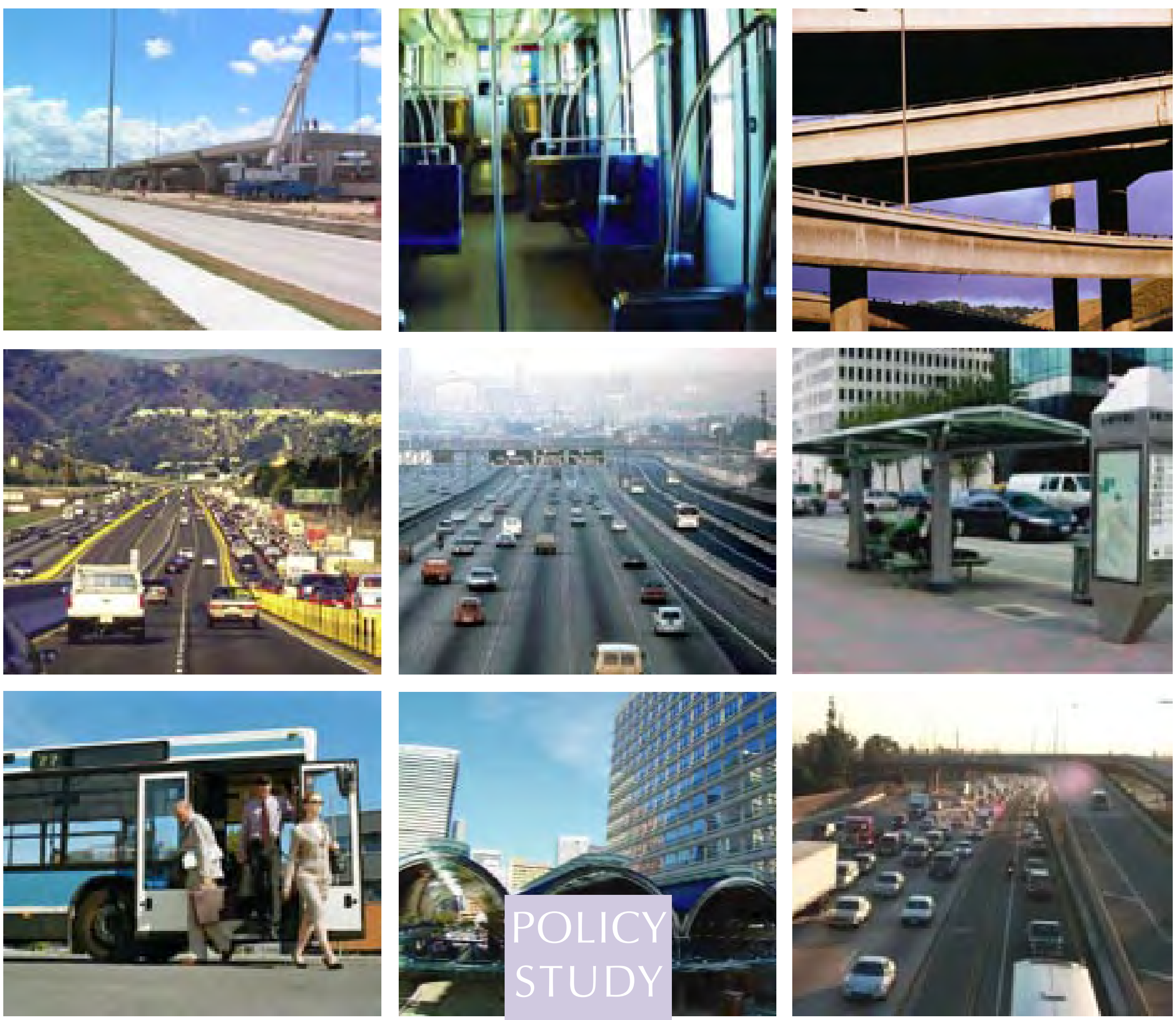
September 2005

Virtual Exclusive Busways:
Improving Urban Transit while Relieving Congestion

by Robert W. Poole, Jr. and Ted Balaker



Policy Study 337

Reason

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Executive Summary

Bus rapid transit can deliver much higher-quality service if operated on exclusive busways where there is no congestion. Only a handful of such busways exist in America today, but this country's growing system of carpool lanes began as "transitways," intended for buses and vanpools. Only when it was found that most such transitways had lots of unused capacity were they gradually opened up to four-person, then three-person, and eventually two-person carpools, becoming high-occupancy vehicle (HOV) lanes.

This strong public policy favoring carpools has led to unintended consequences. It has encouraged these expensive new lanes to fill up with "fampools"—two or more family members who would be riding together anyway. Fampools constitute between one-third and two-thirds of HOV lane users, depending on the facility. Also, by allowing even two-person carpools into specialized lanes, public policy has devastated the vanpool sector, which is the most cost-effective and energy-efficient form of transit. And filling up the most important HOV lanes with two-person carpools destroys their effectiveness as transit guideways, which is especially crucial for bus rapid transit (BRT).

It's time to rethink America's over-emphasis on carpooling and revisit the advantages of busways. Instead of filling up the empty space on a busway with fampools, we could fill it up with paying customers. And because those customers would pay value-priced tolls, their numbers could be limited to amounts consistent with maintaining uncongested conditions even at the busiest rush hours, as proven on the HOT lanes in San Diego and Orange County, California.

