OTTAWA-CARLETON REGIONAL TRANSIT COMMISSION **REPORT**
COMMISSION DE TRANSPORT RÉGIONALE D'OTTAWA-CARLETON **RAPPORT**

Our File/N/Réf.
Your File/V/Réf.

DATE 9 February 2000

TO/DEST. Co-ordinator
Transit Services Committee

FROM/EXP. General Manager

SUBJECT/OBJET **EXPERIENCE OF THE USE OF HIGH OCCUPANCY VEHICLE LANES ELSEWHERE**

DEPARTMENTAL RECOMMENDATION

That the Transit Services Committee receive this report for information.

BACKGROUND

At the Transit Services Committee meeting of 23 June 1999, Commissioner Holmes asked that a full report be presented on the experience with HOV lanes elsewhere. In particular, she wanted to understand their benefits in encouraging a shift away from single occupancy vehicles.

DISCUSSION

The attached report was prepared in response to that request. It concludes, that in cities where transit has a significant modal share, HOV lanes for car pools have a limited role.

This conclusion supports that of the work done as part of the development of Ottawa-Carleton's Transportation Master Plan on the possible role of HOV lanes in the region. In that report, it was concluded that there was little to be gained in Ottawa-Carleton by the introduction of HOV lanes, except where they would facilitate the movement of transit vehicles.

A specific study of the opportunities for HOV lanes, instead of bus-only lanes, in the Woodroffe corridor will be presented to Transportation Committee.

This report concludes that bus lanes, rather than HOV lanes, should be implemented on Woodroffe Avenue. The reasons for this conclusion are:

- Transitway like service along Woodroffe corridor is essential to make the Fallowfield Park and Ride facility attractive. Transitway like service requires dedicated bus lanes and signal priority measures;

- Signal delay would be longer with HOV lanes; some signal priority measures, such as displaying the Transit Priority Signal, cannot be used if HOVs are allowed to use the facility;

- HOV lanes in the Woodroffe corridor have no or very little potential to encourage car pooling;

- Combating the "empty lane syndrome" by allowing HOVs into a bus lane would be detrimental to the quality of transit service and transit ridership in this corridor;

- The HOV concept in this corridor would have operational, violation problems, and negative impact on safety.

Approved by
Gordon Diamond

HEG/sc

Att.

ANNEX A

1. WORLDWIDE HOV EXPERIENCE

SUMMARY

- **Bus-only lanes, which are often referred to as HOV facilities, should not be confused with typical HOV facilities that allow carpools**
- **Most HOV facilities are on the US freeway system**
- **Downgrading bus lanes into HOV lanes has been a common practice in North America**
- **HOV (excluding bus-only lanes) facilities have very limited application outside of North America**
- **In cities, where transit has a significant modal share, HOV lanes for carpools have a limited role**
- **HOV facilities (that allow carpools) can have negative effect on transit ridership**
- **The implications of HOV lanes are different depending whether they were created by conversion or by new construction**

Introduction

High Occupancy Vehicle (HOV) facilities are roadways reserved for vehicles with specified minimum number of occupants. At the beginning of the 1970s, the early years of development, the HOV definition included only buses. Today, the HOV definition is very broad; It includes both transit focused facilities where the average vehicle occupancy is usually 40+, and car focused facilities (most US HOVs) where the average vehicle occupancy is around 2.

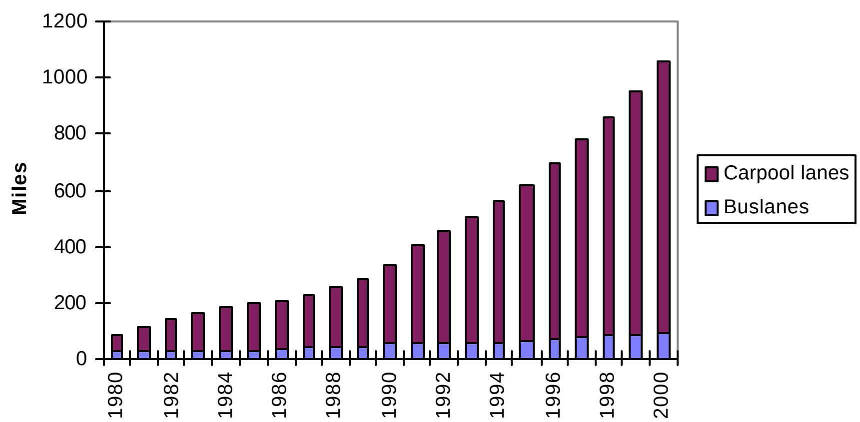
The objective of this report is to analyze the HOV experience in different urban areas and provide relevant background information which is needed when considering the application of the HOV concept in Ottawa. Although the HOV definition includes bus-only lanes, the report will focus on HOV facilities which allow carpools.

__The US Experience of Freeway HOV Facilities__

There are over 20 urban areas in the US with HOV facilities (Emerson, 1994). A small portion of HOVs are bus-lanes, while the majority of HOV facilities allow carpools. Most facilities which allow carpools are on freeways. A list of HOV facilities in North America is presented in Appendix 1.

