but they are far more common elsewhere. Given that the reasons for considering HOV solutions are the same anywhere – skirting congestion, reducing emissions, drawing more people to public transport, reducing dependence on single-occupant auto use – there is good reason to add HOV lanes to the European urban transport planning toolkit.

2 HOV Lane Operational Design Criteria

An HOV lane is a relatively simple marketing device aimed at promoting HOV use, but it has to be properly planned, designed and operated to be functional and effective. A poorly conceived HOV plan will at best be neutral or ineffective, and at worst can trigger a community or political reaction that can set back the notion of demand management and transit priority for years and sometimes decades.

The best potential HOV lane situations are found where:

- there is severe and recurring traffic congestion
- the HOV solution offers significant and reliable travel time savings (typically 5 minutes minimum, to overcome the inconvenience and time taken pick up a passenger)
- the HOV lane will carry at least as many people as the lane would if it were to operate under a general purpose designation

- the number of buses and cars using the HOV lane meets local thresholds of acceptability (avoiding the “empty lane” syndrome)
- implementation results in an improvement in the person-moving capacity of a roadway
- there is political, police, transport agency, transport operator, and public support
- it is enforceable and a commitment to its enforcement is made
- it is cost-effective
- it is physically feasible to implement a safe, accessible facility.

International experience has demonstrated that HOV lanes which do not meet those criteria are at a high risk for sub-par effectiveness or outright failure (i.e. closure and conversion to general purpose use). While substantial public transport use is a major attribute, it is not necessarily a prerequisite for success.

In order to meet planning criteria, decisions must be made on a closely linked set of infrastructure and operational choices:

- Where on the roadway will the HOV lane be designated?
- How will the HOV lane be separated from other general traffic lanes?
- What vehicle or user types will be eligible to use the HOV lane?
- What is the initial and future demand for travel by those modes?
- What hours will it operate?

HOV lanes therefore require thoughtful analysis on a case-by-case basis; there is no one “correct” design, and there are examples of successful application of almost every configuration and set of operating rules.

A connecting network of HOV lanes, or even better, the systematic and integrated development of a combination of HOV lanes, preferential parking for carpools, improved bus service, park & ride lots, employer-based incentive programs, and ridematching will strengthen the effectiveness of each element in the system.

3 HOV Lane Examples

HOV lanes are in operation in nearly a dozen countries around the world. There are over 4,000 lane km in use, spread among approximately 80 arterial projects and over 130 motorway applications. There are HOV lanes on the left, on the right, or in the middle of roads; in part-time or full-time operation; using concurrent, reversible, or contra-flow layouts; separated by barriers, painted buffers, pylons, or simple dashed lines; used by buses and vehicles carrying 2+, 3+, 4+, or 6+ occupants; ranging in length from 200 m to 50 km; carrying 90% buses or 99% carpools; implemented by adding lanes or converting lanes; enforced and unenforced; and ranging from tremendous successes to demonstrable failures.

While the U.S. has been the most active HOV lane proponent (primarily on motorways) dating back to their first application in 1969, arterial and motorway HOV applications have found some support in Europe, Canada, Australia, and elsewhere.

3.1 European Examples

3.1.1 European Motorway HOV Lanes

There are few European examples of motorway HOV lanes from which to draw experience – Madrid, Amsterdam, and – currently under development – the M1 in the UK are the only projects to date. The fact that all three are of different designs demonstrates how difficult it is to generalize about HOV lane planning.

Figure 1: In Spain, Madrid's N-VI median reversible HOV lanes (centre distance of photo) have operated successfully since 1995 [1].

Figure 2: The N4 near Amsterdam was a barrier-separated HOV 3+ facility that operated from 1993 to 1994. It did not attract enough users to overcome public criticism and was opened to general traffic [2].

3.1.2 European Arterial Road HOV Lanes

The principle of transit priority is well-established in cities across Europe. In recent years a few centres (Leeds, Bristol, Trondheim, Linz) have expanded on that concept to plan and implement HOV lanes on arterial roads. The A647 near

Leeds was the first UK HOV lane. It opened in 1998 and is considered to be a success. Trondheim, Norway implemented an arterial HOV 3+ lane in 2001.