Thus, a value-priced busway would be the *virtual equivalent* of an exclusive busway. From the transit agency's standpoint, it would have the same performance (high speed, reliability, absence of congestion) as an exclusive busway. But the large majority of its capital costs would be paid for, willingly, by drivers who chose to pay for its use to bypass congestion.

The nation's first Virtual Exclusive Busway (VEB) is under construction in Houston. It is being developed via a three-way partnership of the local transit agency (METRO), the local toll agency (HCTRA), and the Texas DOT. Four value-priced managed lanes are being added to the Katy Freeway (I-10) as part of a large-scale reconstruction of that corridor. METRO is guaranteed up to 25 percent of the new lanes' capacity for buses and three-person carpools, and has committed to increasing the HOV occupancy level as needed in future years to preserve capacity for its express buses. HCTRA has committed to increasing the value-priced toll levels as needed to maintain uncongested traffic flow.

Networks of such managed lanes, if governed by such partnership agreements, would become VEB networks. They would make possible high-quality (reliable, high-speed) regional express bus service, facilitating new forms of bus rapid transit. The year 2030 long-range transportation plan for the San Francisco Bay Area, adopted in February 2005, includes a proposed $3 billion network of this type, the first to be included in such a long-range plan. Studies are under way for such value-priced networks in Atlanta, Dallas, Denver, Houston, Maryland, Miami, Minneapolis/St. Paul, and Washington, D.C.

Federal transit policy should be changed to facilitate the development of VEBs and VEB networks. First, value-priced lanes that guarantee a portion of their capacity for transit services should be defined in federal law as "fixed guideways" for all federal transit purposes. Second, VEBs and VEB networks should be one of the alternatives studied in the alternatives analysis carried out in applying for Federal Transit Administration New Starts capital funding. And such funding should be available for the transit-specific components of a VEB or VEB network, including park-and-ride lots, direct-access ramps, stations, and buses.

Rubber-tire transit (including express bus and vanpools) can be highly cost-effective, especially when operating on exclusive rights of way. Our experience over the past decade with value pricing shows that such pricing can be used to create the virtual equivalent of an exclusive busway, paid for largely by drivers. This is too good an opportunity for transportation planners to pass up.

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Part 1

The History of American Busways

A. The Promise of Busways

The climate of the 1960s and 70s was rather friendly to the development of exclusive busways. Local transit officials watched as communities boomed with population and traffic. Bus transit's relatively low cost meant officials could quickly expand service to keep up with expanding populations. Local officials looked to the bus's high carrying capacity to help resist gridlock, and often designed busways to function as rubber-tire commuter rail systems.[1] Compared to the automobile, the bus took up less roadway space per person, and this added to the appeal of rubber-tire transit.[2]

Bus transit could appeal to middle-class commuters with features that emphasized comfort and convenience. Stations that provided prompt transfers would decrease the time passengers spent waiting for buses, and clustering bus service with other modes allowed for easy access to long distance bus lines, rail and airport terminals. Features like extra-wide seats and air conditioning made the on-board portion of the commute more pleasant.

Bus transit also offered flexibility. Drivers and dispatchers could share traffic flow information quickly, and this real-time communication allowed for re-routing that often avoided accidents and other gridlock-producing incidents. Flexibility also meant that buses could operate in mixed traffic, which allowed them greater opportunity to pick up and drop off passengers, and thus decreased the need for transfers.

The federal government did its part to codify bus optimism into policy. Both the Federal Highway Administration and Urban Mass Transit Administration (today the Federal Transit Administration) were friendly to bus transit and encouraged the development of busways.

As one U.S. Department of Transportation study put it:

> *It became obvious that building a bus transit system would be the logical, most cost-effective solution in the corridors with moderate or large passenger volumes where considerably higher level of service is needed …*[3]

However, the political climate that favored exclusive busways did not last long. Only a handful of busways were built then, and most of them have since become carpool lanes. In only two cases are these original busways still used as exclusive busways today.