The length of HOV lanes in the US has been growing continuously since the 1970s (Figure 1). If the length of HOV facilities can be considered to be an indication of success, then HOV facilities are successful in the US. However, the factors behind this growth have to be understood before the US experience is applied in other urban areas.

Figure 1: Approximate Route-Miles of HOV Facilities



The US, with its extensive freeway network as the backbone of the transportation system, is the most car dependent society in the world. Since the second World War, most cities have been built assuming almost exclusive car access. The term “urban sprawl” emerged in the US to describe the extremely low density, residential and commercial development that surrounds every American city. As a result, car ownership, usage and dependence is the highest in the world. For most Americans, other modes of surface transportation are practically irrelevant and impossible.

Since the low density development cannot be served effectively by public transit, the transit service degraded to a great extent. Today, in most urban areas, the quality and reputation of public transit service is dismal compared to European and even Canadian cities (Pucher, 1996).

While the supply of new roads kept pace with the increasing number of cars on them, the personal automobile provided unprecedented mobility to most Americans. However, road building did not keep up with the demand. A recent study by the Texas Transportation Institute

(Schrank, 1999) shows that in more than half of the cities studied, the amount of time drivers spend stuck in traffic has grown by at least 350% over the past 16 years.

It has been widely recognized, that the past approach of relying on the single occupant vehicles (SOV) only is physically, financially, socially, and environmentally not sustainable. Public transit, which usually gets more attention in other parts of the world as congestion grows, has limited potential in the US, due to the extremely low population densities in urban areas.

Since the early 1990s, HOV facility construction in the US has been greatly encouraged by the nature of funding and approving roadway projects. Some programs, such as the Congestion Mitigation and Air Quality program, and the Interstate Maintenance fund cannot be used for building new infrastructure, unless it is an HOV facility (ITE, 1994). Furthermore, the Environment Protection Agency's authority to prevent roadway projects which do not comply with the Clean Air Act does not apply to HOV projects (Leman, 1994). As a result, in areas with the worst traffic congestion problems - and consequently, the worst air pollution problems - building new HOV facilities is, in many cases, the only feasible alternative.

Whether or not the HOV concept is a good approach to solve transportation problems in the US, is a frequent topic among many transportation professionals. The proponents of the concept stress the pressing need to do something to prevent further increase in congestion and pollution. Since efficient transit service is rarely a possibility, HOV lanes are usually proposed as a surrogate.

The opposition to HOVs either believe that traffic congestion and pollution is an acceptable consequence of economic development (i.e. there is no problem at all), or they prefer to limit vehicular travel by increasing the cost of it.

Usually, the objectives of HOV facilities is to improve mobility, increase average car occupancy, decrease congestion and air pollution by lowering the total number of vehicles, especially SOVs. Quantitative data, that shows that these objectives are fulfilled, is very scarce. An increase in carpools after opening HOV facilities have been reported in some cases, but no study was found which would suggest how much of the increase is due to new carpools.

On many HOV facilities no significant increase of carpools has been observed. In 1995, Caltrans reported that the number of carpoolers has remained roughly the same between 1990 and 1994, while the percentage of solo drivers increased. (The Urban Transportation Monitor, March 31, 1995.)

Without generating a significant number of new carpools, HOV facilities do not increase the efficiency of the transportation facility, they only redistribute traffic in lanes according to the number of occupants.

Opponents of the HOV concept question the effectiveness of the typical HOV facility in solving congestion and air pollution problems. The three most common concerns are that in many cases:

a) HOV facilities fail to generate significant number of new carpools,
b) If added as new lanes, HOV facilities do not decrease SOV's or air pollution,
b) HOV lanes are underutilized.

Recently, it has been successfully argued that two HOV facilities in New Jersey neither encouraged carpooling nor reduced congestion. In November 1998, the HOV restriction was removed on Routes 80 and 287 and the lanes become general purpose lanes. The decision about the conversion has been made after an announcement that the state will not have to return federal funds which were used to build the HOV facilities.

In early 1999, a bill was introduced to the California state legislature which calls for the abolishment of HOV lanes in California until a "certification of competency is obtained " (The Urban Transportation Monitor, April 30, 1999). The Bill has not been successful so far, however, it indicates the existing controversy behind HOV lanes.

The minimum requirements for an HOV facility to be technically successful are:

a) congestion in the general purpose lane and
b) travel time saving compared to the adjacent general purpose lanes.

It has been observed that when congestion is eased, even temporarily, by additional HOV lanes, the incentive to carpool is lost. Furthermore, without a certain number of carpools the HOV lane stays underutilized. Due to the lack of political and public support, the HOV lane is converted to general traffic (Neily, 1998).

The other critical issue in operating a successful HOV facility is how to maintain appropriate traffic volumes . Too strict restriction (e.g. 3+) may produce not enough eligible vehicles while too low restriction (e.g. 2+) may allow two many vehicles into the HOV lane. Since the minimum occupancy requirement must be a whole number, maintaining appropriate traffic volumes in HOV lanes has serious limitations.