Figure 3: HOV Lanes on (left) A647, Leeds [3], and (right) Elgeseter Street, Trondheim [4].

Figure 4: In Linz, Austria, the sign on B127 (opened 1998) notes that *"This (bus) lane can also be used by (1) small cars with minimum 3 passengers and (2) livestock trucks"*[5].

3.2 International Examples

3.2.1 International Motorway HOV Facilities

Like Europe, cities around the world have implemented transit (bus) priority measures on streets and highways. HOV lanes emerged in the U.S. as a policy measure (aimed primarily at reducing fuel consumption) in the early 1970s. The ability to expand the reach of the fuel efficiency program beyond bus passengers was critical to it having a measurable impact. First applied on Washington, D.C. area freeways, the concept expanded to become a key element in the Transportation Demand Management toolkit of most large centres across North America. In doing so, HOV strategy has gone well beyond its fuel efficiency roots to tackle broader issues of personal mobility, air quality, and the overall impact of commuting practices on infrastructure needs, operational efficiency, and environmental impact.

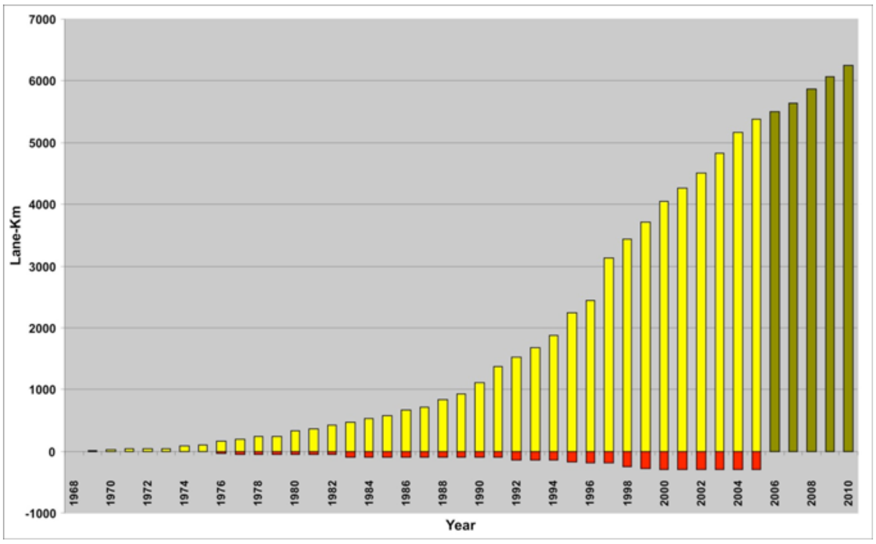

Figure 5: This graph demonstrates the steady and continuing growth in North American motorway HOV lanes (yellow). Despite a few projects garnering attention as high-profile "failures" (red) the vast majority of U.S. and Canadian HOV lanes continue to operate well and more are planned (green).[6] HOV lanes have, in recent years, been implemented on Australian motorways as well.

North American HOV lanes have been implemented in every conceivable configuration:

- concurrent flow, contraflow, or reversible;
- new construction, widening, retrofit, or converted from other use;
- barrier-separated, painted buffer separation, or non-separated;
- solid or dashed lane separator line;
- median side or outside;
- peak period only or 24 hour per day operation;
- 2+, 3+, 4+, 6+, or bus-only use;
- direct HOV-only ramps and motorway-to-motorway links;
- limited or unlimited lane ingress / egress;
- short queue jumps and long corridors;
- with and without supporting programs;
- free access or tolled; and
- with or without carpool parking lots, park & ride lots, and on-line public transport stops / stations.

In the case of I-66 in Washington, D.C., the entire motorway is designated for HOV use in the morning peak period.

The facts that all of the above variations are needed to meet particular corridor needs and opportunities, and that all these facilities operate satisfactorily under day-to-day traffic loads, demonstrate the flexibility of the HOV lane principle. In most cases, necessity has been the mother of invention – HOV lanes have not been protected for, but have had to be retrofit into congested, constrained situations as a “last-ditch” congestion management response. “Ideal” design standards have had to be compromised, albeit without affecting safety and functionality to an unacceptable degree.