New Jersey

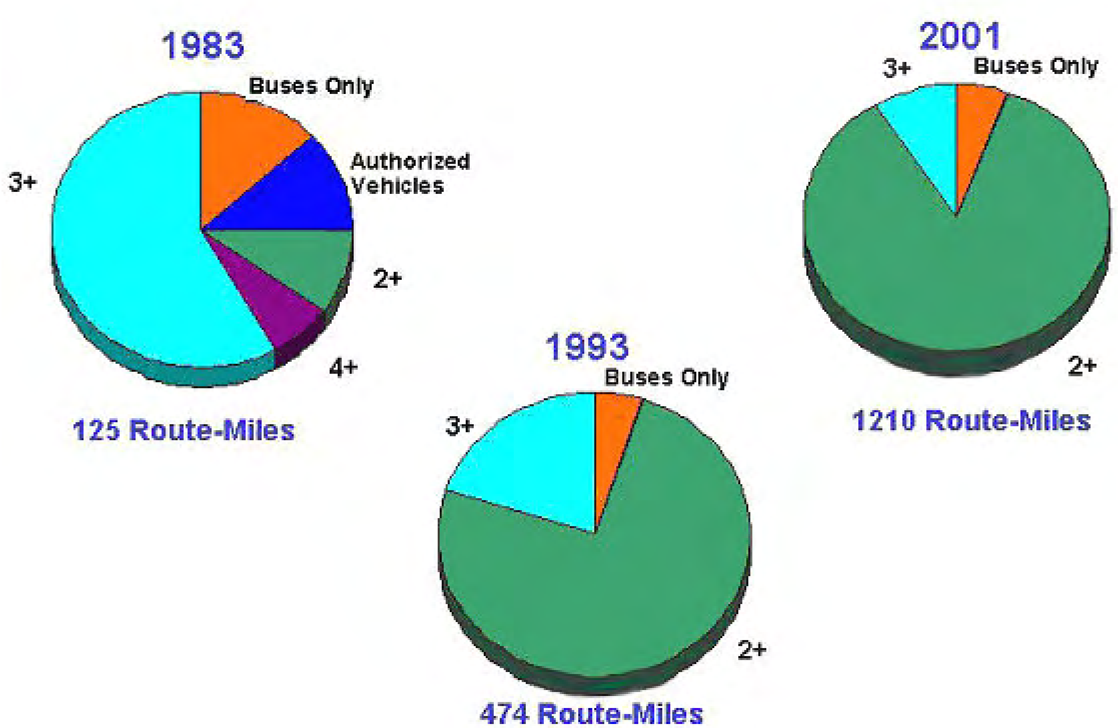
Opened in 1970, the Lincoln Tunnel Exclusive Bus Lane (XBL) is by far the nation's most productive busway. The 2.5-mile facility is located on the approach road to the Lincoln Tunnel, which leads to the Port Authority Bus Terminal in Manhattan. During the peak hour in the peak direction, 730 buses travel on the XBL—roughly five seconds between buses. During the morning rush period the XBL carries nearly 16,000 passengers per lane per hour, and over 25,000 passengers during the busiest hour.[4] Daily weekday ridership stands at about 60,000. This is the highest bus ridership of any corridor in the nation, and exceeds the daily ridership of all light rail lines.

Pittsburgh

Pittsburgh is home to three busways, the first of which opened in 1977. Today daily ridership on the 4.3-mile South Busway averages 13,000 per weekday, while ridership on the 9.1-mile Martin Luther King, Jr. East Busway (opened in 1983) approaches 30,000. The 5-mile long West Busway opened in 2000, and averages ridership of 8,000 per weekday.[5]

All the other original U.S. busways have evolved into carpool facilities, and most evolutions have been incremental, with busways first transitioning to HOV-4, then HOV-3, and finally to HOV-2, where most stand today. Figure 1 shows how, as total HOV lane-miles have grown, HOV-2 facilities have comprised a growing share of HOV facilities.

Figure 1: Evolution of Freeway HOV Lane Eligibility (2002)



Note: Authorized vehicles were vanpools, buses and emergency vehicles

B. From Busways to Carpool Lanes

Washington, D.C.: Shirley Highway

The Shirley Highway (I-395) was home to the nation's first busway, but the busway was not a part of the original plan. Rather, the busway was developed during the reconstruction of the Shirley Highway, and initially officials planned to rebuild the existing route—two lanes each direction separated by a median—into an eight-lane freeway with three lanes in each direction and two reversible lanes in the median.

Beginning in 1964, discussions among highway and transit agencies and two bus companies resulted in proposals to incorporate express bus service into the reconstruction plans. At the time federal policy favored bus lanes, and the area's high growth and downtown Washington's dwindling supply of parking spaces made the bus's high passenger capacity more and more appealing to planners. In September 1969 an interagency plan granted buses exclusive access to the 4.5 miles of completed reversible lanes during the morning rush. The arrangement resulted in a travel time savings of between 12 and 18 minutes, prompting bus ridership to jump 15 percent almost immediately.

The next year officials determined they could extend express bus service during the completion of construction by building a temporary busway in the four miles from where the completed reversible lanes ended to the Potomac River. The first 1.5 mile section of the temporary busway opened in September 1970, and the final 2.5 miles opened the following April, creating a continuous 11-mile exclusive busway from Springfield, Virginia to the Potomac River. The District of Columbia added to the bus's swiftness by implementing peak-period bus priority lanes and turn advantages.

Park-and-ride lots increased convenience, and new buses equipped with special features like air conditioning, wide seats and aisles and carpeting increased comfort. Two-way radios allowed bus drivers and dispatchers to quickly re-route buses away from accidents and traffic snarls.

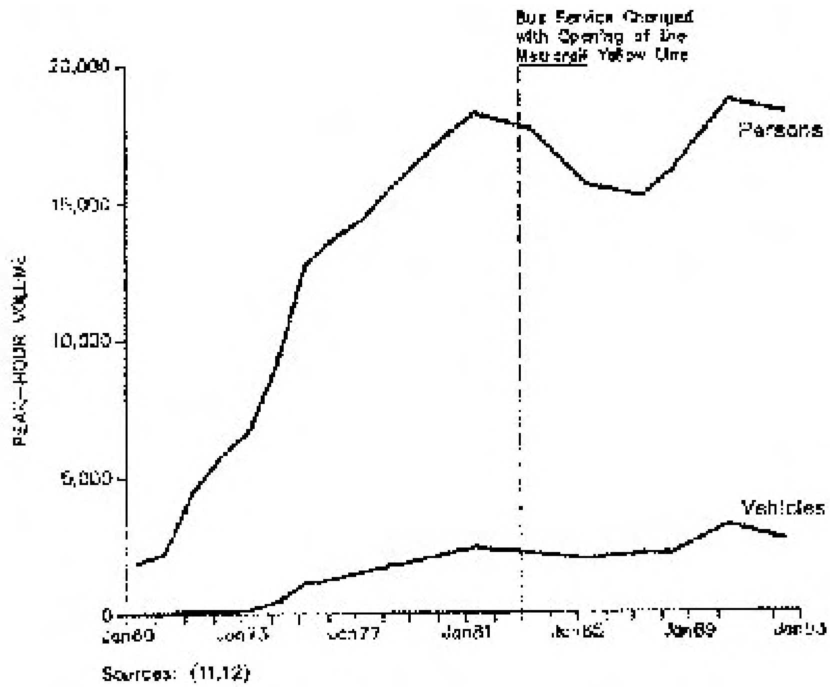
Bus ridership continued to soar, and yet there was still unused capacity in the lanes. In 1974, an official with the Northern Virginia Transportation Commission (NVTC) observed:

> *During a recent traffic count, 7,700 bus passengers were observed on the bus lanes, while only 7,100 car passengers were observed on the three auto lanes of the highway. The bus lanes still have a substantial additional capacity, while the auto lanes at this volume are at the capacity of the roadway.*[6]

Officials wanted to increase carpooling to reduce congestion, pollution, and fuel consumption, and since the busway had extra capacity, the bus-only status ended in December 1973, when vanpools and HOV-4 vehicles were allowed access. The following year the decade-long Shirley Highway reconstruction and expansion project was completed, and along with it, the completion of the two-lane, barrier-separated HOV facility.

Figure 2 shows the tremendous growth of the facility's traffic volumes. During the first year of operation, approximately 39 buses carrying 1,920 people used the lanes during the morning peak hour. By 1974, the figure had increased to 279 buses and 11,340 passengers, and by 1991 the morning peak-hour volume for buses, vanpools and carpools was 2,773 vehicles and 18,406 passengers.[7]

Figure 2: Shirley Highway HOV Use



The vehicle occupancy requirement would remain unchanged until January 1989, when it dropped to HOV-3 after traffic studies suggested a lower threshold would not congest the HOV lanes.[8] In September 1992, Virginia law gave motorcycles access to HOV facilities statewide, and a subsequent law opened up HOV lanes to hybrid vehicles, as well.

Los Angeles: El Monte Busway

Located on the San Bernadino Freeway (I-10), the El Monte Busway is one of the nation's oldest transitway facilitates. It originally operated as an exclusive busway, with the easterly section opening in January of 1973, and the westerly section in May 1974. During a 1974 Southern California Rapid Transit District bus driver strike an emergency measure turned the Busway into an HOV-3 facility. Once the strike was settled the HOV-3 status was discontinued, but it returned again in 1976.

From 1973 to 1976, the number of buses using the lane during the morning rush increased from 21 to 64, and the return to HOV-3 in 1976 did not have a noticeable impact on ridership. In 1989 a one-mile extension into downtown Los Angeles brought the Busway to its current 11-mile length.

In 2000, the occupancy requirement dropped to HOV-2 during a six-month demonstration project, but increased congestion prevented the project from becoming permanent. Although the Busway would remain HOV-2 during off-peak hours, it returned to HOV-3 during peak hours. After the peak hour HOV-3 requirement was re-established, Busway travel speeds increased, though they would not equal their previous speeds.[9] Today, El Monte remains one of the most productive facilities of its kind, carrying peak- hour volumes of over 60 buses and over 1,200 HOV-3 vehicles.[10]

Houston Transitways

In the mid-1970s both the Texas Highway Department (THD) and Houston's Office of Public Transportation (OPT) were concerned about increasing traffic congestion. The bodies found common ground with an approach that would boost bus and vanpool use. Using a mix of federal, state and local funds, Houston decided upon a demonstration project that included a nine-mile contraflow HOV lane (a lane in the off-peak direction for HOV travel in the peak direction), park-and-ride lots, freeway ramp metering and contracted bus service.

(1) North Freeway Transitway

In 1979, the newly created Metropolitan Transit Authority of Harris County (METRO) replaced OPT and later that year the contraflow transitway began operation on I-45 North. During the morning rush, the lane operated in the inbound direction toward downtown, and it switched during the afternoon rush to accommodate outbound traffic.

Plastic pylons separated the oncoming traffic, meaning each morning and afternoon METRO crews had to set up and remove them. Because of the safety concerns inherent in such an arrangement, only authorized buses and vanpools—subject to rigorous safety inspections and special training—were allowed on the transitway. Safety concerns prevented the temporary contraflow lane from being considered for use by any other types of vehicle.[11]

Prompted by the oil embargo of 1979 many downtown employers subsidized vanpool service for their employees into the early 1980s. The transitway proved highly productive. During the morning rush, it carried as many people as the adjacent two freeway lanes. During the first few years of the project, some 8,000 bus riders and vanpoolers used the lane on a daily basis. That figure increased to 15,000 daily riders after a 3.3-mile concurrent flow lane from the entrance of the contraflow lane was added in 1981. The demonstration suggested that drive-alone commuters were willing to try buses and vanpools.

Surveys found that nearly 40 percent of bus riders and between 30 and 42 percent of vanpoolers had previously driven alone.[12] The success of the demonstration project led to the creation of a permanent transitway, a barrier-separated, reversible facility located in the freeway's center median. The permanent lane replaced the contraflow lane in 1984, and several years later a change to FHWA policy allowed carpools in HOV lanes.