A recent attempt to continuously control the number of vehicles in the HOV lane is to allow, in addition to HOV vehicles, ineligible low occupancy vehicles onto the facility for a variable or fixed fee. The Intermodal Surface Transportation Efficiency Act of 1991 introduced and the Transportation Equity Act for the 21st Century re-authorized a limited number of demonstration projects to test congestion pricing. Table 1 lists High Occupancy Toll (HOT) facilities.

Table 1: HOT Lanes

Location	Description
San Diego, I-15, Implemented in Dec 1996	Three year demonstration project, objective to improve transportation service and generate revenue for transit service, transit service is 2 buses/hr during the peak periods (525 passengers/day), Electronic toll collection, variable toll $0.5-$4. HOV2+ are free
Orange County, Riverside Freeway SR 91, 16 km, opened in December 1995	Electronic toll collection, until Jan 1998 HOV 3+ did not pay toll since Jan 1998 HOV 3+ toll is $0.50, all other pay variable toll $0.75-$3.50
Houston, TX, I-10 (Katy Freeway), 21 km, opened in Jan 1998	Due to congestion, the HOV 2+ restriction was changed to HOV 3+ which resulted in under-utilization. HOV 2+ were allowed for a fee. HOV 3+ free, HOV 2+ for $2 fee
Minnesota I-394	Planned (1997)
Hampton Roads, VA, I 64	Planned (1997) due to low HOV utilization (HOV 2+)

The concept of charging for the use of freeways has not yet gained too much political support. The length of existing and planned HOT lanes is insignificant compared to HOV facilities', but the approach has been generating substantial interest.

From the transportation policy viewpoint, the development of HOT is an interesting issue, because it challenges the objectives of HOV lanes. The objective of HOVs is to decrease congestion by increasing average car occupancy. One of the objectives of HOTs is to utilize the spare capacity of HOV lanes which may mean an increase of SOVs (Shin, 1998, Parkany, 1998).

Since the early days of HOV implementation in the US, lowering HOV occupancy restrictions has been quite common. Whether this is the result of the evolution of the transportation system, or the failure or lack of a transportation and a land use policy, is a contentious issue.

The backslide started by allowing carpools into bus lanes and continued by lowering the eligibility requirement from 4+ to 3+ then to 2+, and in some cases, to complete elimination of restrictions. On facilities, where buses used to be the main beneficiaries of the occupancy restriction, easing restrictions contributed to the reduction of transit usage.

Houston's "transitway" on Katy Freeway (I-10) opened in 1984 for buses and vanpools. Six months later, 4+ carpools, and seven months later 3+ carpools were allowed to use the facility. In 1986, less than two years after opening these lanes they (and Houston's other transitways) were opened to carpools with only two occupants. (The 3+ restriction has been reinstated recently in conjunction with a toll for 2+ vehicles.) Similarly, lanes built exclusively for buses have been opened up to carpools on Virginia's Shirley Highway (1975), San Bernardino Freeway (1976) and other places. Information on other downgradings can be found in Appendix 1. These changes severely compromised the speed and safety of the buses and vanpools for which the transitways were originally built (Leman, 1994).

Regarding the downgrading of the 3+ facility to 2+ in the Seattle area, Leman (1994) writes "people left buses (now slowed by the traffic) for carpools and left vanpools and larger carpools for 2+ carpools".

According to the Washington Metropolitan Area Transit Authority, since the HOV occupancy restriction were eased on I-66 from 3+ to 2+, the Metro rapid rail which runs in the median of the freeway, lost 4% of its riders while on the rest of the rail system, ridership declined by only 1 % over the same time period (The Urban Transportation Monitor, July 7, 1995).

Vuchic (1995), a prominent expert in public transit, concludes that "the empty lane syndrome based on the fallacious belief that filling the lanes does not have any negative impacts on buses, has resulted in degradation of bus service... The conversion of busways to HOV facilities has had major negative impacts from the transportation system policy point of view for two reasons. First, the common 'transit incentive/auto disincentive' package, used successfully in many countries, has been gradually converted into a far more expensive and less efficient 'transit incentive/auto incentive' package. And second, **downgrading of busways onto HOV facilities has virtually eliminated exclusive busways as a viable, high quality transit system.**"

Beside lowering the HOV occupancy requirement, reducing time restrictions on HOV facilities to peak periods only, is also common practice. As a result, lanes that are HOV only at peak periods offer an opportunity for some drivers to sincerely or insincerely plead confusion (Leman, 1994). In response to proposals to open up Orange County's 24 hour HOV lanes to general purpose traffic in non-peak periods, the California Highway Patrol responded that 24-hour HOV status is "less confusing to the public, generally safer to operate, and easier to enforce" (Orange County Transportation Authority, 1991).

Today, the majority of HOV facilities in the US have the lowest possible restriction of 2+. There are only a few examples where the eligibility requirement was raised to improve the level of service of the facility.