Given this experience, it is now common for North American motorway corridors to consider HOV lane needs and opportunities much earlier in the planning and design stages, and to protect adequate cross section for HOV lane implementation at some point. There are few urban motorways currently being planned that can look three decades or more into the future and conclude that no form of traffic management will ever be required.

Figure 6: From Toronto, Canada, this photo of Highway 404 illustrates “best practice” for motorway HOV lanes – a painted buffer separator, designated areas for HOV lane access and egress, extensive signage, wide shoulder adjacent to the HOV lane for enforcement purposes, and protected pockets in the median (not shown) for police observation [7].

Figure 7: In Brisbane, Australia, the HOV lane design used on the Pacific Motorway is similar to that in Toronto (Figure 6), but with different signage (and motorists driving on the left) [8].

Figure 8: This direct ramp in Los Angeles allows HOVs to enter and leave the median HOV lanes without having to weave across congested general traffic lanes or get caught in delays at a nearby interchange [9].

Figure 9: I-15 in San Diego has a 13 kilometre long barrier-separated reversible two-lane core available free for carpoolers and for a price (which varies according to demand and congestion levels) to non-HOV users [10]. Part of the toll revenue is dedicated to enhancing I-15 bus service.

3.2.2 International Arterial HOV Facilities

Arterial HOV lanes have a lower profile than motorway facilities, but nevertheless have been implemented in close to eighty corridors worldwide. Following is a sample of the situations encountered.

Figure 10: A reversible HOV 2+ lane is used in Ottawa, Canada to maximize the person-carrying capacity of a three-lane bridge crossing [11].

Figure 11: Sydney, Australia features an extensive network of motorway and arterial HOV lanes, called "Transit Lanes" [12], as well as Bus Lanes.

Figure 12: This photo illustrates a right-side HOV 3+ lane in Seattle, US, that can be used by motorists for access to mid-block entrances [13].

Figure 13: In Brisbane, Australia (as in several U.S. centres), HOVs are provided with bypass lanes at signal-controlled motorway entrance ramps [14].

Figure 14: An AM peak period curbside HOV 3+ lane on Onewa Road in Auckland, New Zealand has been in use since 1982. Dramatic improvement in HOV lane operations occurred in 2003 after municipal parking control officers were trained by the police and granted the responsibility of enforcing HOV lane operation. Now new HOV lanes are being planned in the area [15].

4 Results

4.1 Successes

With a broad selection of HOV facilities in operation worldwide, it is relatively easy to highlight projects that have yielded positive results:

- N-VI, Madrid, Spain: Public transport mode share grew from 23.5% to 34.8% after implementation; single occupancy vehicle use on N-VI dropped from 70% of autos to 48% [16].
- I-5 in Portland, OR, US: HOV lane carries 33% more people than the adjacent non-HOV lane [17].
- Barnet-Hastings Highway, Vancouver BC, Canada: HOV lane triggered an increase in Average Vehicle Occupancy (AVO) from 1.22 to 1.35 persons per vehicle in the AM peak hour, thereby increasing the person-carrying capacity of the highway by 11% [18].
- Long Island Expressway, NY, US: After 6 months of operation, the HOV lanes produced an increase in AVO of 14%, from 1.14 to 1.30 in the AM peak period, and from 1.24 to 1.42 persons per vehicle in the PM peak. Estimates are that, in the first 8 months of opening, at least 1,000 people started ridesharing as a direct result of HOV lane implementation [19].
- I-15, San Diego, CA, US: The first 6 years of HOV lane operation showed non-HOV person trips on I-15 increased by 17% while person trips in HOVs grew 109%. The AVO on I-15 increased from 1.25 to 1.38 [20]
- I-210, Los Angeles, CA, US: The addition of a 27km long HOV lane triggered an increase in carpool use of 500 persons (i.e. 13%) in the peak hour 6 months after opening [21].
- San Francisco Bay Area, CA, US: 33% of carpool drivers changed from driving alone to carpooling in order to use HOV lanes. 6% changed route and 16% changed time. The rest had been carpooling already [22].