(2) Katy Freeway Transitway

The I-45 contraflow lane's success spawned a second transitway in the Houston area. The Katy Freeway Transitway opened in October of 1984, and like the I-45 HOV lane, would only allow buses and vanpools. However, because of the relatively low bus and vanpool use, the vehicle occupancy requirement was lowered to HOV-4 in 1985.[13]

In the wake of oil shortages and changes to FWHA policy that reversed an earlier preference for BRT, carpooling grew in popularity. In Houston, the vehicle occupancy requirement continued to drop, from HOV-3 later that year to HOV-2 in 1986. Carpools quickly overtook bus and vanpools, and within three years morning rush vanpool volumes had dropped by nearly 70 percent (see Table 1). The move to HOV-2 brought more traffic, and more congestion, and bus riders were particularly vocal in their frustration.

To address the mounting congestion, in October 1988 officials increased the vehicle occupancy requirement to HOV-3 from 6:45 to 8:15 AM. During other times the requirement remained HOV-2. The HOV-3 restriction on the Katy Freeway has changed over the years. In 1990, the time period was shortened slightly to end at 8:00 AM, and the following year the HOV-3 restriction came to the afternoon rush, from 5:00 to 6:00 PM. Bus volumes stagnated, and vanpooling continued to slide. Carpooling began to rebound, but could not reach pre-1988 levels. In order to allow for more efficient use, officials changed the operating policy to High-Occupancy Toll in 1997, which allowed HOV-2 motorists into the HOV-3 lane upon payment of a toll.

Houston's transitway system grew rapidly and by 2003 there were 100 miles of HOV lanes operating on six freeway corridors. Apart from the Katy and Northwest facilities, all these facilities now operate as HOV-2. As Houston's facilities evolved from busways to carpool lanes, the terms used to describe the facilities also evolved—"transitway" eventually gave way largely to "HOV." Houston's system was designed to promote bus transit. It was developed by and funded by transit agencies. The local agency sought funding from the FTA, which was not especially enthusiastic about funding HOV lanes. For these reasons, "transitway" was a more appropriate term. As occupancy requirements fell and HOV lanes became a fixture in Houston, and around the nation, eventually "HOV" supplanted "transitway."[14]

Table 1: The Evolution of the Katy Transitway

		AM Peak Hour HOV Lane Vehicle Vol.			
Vehicle eligibility and vehicle-occupancy requirements	Date	Carpools	Vanpools	Buses	Total
Buses and Vanpools	Oct 1984	--	66	20	86
HOV-4	April 1985	3	68	25	96
HOV-3	Sept 1985	53	59	31	143
HOV-2	Nov 1986	1,195	38	32	1,265
	Nov 1987	1,453	21	37	1,511
HOV-3*	Oct 1988	510	24	36	570
	March 1989	660	28	40	728
	Dec 1989	611	19	37	667
	1996	858	19	33	910

* The HOV-3 carpool requirement was implemented for the period of 6:45 to 8:15 AM in Oct 1988. In May 1990 it was shortened to end at 8:00 AM, and in Sept 1991 HOV-3 was implemented from 5:00 to 6:00 PM.

Source: Richard H. Pratt, et al, "Traveler Response to Transportation System Changes, Interim Handbook," Transit Cooperative Research Program, Washington, D.C. 2000.

C. Why Busways Became HOV Lanes

Many factors contributed the decline of busways and the rise of carpool facilities. Some factors were very practical. From a transit official's perspective, separate busways had both advantages and disadvantages.

Being separated from other traffic gave the bus great speed advantages, and it allowed transit agencies to offer a service far superior to the sluggishness and unpredictability of conventional bus travel.

And yet it was difficult to justify reserving so much capacity solely for bus riders. For all their transit advantages, busways also meant that much roadway capacity—created at significant cost—would go unused. It was simply smart policy to make the most use of the available capacity. Transit officials thought carpools would put unused capacity to good use, and still provide an alterative to single occupancy driving. These officials argued for a federal policy that would grant them the flexibility to introduce carpooling.

Another factor, which at first glance would seem to be only a clear-cut asset, also emerged as a liability. Flexibility is one of the primary assets of the bus; it allows for quick re-routing, prompt changes in service areas, and the ability to travel through mixed traffic. Yet flexibility also implies lack of permanence, and this perception left busways vulnerable to pressures that would erase the advantages of bus transit. After all, the presence of a busway also makes "that strip of asphalt very attractive to all other drivers."[15]

And so, while officials within local transit agencies pushed for carpool lanes, outside political forces also played an important role in the evolution away from busways. Highway departments and motorists pressured local officials to drop vehicle requirements to HOV-2 in order to avoid the "empty lane syndrome," and fill in the empty spaces on the road. Transit advocates were not impressed with such rationale:

> *The public, and even most of the transportation authorities and planners, are blinded by the attraction of "free space" between buses on exclusive busways. They do not understand that "filling the space" with automobiles and other vehicles deteriorates the performance of buses, and in the long run, destroys the concept of a Bus Transit System.*[16]

However, carpool momentum continued to mount. World events, such as the oil embargo and oil shortages of the 1970s, helped quicken the turn toward carpooling, as more and more lawmakers regarded the practice as a way to conserve fuel and decrease dependence on foreign oil. Even with higher gas prices, private auto travel continued to grow, and here carpooling offered an aspect of realism and compromise. Americans would not have to give up their cars to make use of this conservation technique.