HOV Facilities for Carpools on Arterial Roadways

Toronto

In contrast to freeways, there are very few arterial HOV facilities which allow carpools. The most ambitious and comprehensive scheme has been developed for Toronto. In the initial stage, the HOV network was supported by funding from the province. This funding has disappeared since then, and with the recent municipal restructuring, further expansion of the HOV network is on hold. While attempts, often provincially sponsored, have been made to promote carpooling, the HOV lane network has never been backed up with a comprehensive, effective package of incentives and marketing (McCormick Rankin Lty, 1999). In addition to the arterial HOV network, the Province has developed plans and policies regarding the implementation of HOV2+ on almost all of the Toronto-area freeway network, but has not implemented anything to date.

Implementation of the arterial HOV network was planned to occur in three stages. Stage 1 included the conversion of existing bus/taxi lanes and the conversion of a mixed flow lanes. Stage 2 and Stage 3 included further conversion of mixed flow roadways and building new lanes for HOV (McCormick Rankin, 1992).

The plan did not specify any time lines. Stage 1 was considered to be high priority in order to establish a minimum network as fast as possible. It was recognized that further conversions and the construction of new lanes will require time to implement.

By 1994, 65 lane-km of the original plan of 600 km arterial HOV 3+ lanes had been implemented. Most of the 65 kilometers were created by converting existing bus-only lanes or "de-facto" bus lanes . There has been no expansion of the HOV network after 1994.

Table 2: Roadways with HOV 3+ lanes and their origin

Road section	**Description of implementation**
Yonge Street from Bishop Ave to Steeles Ave	1993 Converted mixed flow lanes (which operated as de-facto bus lanes)
Allen Road/Dufferin Street from Transit Road to Finch Avenue	1993 Converted bus lanes
Eglinton Avenue from Leslie Street to Markham Road	1993 Converted mixed flow lanes
Pape Avenue and Overlea Boulevard from Danforth Avenue to Don Mills Road	1993 Converted bus lanes
Don Mills Road from Overlea/Gateway Boulevard to Finch Avenue	1993 South of York Mills Road - Converted bus lanes 1994 Extended to Finch (built as a bus lane then converted)
Dundas street from Highway 427 to Kipling Avenue	Converted mixed flow lanes (which operated as de-facto bus lanes)

In 1994 and 1995, car occupancies were compared in the HOV lanes with those in the general flow lanes. Average car occupancy were similar in both years and they were 25-50 % higher in the HOV lanes. (Table 3). The data in Table 3 also shows that vehicle occupancies in the HOV lanes were significantly lower than the 3+ minimum. This indicates the high number of low occupant cars violating the HOV restriction (The Municipality of Metropolitan of Toronto, 1995).

Table 3: Comparison of average car occupancies in the HOV3+ and the general purpose lanes

Road section	**Car Occupancy Rate (person/veh)**	
	HOV 3+ lane	General lanes
Yonge Street from Bishop Ave to Steeles Ave	1.8	1.2
Allen Road/Dufferin Street from Transit Road to Finch Avenue	1.8	1.2
Eglinton Avenue from Leslie Street to Markham Road	1.6	1.3
Pape Avenue and Overlea Boulevard from Danforth Avenue to Don Mills Road	N/A	N/A
Don Mills Road from Overlea/Gateway Boulevard to Finch Avenue	1.7	1.2
Dundas street from Highway 427 to Kipling Avenue	1.5	1.2

Source: The Municipality of Metropolitan Toronto: Review of High Occupancy Vehicle Lane Operation and Policy, September 19, 1995

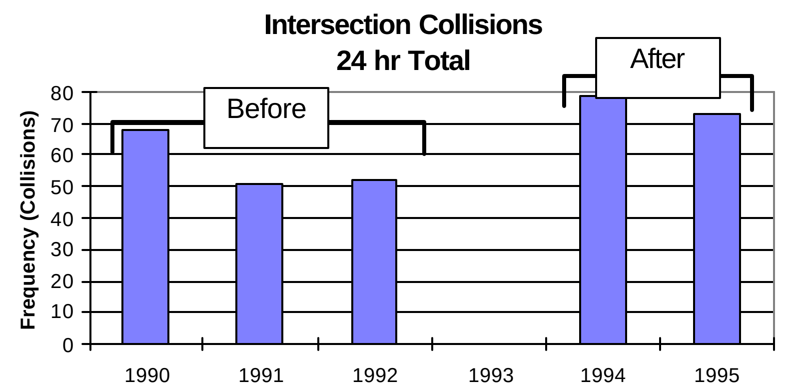
High violation rates were reported at most HOV sections (The Municipality of Metropolitan Toronto, 1995) (Table 4). After an increased enforcement for the first six months of 1995 (600 motorists were ticketed), the violation rate decreased only by 5-10 %. It was concluded that continuous enforcement is essential although enforcement is not sufficient. A strategy, including increased fines and marketing was prepared. In a report to the Planning and Transportation Committee (February 20, 1996) it was suggested that " It is clear that too many drivers currently disregard the HOV lane restriction. If not corrected, this could ultimately make the HOV program meaningless in the eyes of the public." At the present, continuous enforcement does not exist, and violations continue to be a major problem.