It is worth noting from the above results that even “successful” HOV lane projects face significant and inherent limitations; there is no HOV project anywhere that has transformed thousands of single-occupant motorists into carpoolers and bus riders to the extent that traffic congestion is eliminated or even eased significantly.

Conversely, many facilities have had impacts far beyond their volume and travel time results. The most “successful” facilities are those that:

- have contributed to a multi-modal regional-scale transportation strategy that increases personal mobility while decreasing transportation’s environmental impacts;
- have become an established and publicly-supported part of the transportation system; and
- continue to attract new users.

A large part of a "successful" project, therefore, is how it fits within the regional transportation strategy and how other related initiatives can leverage increased benefits off the HOV facility's presence. An employer-based Transportation Demand Management program or a community-based ridesharing initiative, for example, can be made much more attractive when there is an HOV facility in play. A physical, demonstrated public commitment to HOV infrastructure makes a powerful statement as to society's priorities – demonstrating, for example, that the government is serious about providing travellers with options to reduce single occupant vehicle use. This in turn can be a high-profile marketing tool for raising public awareness of transportation issues, options, and solutions. It is the difference between a general plea - "Please share a ride to work" – and an incentive-based pitch focusing on HOV lanes - "Those of you who share a ride to work will avoid congestion and get there faster".

4.2 Enforcement

International experience with enforcement of HOV lane operating rules can largely be characterized as "successful", even though violation rates in some projects are unacceptably high. Since HOV lanes are always implemented in congested corridors, there is a natural tendency for motorists to want to use all available road capacity, balanced against the public's general adherence to reasonable rules. Although not absolute, a common "rule of thumb" for motorway HOV 2+ lanes is that the violation rate should be kept under 10% of lane users during peak periods; above this level, complaints from other motorists get louder, and disrespect for the HOV rules (correlated with an obviously low risk of being penalized) begins to negate public support for HOV priority.

Some HOV projects in the U.S. have been implemented largely as a device to secure federal funding for capacity expansion and have been left to operate with minimal enforcement; these quickly attract a high level of violation and effectively function as an additional general purpose lane. Some other projects have been retrofit in constrained situations where there are very few opportunities for police to observe and pull over violators; these too become an intractable violation problem. Early HOV projects, on occasion, suffered from fine / penalty rates that were so low as to be ineffective; fines have all been raised to the point where they are an effective deterrent.

Nevertheless, the Los Angeles HOV system reports violation rates of less than 2% [23], while Houston's barrier-separated lanes have similar results. These project feature a combination of a commitment to enforcement, fine levels that are an effective deterrent (in California's case, close to $US300), and physical provisions (e.g. wide shoulders, buffers, barriers) that allow police to do their work safely and efficiently.

Arterial HOV lanes have been notably more difficult to enforce; violation rates of over 50% are common, largely due to the lack of the above enforcement tools (commitment, adequate fine levels, and physical provisions).

HOV lane enforcement to date has been entirely by manual means – police physically observing vehicles on the road, stopping non-compliant ones, and issuing a citation. Ticket-by-mail (i.e. observing a violator and sending a citation to the vehicle owner rather than stopping them in the field) has been generally unsuccessful due to privacy and reliability concerns.

The use of remote technology to observe and cite HOV lane violators has been tested but has not been developed to the point of widespread applicability. The use of out-of-vehicle cameras has numerous concerns and inherent limitations but is just now coming into use in controlled environments (e.g. Forth Bridge, Scotland [24]). A more promising long-range solution lies in the integration of in-vehicle occupancy sensors (which most vehicles now have, as part of their air bag systems) with transponders and roadside reader / communications systems [25]. Widespread implementation of automated occupancy detection systems has the potential to transform HOV lane operations by eliminating violations, allowing targeted incentive programs, resolving arterial HOV lane enforcement issues, and creating toll buy-in opportunities.