Although there were no watershed events, policies at all levels of government began to permit, and eventually favor, carpooling. During the 1970s various projects allowed for HOV-3 facilities. Often, officials were pleased with the results of temporary demonstration carpool projects. In some cases, unexpected events spawned unexpected carpool demonstration projects (for example, the opening up of the Los Angeles El Monte busway to HOV-3 vehicles due to a transit strike). Temporary projects became permanent and the success of early experimentation with carpools spurred new rounds of carpool facilities. In some cases HOV-3 facilities still left lanes with excess capacity, and that led to more consideration of HOV-2.

Still, not everyone was embracing carpool lanes. Even into the 1980s FHWA argued that the HOV-2 requirement:

> *accomplishes little more than rearranging traffic in lanes according to the number of occupants. The number of vehicles using the HOV lane may increase, but this is offset by a decrease in the average vehicle occupancy in the other lanes. Use of HOV-2 does not generally accomplish the purpose for which priority treatments are implemented; i.e., to move more people in fewer vehicles and encourage people to use high occupancy vehicles.*[17]

However, momentum continued to build for lower vehicle occupancy requirements. In the early 1990s, policy solidified into more specific laws that favored carpool lanes. Even FHWA had warmed to the concept. In 1990 FHWA directed regional administrators to promote HOV lanes, and the FHWA Administrator declared that FHWA “strongly supports the objectives of HOV preferential facilities.”[18]

America’s heightened concern about environmental quality provided yet another reason to support carpooling. The Clean Air Act of 1990 listed HOV lanes as a transportation measure states could use to attain federal air quality standards, and the 1991 Intermodal Surface Transportation Efficiency Act (ISTEA) encouraged the construction of HOV lanes by making such facilities eligible for Congestion Mitigation and Air Quality (CMAQ) funds. ISTEA also changed the federal government’s involvement in highway funding. Previously, states could receive a 90 percent federal matching ratio if they added general-purpose lanes. After ISTEA, that arrangement was only offered to HOV projects. ISTEA also allowed states to define a “high occupancy” vehicle as one that has as few as two occupants.

Many transportation experts bristled at the new, official definition. One called it “almost Orwellian to use the term ‘high occupancy’ to refer to a vehicle with only two occupants.” Another posed the following hypothetical:

> *Suppose before HOV became a popular term, we had shown someone a chart displaying the full range of vehicles using the highways, from a driver-only automobile to a large, full bus, and asked which point separated vehicles with a high occupancy from the rest. Would anyone, faced with such a choice, have picked four, much less three or two?*[19]

But once officials lowered occupancy requirements, they created a new interest group that cried foul if attempts were made to revoke its new privilege. So while it is relatively easy to surrender to pressures to lower occupancy requirements, it is politically difficult to raise them again, even if congestion mounts and vehicle occupancy drops. When Seattle downgraded from HOV-3 to HOV-2 there was a large increase in vehicles in the HOV lanes, but not a significant reduction of vehicles in the regular lanes:

> *In fact, there was a decrease in the freeway’s overall vehicle occupancy and an increase in the proportion of single occupancy vehicles (SOV). People left buses (now slowed by the traffic) for carpools and left vanpools and larger carpools for 2+ carpools. They also shifted onto the freeway from parallel arterials, and traveled more at peak periods. And they took trips that formerly they would have not made at all. Collisions also increased.*[20]

Yet even these disappointing results did not prompt Washington State to return the lanes to HOV-3. Commuter information culled from transit agencies nationwide reveals that lowering occupancy requirements clogged carpool lanes and soured commuters on ridesharing.[21] Coordinating one’s schedule to accommodate a carpool or vanpool can be quite a chore, one that commuters will avoid if the benefits—faster travel times—are not obvious.

In the past decade, HOV facilities did not evolve from busways to carpool lanes or even from HOV-3 to HOV-2. Rather, they were built as HOV-2 facilities from the beginning.
Yet the outcome remained the same: a policy designed to combat gridlock and increase vehicle occupancy often failed to accomplish either goal.

Throughout the ’90s and into the 21st century automobile travel continued to grow while all other surface transportation modes shrank in significance. It is easy to see how carpooling, itself a partial concession to the auto's dominance, would be regarded by policymakers as the most realistic alternative to driving alone. Even as carpooling's work trip market share slipped, transportation decision-makers could reasonably assume that extending more privileges to carpoolers (i.e. building more carpool lanes) would entice more people to carpool. Yet even with thousands of miles of new carpool lanes, the practice continued to decline.

D. The New Busways

Decades after the first exclusive busways were developed, a renewed interest in a concept known as bus rapid transit (BRT) prompted the development of a few new facilities that often granted buses exclusive access.

Miami

The 8.2-mile South Miami-Dade Busway runs parallel to US1 and has an average weekday ridership of 12,500. Weekend ridership is actually somewhat higher, and stands at 13,600. The facility opened in 1997, and was built on an abandoned Florida East Coast Railroad right-of-way. An 11.5-mile-long second phase will expand in two segments. The first is a 5-mile segment that extends the busway southward to SW 264 Street, while the 6.5-mile second segment will reach farther south to SW 344 Street.[22]

Orlando

Lymmo, Orlando's no-fare Bus Rapid Transit system, has operated since 1997 and carries an average of 4,200 passengers per weekday.[23] It offers free service on its circular 2.3-mile route, which operates in the central business district. Though operating on surface streets, it has been given an exclusive lane in which to operate.