Table 4: HOV lane violation rates (ineligible vehicles as a percentage of all vehicles in the HOV lane)

Road Section	**AM peak hour**	**PM peak hour**
Yonge Street from Bishop Ave to Steeles Ave	52 %	44 %
Allen Road/Dufferin Street from Transit Road to Finch Avenue	48 %	52 %
Eglinton Avenue from Leslie Street to Markham Road	61 %	66 %
Pape Avenue and Overlea Boulevard from Danforth Avenue to Finch Avenue	61 %	79 %
Don Mills Road from Overlea/Gateway Boulevard to Finch Avenue	52 %	60 %
Dundas street from Highway 427 to Kipling Avenue	70 %	74 %

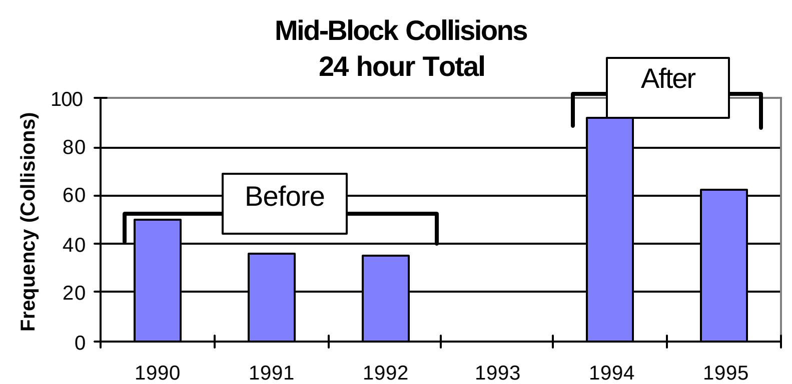
Source: The Municipality of Metropolitan Toronto: Review of High Occupancy Vehicle Lane Operation and Policy, September 19, 1995

Figure 2:



Source: G.B.Bahar et al, Safety Evaluation of HOV Lanes in Metro Toronto, 1998

Figure 3:



Source: G.B.Bahar et al, Safety Evaluation of HOV Lanes in Metro Toronto, 1998

The collision frequency increased along most HOV 3+ lanes (Bahar, 1998) (Figure 2 and 3). Most of the collisions (74 %) are connected to left turns at both intersection and mid-block locations. This type of collision occurs when a left turning vehicle - into a street, plaza or driveway- gets "waived through" by the two lanes of opposing vehicles which are stopped due to congestion (Figure 4). Left turning vehicles collide with approaching vehicles in the free-flowing HOV lane (Bahar, 1998). This type of collision is much less frequent if only buses are allowed to use the HOV lane. Approaching buses, due to their size, are easily noticed by drivers making the left turn.

Figure 4: Collisions involving left turning cars and cars in the HOV lane

The Toronto Transit Commission (TTC) accepted the HOV 3+ concept, because they hoped that eventually buses would have a larger network then with the previous bus-only lane approach. The TTC has, in the past derived significant, measurable benefits from bus-only lanes created by conversion of the curb lane or widening of the road. However, to date, most of the HOV 3+ network was created from converting curb lanes that were already designated as bus-only lanes, or operating de-facto as such. This being the case, and because there are not large numbers of 3+ autos in the HOV lanes, the TTC has not, to date, experienced any significant benefit or disbenefit from the HOV 3+ installation (Sinikas, 1999).

Vancouver, BC

The Transport 2021 Plan envisages certain role of HOV's in the Region's transportation system. The long term HOV strategy targets the seven major bridges and three long road corridors, one freeway and two arterial corridors. Currently, there are only a few arterial HOV facilities (that allow carpools).

The Barnett-Hasting Arterial HOV was Created in 1996 by converting 6 km general purpose lanes and by constructing 12 km additional lanes to a two lane cross section roadway. Although there was a strong policy support for a 3+ restriction, it was opened as an HOV 2+ . The 18 km corridor includes three distinct sections:

- Hasting Street (6.9 km), an urban arterial with numerous cross streets and posted speed limit of 50 km/hr,

- Barnet Highway, a rural highway (8.2 km) limited access and a posted speed limit of 70 km/hr, and
- St. John's Street (2.9 km), a short section of municipal arterial with posted speed limit of 50 km/hr.

A recent evaluation (Bracewell et.al.1999) concludes that the Barnet/Hasting HOV facility has been effective at providing a travel time savings advantage to occupants of HOVs. As a result, there has been an increase of HOVs on the facility. However, this increase has been mainly the result of a mode shift by transit riders and route shift by carpools and vanpools from parallel corridors. The percentage of bus commuters has decreased 5 percent in both directions. In addition, solo drivers from parallel corridors shifted to the Barnet/Hasting corridor (increase of SOVs of 32% -35%) apparently because of the improved service in the general purpose lanes.