4.3 Problems

Although there is a long list of problems that can be cited in the HOV lane field, only a few have proven to be significant enough to result in lane closure. Although there are project-specific problems that can be drawn from almost any HOV facility, they can be generalized as follows.

- Underutilisation: If the lane does not carry at least as many people during peak periods as it would as a general traffic lane, then it would be a better use of limited road space to allow the lane to be used by general traffic. If the lane appears to be under-used while general traffic experiences severe congestion, public concern will be aroused and pressure will mount on elected officials to open it to general use.
- Enforcement: If there are no provisions to allow enforcement to take place, and/or if there is an inadequate commitment by the enforcement agency to implement an effective enforcement program, and/or the penalties in place are an insufficient deterrent to HOV lane violators, the lane will attract an unacceptably high level of non-HOVs. This harms the operational integrity of the facility, but the more critical problem is that it engenders public cynicism and lack of support for the HOV lane in particular and HOV programs in general.
- Safety: If the lane design does not adequately isolate HOVs from other vehicles (particularly in intermediate access / egress zones and at HOV lane terminus) and does not provide adequate breakdown areas, the facility is at higher risk of collisions, and operating speed and reliability will be compromised. Public perception may also be affected.
- Connectivity: A lane must be long enough to offer significant time savings to its users; in many places this requires linking segments of HOV lane together via costly HOV ramps. If the financial commitment to complete an effective network is not in place, all the component segments may not be effective enough on a standalone basis to be worthwhile.

- Jurisdictional Co-ordination: HOV projects require the long-term co-operation – and often joint funding – of many agencies and authorities that often do not otherwise work together. Transit agencies do not usually design highways; highway agencies do not usually fund enforcement; toll agencies do not usually promote ridesharing; and ridematch organisations do not usually build carpool parking lots. The "transit first" philosophy of many public transport agencies, in particular, can cause difficulties in supporting initiatives that give equal weight to promoting private ridesharing. Without a mechanism to make effective use of the strengths and responsibilities of each partner, HOV facilities run the risk of being "orphans" with no single proponent or "champion" to lead the project through adverse situations.

It should be noted that most of the problems likely to face an HOV project are readily identified in the project planning stage. If, as in most projects, problems are recognized and dealt with at that point, the project will be implemented with little risk of failure. The vast majority of HOV projects are successful once implemented; if they are likely to fail it will be in the planning stages rather than after a commitment has been made to invest in and operate them.

Furthermore, if problems arise after implementation, there are numerous operational tools available to a jurisdiction committed to maintain an HOV facility – to address safety concerns, to increase time savings, to reduce or increase usage, and to build public support.

4.4 Lessons Learned – European Applicability

The first few HOV "pilot projects" on European streets and motorways have demonstrated that the principle of prioritizing certain "desirable" modes or classes of road traveller is as valid in Europe as elsewhere. The continued day-to-day operation of HOV facilities around the world further demonstrates the universality of the principles behind promoting the most efficient means (in terms of time, space, and cost) of urban travel.

HOV lanes are, however, inherently problematic from their very concept through to their day-to-day operation. Since HOV lanes are only applied (and are effective) in situations of severe recurring congestion, they are conceived as solutions to problems, not as aspirations in and of themselves. If the streets and motorways and public transport systems are all working well, then HOV lanes are not needed.

It is therefore necessary to carry out an informed debate among transport planners, public transport operators, elected officials, and motorist groups as to what the reasonable and realistic objectives of the regional transport plan are before settling on HOV lanes as potential elements in that plan.

Every HOV lane project must be chosen carefully – in many places where an HOV lane has "failed", it has been many years before that jurisdiction has attempted another such facility. If, in the meantime, promising opportunities are lost, the legacy may be that no reasonable HOV system will ever be possible.

Initial projects in particular must be well-executed – the Santa Monica Freeway debacle of 1976 in Los Angeles, New Jersey's I-80 experience in 1998, and even Amsterdam's A1 lane in 1994 clearly demonstrate the long-term consequences of a project failure.