Las Vegas

This 7-mile route opened in July 2004, and runs from downtown to Nellis Air Force Base. Known as MAX, the bus line uses futuristic buses that from most angles are nearly indistinguishable from light rail cars.[24] Like the Orlando system, it operates on an exclusive transit-only lane.

Seattle

The 1.3-mile underground Metro Bus Tunnel is designed for dual-power buses, which use diesel on surface streets and electric power while underground. Roughly 40 percent of rush-hour bus trips through downtown use the tunnel, and all tunnel stations are within Seattle's "Ride Free" area. Once outside the Tunnel area, the buses enter HOV lanes on the Seattle freeway system.

Even with the new wave of busways, the total number of BRT facilities remains quite small. And even though the concept has much potential, no U.S. metro area has attempted to recreate the success enjoyed by cities like Ottawa or Curitiba, Brazil, where BRT on exclusive lanes serves as transit's centerpiece.

Part 2

Second Thoughts on Carpool Lanes

A. The Evolution of Carpooling

In the early days of the automobile, carpooling was a matter of economic necessity. Cars were simply too expensive and households too large for most families to avoid carpooling. Hitchhiking was commonplace, and although it would be decades until governments implemented separate high occupancy vehicle (HOV) lanes, government pushed for carpooling in other ways. Wartime rationing discouraged driving alone, and publicity campaigns even tied carpooling to the war effort. "If you ride alone, you ride with Hitler," warned one World War II-era advertisement.[25]

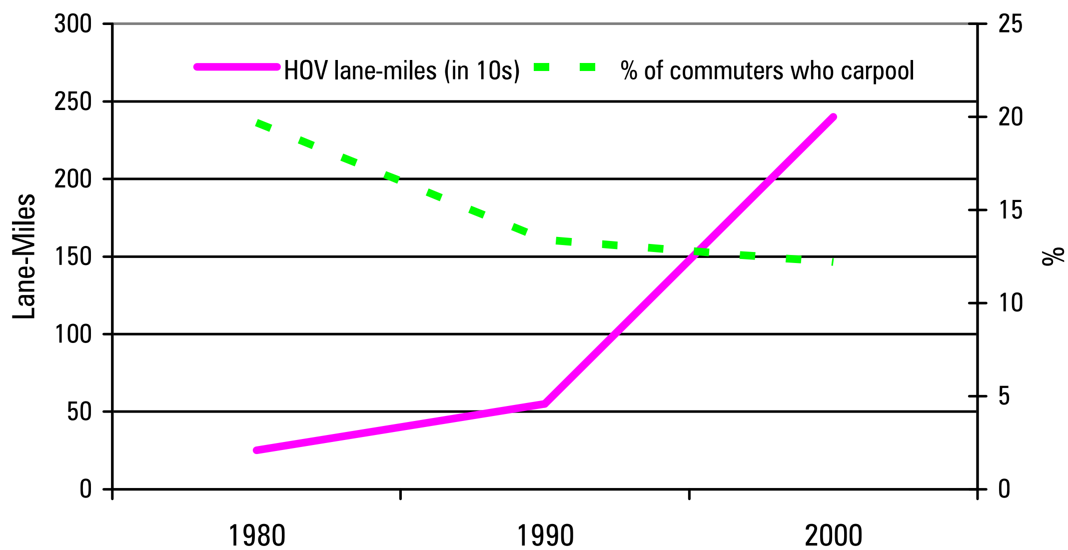
As society grew wealthier, more households could afford a car of their own. Shrinking family sizes meant more cars per person, thus decreasing the necessity of carpooling. During the 1970s governments again began to push for carpooling. Publicity campaigns touted the carpool's ability to soften the effect of oil crises, ride-matching services found potential carpool partners for commuters, and federal policy began to support the creation of HOV lanes.

Carpooling peaked in 1980 when nearly 20 percent of Americans commuted to work with at least one other person in the car. But as wealth increased, more Americans chose to buy their own cars, and fewer chose to carpool. Today 92 percent of households own at least one car, and approximately 65 percent own two or more.[26] Even approximately 80 percent of households earning less than

$25,000 per year own at least one car.[27] Amazingly, even those who live in households with no car are more likely to rely on auto transportation (36 percent of trips) than on transit (20 percent).[28]

Carpool lane-miles have increased dramatically since the 1980s. Today, our nation is home to 2,400 carpool lane-miles, roughly the distance across the continental United States. Current expansion plans will add over 1000 more lane-miles. Even so, as America has added more carpool lanes, the rate of carpooling has actually declined. Since 1980 when 19.7 percent of commuters carpooled, carpooling has fallen to 13.4 percent in 1990 and to 12.2 percent in 2000[29] (see Figure 3). The most recent national figure, from the American Community Survey, shows that carpooling accounted for only 10.4 percent of work trips in 2003.[30]

Figure 3: Carpool Lanes Expand, While Carpooling Declines



Source: U.S. Census Bureau and Fuhs and Obenberger p.26: http://www.hovworld.com/PDFs/Fuhs_Obenberger-final%20paper.pdf

Some metro areas like San Francisco and Washington, D.C. have popularized a practice called "slugging" or "casual carpooling" in which strangers share rides to meet HOV requirements. Drivers who need extra passengers approach lines of people waiting for rides to work, and seek out those who are going to the same destination. But even with this intriguing development, carpooling in the San Francisco and Washington D.C. metro areas has declined during the past decade and now stands only slightly above the national average.[31]