The Barnet/Hasting HOV corridor has not achieved its desired level of 85% compliance, but has maintained an effective rate of no less than 79 %. The original plan called for intensive enforcement when the compliance rate falls below 85 %, however, due to budget constraints and other priorities, currently there is very little or no enforcement.

Ottawa

During the construction of the Queensway (late 1980s), one lane in the peak direction was converted to HOV 3+ on Innes Road and Industrial Road as a temporary measure. The primary purpose of the conversion was to maintain bus schedules. It was too short to be effective incentive for carpools. Peak hour usage was in the order of 50 buses, 20-30 carpools, and 80-100 violators (McCormick Rankin, Operational Design Guidelines for HOV lanes on Arterial Roadways). The HOV restriction was removed after completion of the freeway.

Outaouais (Hull, Aylmer, Gatineau)

An HOV program started in 1991 with the objective to provide a less congested lane for buses and to increase average car occupancy. Currently, HOV facilities can be found along two corridors and on one inter-provincial bridge. The occupancy restriction is 3+ (presently it is lowered to 2+ on Portage Bridge due to construction). Most of the lanes were created by converting general purpose lanes (Table 5).

Table 5: HOV 3+ lanes in the Outaouais

Location	**Approximate Length**	**Origin**
Ch. D'Aylmer	3.7 km EB & WB each	Conversion/New construction
Bvld. Alexandre Tache	2.4 km EB 1.2 km WB	Conversion
Bvld. Maisonneuve	1.1 km NB & SB each	Conversion
Queue jump on Bvld. Fournier	400 m EB& WB each	Conversion/New construction on shoulder
Queue jump on Bvld. Greber at Lady Aberdeen Brdg.	300 m EB & 400 m WB	Conversion
Portage Brdg.		Conversion

In the initial stage there was a pilot program to help form carpools, however, that has been discontinued. Currently, there are no specific incentives to encourage carpools. Occupancy enforcement is a continuous problem (Salah Barj, 1999).

STO finds the HOV network beneficial for the transit service (compared to the previous general purpose lanes).

Seattle, WA

Seattle is one of the few North American jurisdictions to plan and implement HOV lanes on both freeways and arterials as part of an integrated network. The first initiatives were on selected freeway segments. Currently, almost every freeway in the Seattle area is earmarked for inclusion in the already extensive HOV network. All facilities have a 2+ restriction. The arterial applications of carpool lanes is much more limited.

In 1993, a peak hour HOV 2+ facility was implemented on Airport Rd. The 5.4 km suburban arterial road section has minimal bus service. The roadway is somewhat unique in that commuter travel in the corridor is dominated by trips to and from one major employer - the Boeing Company which has a very strong ridersharing program (Wellander, 1999).

Seattle has a very strong HOV supporting program which includes:

- employer based ridersharing
- corporate and public vanpool programs

- regional ridematching and marketing
- guaranteed ride home program for carpools
- park&ride lots and carpool parking lots
- preferential parking rates and facilities for carpools
- strong HOV enforcement programs
- public participation in HOV lane enforcement
- transit service coordination
- advanced passenger information systems
- strong media involvement and support
- mandatory Transportation Management Plans for major trip generators
- interagency coordination and cooperation, with transit agencies responsible for all modes of a shared-ride travel (including buses, vanpools and carpools)

San Tomas Expressway, San Jose, CA

In 1982, 10 km of general purpose lanes were converted to HOV 2+. Later, new lanes were constructed for HOVs. The lanes are restricted only during the peak hours in the peak directions. From 1982 to 1988, the number of HOV 2+ carpools increased by 46.7 % (from 300 to 440) during the AM peak hour, and by 31.5 % (from 351 to 462) during the PM peak hour. In 1988, the vehicle occupancy rate for the whole facility (including general purpose lanes) remained relatively low, 1.15 and 1.2 for the AM and PM peak hours respectively (McCromick Rankin, 1992).

Montague Expressway, San Jose, CA

The 6.6 km long HOV 2+ lanes were opened in 1983. A very little increase in ridesharing (0% for AM peak, and 9% for PM peak) has been reported (McCromick Rankin, 1992).

Route 237, San Jose, CA

A 7.5 km section, opened in 1984 (McCromick Rankin, 1992).

Kalanianaole Highway, Honolulu, Hawaii

A contraflow HOV 3+ facility opened in 1987 (McCromick Rankin, 1992).

Kahekili Highway, Honolulu, Hawaii

A buffer separated reversible HOV 3+ lane in the centre of the roadway (McCromick Rankin, 1992).

HOV Experience outside of North America

Research by Turnbull (1992) identified a number of HOV facilities all over the world. In contrast to North America, however, most HOV lanes are reserved only for public transit buses. There are only a few HOV facilities which allow carpools.

Sydney, Australia

The Roads and Traffic Authority (RTA) implemented bus lanes, HOV 2+ and HOV 3+ lanes mainly by converting general purpose curbside lanes. Enforcement and the consequent violation rate has been a continuous problem. The inconsistency of operation
- both eligibility and operating hours vary from route to route - adversely affect both enforcement and public understanding (McCormick Rankin Pty., Ltd., 1999).