Expectations for HOV programs must be carefully managed. They are targeted corridor-level programs that are not likely to, on their own, have significant regional-scale impacts, nor will HOV lanes eliminate (or even reduce) chronic congestion. They do fit well, though, in a cultural environment of environmental responsibility, management and optimization of infrastructure and traffic operations, sustainability, and constraints on growth.

One key aspect of HOV lane implementation that has rarely been successfully addressed outside Europe is the conversion of existing general traffic lanes on motorways to HOV use. There is no reason to believe that European motorway users will be any more accepting of capacity reduction than motorists elsewhere. There are, however, certain circumstances (high pre-existing HOV mode share) and designs (contra-flow lanes) where lane conversion can reasonably be considered, and it should not be dismissed out-of-hand. European cities, on the other hand, have extensive experience in converting street space to bus lanes, and it is only a small step from there to create an HOV lane instead.

Where the HOV concept has proven particularly valuable has been in the creation of priority lanes benefiting public transport on roads where buses by themselves are not numerous or frequent enough to warrant a bus-only lane. Once the priority lane is established, bus service may then grow over time and the lane subsequently shifted to bus-only use (Toronto illustrates this process).

The use of dynamic and differentiated pricing schemes to manage traffic flow is beginning to be used in some locales, and HOV priority can readily be incorporated in such schemes. This area of urban transport practice is likely to grow and European practitioners might be well advised to pay heed to opportunities in that area, as discussed below.

5 The Future

The heady predictions of the 1970s - fuelled by energy and pollution concerns - that HOV lanes would help carpooling and transit use to become a way of life for millions of commuters have been tempered by experience and realism. Energy use and air quality have been found to be more effectively tackled at the source through rules and tax regimes that influence all travellers. Motorists have been reluctant to give up their cars, while one of the world's biggest industries continues in its dedication to making auto use as attractive as possible. Socio-demographic and economic trends have pushed urban commuters towards more, rather than less, auto use. HOV lanes themselves have proven to be difficult – but not impossible - to implement and sustain and have yielded only mixed results.

Nevertheless, the role of HOV facilities within a regional transportation strategy has come to be understood and their value, even despite inherent limitations, has meant that they continue to be operated and implemented around the world. In 2005, for example, the UK Minister for Transport, Alistair Darling, announced that the UK would trial HOV lanes on a segment of the M1, noting that “It works elsewhere and there is no reason why it can't work here as well.” Ontario, Canada, implemented its first motorway HOV lanes in December 2005 after lengthy deliberation, examination of practice elsewhere, and development of comprehensive local standards.

European transport jurisdictions, in focusing on other aspects of the transportation system while North American and Australian centres implemented HOV projects, now have the advantage of being able to draw from others' experience in developing locally-relevant transport solutions and in avoiding the repetition of others' mistakes.

Trends in transportation technology are very supportive of HOV objectives – smart ridematching, automated occupancy detection, ubiquitous transponder systems, reduced technology costs, better management of public transport vehicles, improved communications capacity, better models for highway operations management and demand forecasting, and greater ability to monitor traffic conditions and communicate that information to motorists will all come in to play in future HOV facilities. The most forward-thinking planners are incorporating or providing for these developments in new HOV projects.

One area where European practitioners may have an advantage over those in North America is in the ability to tie together workplace-based bus and ridesharing incentives (primarily related to the relative paucity of open space for free parking), a well-established systemic approach to priority for public transport vehicles and users, and a generally more “sympathetic” populace in terms of attitudes towards the natural environment and “green” transport initiatives. HOV facilities fit well within this context.

Another area of HOV focus in Europe may well be on arterials rather than motorways; while there is an argument that existing bus lanes should be preserved from incursion by other users, there is a counter-argument that, with effective design and operating controls, bus lanes could be adapted to achieve broader goals without diminishing their transit priority function. Furthermore, HOV lanes can be a means by which transit priority can be established in situations where buses alone would not warrant the investment. The co-ordination of arterial HOV lanes, motorway HOV facilities, and areawide TDM programs represents a substantial opportunity for most urban regions (the Seattle area in the U.S. has gone the farthest along that path).