There was only a moderate effort put into promoting carpooling and the RTA reported that a major effort to encourage automobile drivers to carpool has not been successful (The Urban Transportation Monitor, September 3, 1999).

The benefits of the network of bus and HOV (carpool) lanes to transit are widely recognized. The Transport Plan 2010 proposes 90 km bus-only transitways in seven corridors. In addition, all new roads must include some measures of transit priority and all six lane arterials in Sydney (about 500 km) are viewed as potential corridors for HOV and/or bus lanes. (McCormick Rankin Pty., Ltd., 1999).

Melburn, Australia

The Eastern freeway has a median HOV 2+ lane and shoulder bus lane. There are no plans to implement HOV lanes on arterials because the focus is on developing the existing tram network (McCormick Rankin Pty., Ltd., 1999).

Canberra, Australia

In 1993, two new bus lanes were opened on Athlon Drive, a 1.1 km congested road section. Within a year, the lanes were re-designated as peak hour only HOV 3+ lanes (McCormick Rankin Pty., Ltd., 1999).

Auckland, New Zealand

The 1 km carpool lane in Auckland which provides access to a bridge operates successfully since 1982 with regular enforcement.

The HOV Experience in Europe

European cities have been implementing car restrictive measures for a many years. However, very little effort has been made to encourage carpooling. The HOV (excluding bus-lanes) concept has had a limited application in European cities.

A well publicized HOV facility in Amsterdam, Holland opened in 1998 and was discontinued a year later. The 8 km long HOV 3+ facility was barrier separated, reversible and operated only during the peak hours. Although, travel time saving was up to 20 minutes, the facility was closed because of underuse and lack of public support (The Urban Transport Monitor, July 9, 1999).

Since 1995, Madrid, Spain has a section of an HOV facility which allows carpools, and in 1998, Leeds, England started an HOV 2+ pilot project on a short roadway section.

The HOV demonstration project in Leeds is one element in a comprehensive European Union research program. The Increase of Car Occupancy through innovative measures and technical instruments consortium (ICARO) defined nine different projects which investigate the possibilities to increase car occupancy.

The ICARO initiative highlights the difference between the US and the European approach in solving transportation problems. In the US, the focus is primarily on the automobile; US measures to encourage carpooling, in many cases, start with the provision of additional road infrastructure for HOVs. Only one ICARO project, the experiment in Leeds, involved creating HOV 2+ lanes. The HOV lane was converted from general purpose lane. All other projects focused on measures which did not require road infrastructure (Table 6).

Table 6: List of ICARO projects in the Europe

Location	**Description**
Leeds, UK	Converting a congested general traffic lane into an HOV 2+ lane
Salzburg, Austria	- Car parks for carpools at 12 locations - Preferential parkings - Media information campaign - Matching and information center - Ride home for half price transit ticket
Brussels, Belgium	Carpool coordination center as an element of a wider strategy that includes a park& ride facility, promotion of public transport and bicycle use
Graz, Austria	Encouraging drivers to give other people a lift to the next public transit stop
Rotterdam, Holland	Guaranteed ride home scheme
Pilzen, Czech Republic	Development of a car pool program
Switzerland	Preferential parking for carpools at train stations

The final evaluation of the pilot projects is not yet available but the interim observations point out the importance of placing more emphasis on public transit and less emphasis on private car travel. Furthermore, most recommendations suggest that carpools should be an integral part of the transit feeder service.

Conclusions

1. The operational characteristics of busways (e.g. Transitway in Ottawa-Carleton) and the typical HOV 2+ facilities are fundamentally different. Busways should not be confused with typical HOV facilities.

2. In corridors with transit service, a decrease of transit ridership can occur especially when the HOV lanes are created by new construction.

3. A significant network of HOV lanes which allow carpools exists only in the US. Most HOV lanes are on freeways. On arterial roadways, HOV lanes for carpools found limited application anywhere in the world.

4. HOV's inability to attract carpools, often resulted in reducing the requirement to the minimum of 2+ , and in experimenting with allowing ineligible vehicles in the HOV lanes for a fee. This downgrading can be described either as the evolution of HOV facilities, or as the failure/lack of transportation and land use policies.

5. The low-density development in the US and the degradation of bus only lanes into HOV facilities, in many cases, eliminated the potential of developing a high quality bus-based transit system.

6. In European cities, encouraging car drivers to carpool instead of taking transit is not an objective. Another reason for not focusing on HOVs is that restrictions on car use are often used together with transit improvements.

7. All HOV facilities on arterial roadways experience relatively high violation rates. Although bus lane violation is also a common problem (without strict enforcement), enforcing the HOV 3+ restriction is a much bigger challenge than enforcing a bus-lane.

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Appendix 1: *HOV facilities in the US*

(Source: The Urban Transportation Monitor, February 27, 1998 and March 13, 1998)

Urban Area	**Highway**	**Eligibility**	**Changes in Eligibility Rules**
BUSWAY			
Miami, FL	US 1	Buses only	
Pittsburg, PA	East/West Pathway	Buses only	
BARRIER SEPARATED: TWO-WAY			
Los Angeles, CA	I-10 (El Monte)	3+	Changed from BOL
Los Angeles, CA	I-105/I-110 Fwy/Fwy connectors	2+	
Orange County, CA	I-5	2+	
Houston, TX	I-610/US 290elevated, opposing flow not separated	2+	
Seattle, WA	I-90	2+	
BARRIER SEPARATED: REVERSIBLE FLOW			
Denver, CO	I-25	2+	Changed from BOL
Northern Virgina	I-395 (Shirley Highway)	2+	Changed from BOL to 4+ and 3+
Houston, TX	I-10 (Katy Freeway)	3+ peak 2+ off peak	Toll road pending
Houston, TX	I-45 Gulf Freeway	2+	
Houston, TX	US 290 Northwest Freeway	2+	
Houston, TX	I-45 North Freeway	2+	Changed from BOL
Houston, TX	US 59 Southwest Freeway	2+	
San Diego, CA	I-15	2+	Toll for SOV
Minneapolis, MN	I-394	2+	
Pittsburg, PA	I-279/579	2+	Changed from 3+
Norfolk, VA	I-64	2+	
Seattle, WA	I-5 North Express Lane	2+	Changed from 3+
Seattle, WA	I-90	2+	
CONCURRENT FLOW: BUFFER SEPARATED/NON SEPARATED			
Phoenix, AZ	I-20	2+	Changed from 3+
Phoenix, AZ	SR-202	2+	
Phoenix, AZ	I-17	2+	
Vancouver, BC	H-99	3+	Changed from BOL
Los Angeles, CA	I-10(El Monte) San Bernardino Fwy	3+	Changed from BOL
Los Angeles County, CA	I-105	2+	
Los Angeles County, CA	I-110	2+	
Los Angeles County, CA	I-210	2+	

Los Angeles County, CA	I-450 (Includes Orange Co. Line to I-710	2+	
Los Angeles County, CA	SR 91	2+	
Los Angeles County, CA	SR 118		
Los Angeles County, CA	SR 134	2+	
Los Angeles County, CA	SR 170	2+	
Los Angeles County,CA	I-605	2+	
Los Angeles County, CA	SR 57	2+	
Los Angeles County, CA	SR 30	2+	
Orange County, CA	I-5	2+	
Orange County, CA	SR 55	2+	
Orange County, CA	I 405	2+	
Orange County, CA	SR 57	2+	
Orange County, CA	SR 91	2+	
Orange County, CA	SR 91	3+, toll	toll on HOV 3+
Riverside County, CA	SR 91	2+	
San Bernardino County	SR 60	2+	
San Bernardino County	SR 71	2+	
Santa Clara/San Mateo Counties, CA	US 101	2+	
Santa Clara/San Mateo Counties, CA	SR 237	2+	
Santa Clara/San Mateo Counties, CA	SR 85	2+	
Santa Clara/San Mateo Counties, CA	I 280	2+	
Santa Clara/San Mateo Counties, CA	Capitol Expy (shoulders)	2+	
Santa Clara/San Mateo Counties, CA	Lawrence Expy (shoulders)	2	
Santa Clara/San Mateo Counties, CA	Montague Expy (shoulder)	2+	
Santa Clara/San Mateo Counties, CA	San Thomas Expy (shoulder)	2+	
Alameda County, CA	I 880	2+	
Contra Costa County, CA	I 80	3+	
Contra Costa County, CA	I 680	2+	
Conta Costa County, CA	I 580	2+	
Marin County	US 101 (2 projects)	2+	
Sacramento, CA	SR 99	2+	
Denver, CO	US 36 Boulder Turnpike	Buses only	
Hartford, CT	I 84	2+	Changed from 3+
Hartford, CT	I 91	2+	
Ft. Lauderdale, FL	I 95	2+	
Norfolk/Virginia Beach, VA	I 564	2+	
Norfolk/Virginia Beach, VA	I 264	2+	
Seattle, WA	I 5 North	2+	Changed from 3+
Seattle, WA	I 5 South	2+	
Seattle, WA	I-90	2+	Converted from mixed flow
Seattle, WA	I-405 (median & shoulders)	2+	
Seattle, WA	SR 167	2+	
Seattle, WA	SR 520 (shoulder)	3+	Changed from bus only

CONTRAFLOW

Honolulu, HI	Kalanianaole Hwy	2+	Changed from 3+
Honolulu, HI	Kahekili Hwy	2+	
New Jersey	Rt 495 (to Lincoln Tunnel)	Buses only	
New York City, NY	I-495 Long Island Expressway	Buses, vanpools,Taxis	
Dallas, TX	I-30 East (R.L. Thornton Fwy)	2+	
Boston, MA	I-93 SouthEast Expy	2+	1995: opened as 3+ Sep 96: 2+allowed with sticker Feb 99: all 2+ allowed