Continued evolution of motorways towards “managed” facilities appears inevitable, although the pace at which that will occur remains difficult to discern. Since HOV lanes are the second step along that path (after basic electronic traffic management systems already in place on congested motorways and major arterials), it is a logical progression to High Occupancy Toll (HOT) lanes, then to Managed Lanes using dynamic pricing, and ultimately to whole-of-motorway pricing. This will differ from traditional tolling in that pricing will be used explicitly as a transportation demand management tool, to optimize throughput rather than profit. There are already several HOT facilities in operation in the U.S. (San Diego, Los Angeles, Houston, Minneapolis) along with a few Managed Lanes projects, so these are very real and achievable prospects.

It should be considered that a HOT lane project will be most viable and attractive as a two- or three-lane facility rather than as a single lane. Operation of a single HOV lane is governed by the slowest vehicle on it, and at least half of its capacity will be used by non-tolled HOVs, so a two-lane HOT facility is desirable in order to attract enough tolled traffic to both make the facility self-financing and to have a significant impact on general traffic conditions. The scenario then arises of adding one new lane per direction to a motorway but designating both that lane and one existing lane as Managed lanes, thereby creating an effective HOT facility without diminishing operating conditions for general traffic. This type of project is under consideration in Denver, Toronto, and elsewhere.

There is a compelling logic to using management tools to optimize the transport flow on limited-capacity roadways, but there is a concern that HOV objectives – to promote use of public transport and ridesharing – may be subverted in the process. If, for example, the HOT lane becomes congested, will the policy be to tighten access for tolled vehicles and continue to promote HOVs, or will it be to "skim off" HOV 2+ vehicles in order to make room for more toll revenue? A successful (full) HOV lane has little potential to accommodate tolled vehicles, but others will argue that the value of two-occupant vehicles in reducing emissions and promoting efficient use of road space is minimal and that HOV program should continue to push towards 3+ occupant vehicles and buses in any case (by including two-occupant vehicles in the "tolled" group rather than in the "HOV" group).

Some critics also decry the inclusion of "family carpooling" (i.e. a parent taking a child to school) as not contributing to HOV objectives related to reducing private vehicle travel, and promote the restriction of HOV lanes to "true" carpools (two or more people travelling together as an alternative to driving alone). The technology to make these kinds of distinctions is available now, and the issue may come to the fore in the future as HOV lanes reach maturity and become congested under general "2+" operating rules.

Another option, of course, is to skip all these lane-by-lane steps and apply pricing mechanisms and controls directly to the vehicle so as to manage vehicular movement throughout the road network. That, however, appears to be too great a leap to take from the current situation whereas HOV lanes offer a more reasonable "next step" in that direction.

In the near term, new HOV projects should therefore be treated as "Managed" facilities right from the start. There are different management tools available – simple signs stating "HOV 2+" are the simplest and most readily implemented, while more sophisticated flat-rate tolling, buy-in, and dynamic pricing plans can be applied now or later to fine-tune and optimize lane performance. The key is to use the best available techniques now, while preserving the ability to manage the future evolution of that 4 m wide strip of asphalt into a piece of infrastructure that achieves its maximum functional potential within the urban transportation system.

So it may be that HOV lanes per se are already passé, and that their greatest potential will be realized in the future as Managed lanes, in which HOV-related objectives can be realised along with more substantial mobility achievements.

6 Resources

There is a substantial library of HOV-related literature available. It has primarily been generated in the U.S. and specific details may be relevant only to U.S. applications. Great efforts have often been made in other countries (Australia, Canada) to research and develop local guidelines prior to any implementation.

The internet is a primary tool for searching out HOV resources. Both www.hovworld.com (a volunteer-run site by the U.S. Transportation Research Board's HOV Subcommittee) and http://ops.fhwa.dot.gov/freewaymgmt/hov (run by the U.S. Federal Highway Administration) provide basic resources for U.S. projects. Facility-specific information is more readily obtainable from the respective State Department of Transportation internet sites.

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[13] Photo: from HOV Interactive 1.0

[14] Photo: S. Schijns, McCormick Rankin Corporation, May 1999

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