In the D.C. metro area, for example, vehicle occupancy rates have dropped steadily in recent decades. Average occupancy rates for morning trips into the D.C. employment core peaked in 1980 (1.49), then fell to 1.25 in 2002. Similarly, occupancy rates for vehicles crossing the Beltway during the morning commute have fallen since the early 1980s and now stand at 1.18.[32]

In fact, average occupancies in D.C. area HOV lanes are often *below* the minimum occupancy requirement. We might expect an HOV-3 facility to have an average occupancy rate of somewhere above 3. After all, it's against the law to drive in an HOV-3 lane if your car has fewer than three people, and drivers who thwart the law face stiff fines. Even so, it would seem that many commuters ignore HOV occupancy requirements. During the A.M. peak period in 1999, the average occupancy on the HOV-3 facility on the I-95 was 2.8, and 2.9 on the I-395. On HOV-2 facilities the A.M. peak period average occupancies ranged from 1.7 to 1.9. During the P.M. peak period, the average occupancy on HOV-2 corridors ranged from 2.1 to 1.6.[33]

B. Carpooling or Fampooling?

Although it can be difficult to come by detailed analysis of the issue, the data that are available suggest that modern carpoolers are not necessarily taking cars off the road. In 1997, Allan Pisarski's seminal study, *Commuting in America II* found:

> *Most carpooling today is not carpooling in the sense we knew it just a few years ago: a voluntary arrangement among co-workers or neighbors. That is dying; most of the surviving carpool activity consists of family members with parallel destinations and timing.*[34]

Pisarski coined the term "fampool" to describe family members who would travel together with or without HOV lanes. Surveys of various metro areas place the prevalence of fampooling at somewhere between one-third and two-thirds of carpoolers.

- **San Francisco Bay Area:** According to a 2003 survey, only 8 percent of Bay Area commuters who engage in ridesharing do so via casual carpooling. The same survey places the prevalence of fampooling at 33 percent.[35] A 1998 survey found a fampooling rate of 35 percent.[36]

- **Southeastern Wisconsin:** A 1994 study of commuters discovered a fampooling rate of 33 percent, although the sample size was small (57 carpoolers).[37]

- **Southern California:** A 2000 report by the Southern California Association of Governments (SCAG) found that carpooling with household members was the most common form of carpooling. The percentage of fampoolers increased—from 49 percent of carpoolers in 1996 to 55 percent in 1999—even while the overall rate of carpooling declined. Meanwhile, those who found partners through matchlists dropped to only 2 percent of carpoolers in 1999.[38]

- **Minneapolis/St. Paul:** An analysis of the 2000 Twin Cities Transportation Behavior Inventory (TBI) Survey found a fampooling rate of 67 percent among two-worker households in the Twin Cities seven-county metro area.[39]

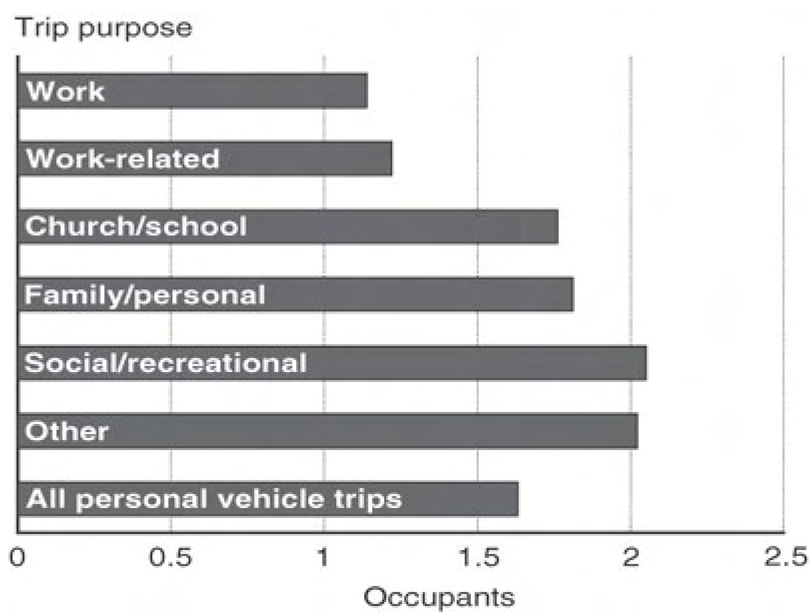
- **Nationally:** An analysis for the Transportation Research Board analyzed data from the National Personal Travel Survey and the National Household Travel Survey. It found that fampools (carpools consisting entirely of members from the same family) constituted 75.5 percent of all journey-to-work carpools in 1990 and 83 percent in 2001.[40]

C. The Why and When of Carpooling

Observing why and when vehicle occupancy rates rise and fall further suggests that carpools are likely to be fampools. According to National Household Travel Survey (NHTS), the highest occupancy trips are not work trips. This is significant because policymakers have devoted most of their carpool-encouraging efforts toward work commuters, and for good reason. Many people are surprised to learn that, even during rush hour, most trips are not work trips. Analysis of 2001 National Household Travel Survey data by Bumsoo Lee at the University of Southern California found that 62 to 64 percent of AM peak trips and 76-80 percent of PM peak trips are not work trips.[41] Even so, because work trips tend to peak during the morning and afternoon rush, roads tend to be most congested during the time most people commute to and from work. And so ride-matching services attempt to match workers who travel to work along similar routes, businesses often receive incentives to encourage carpooling among their employees, and many facilities have higher vehicle occupancy requirements during the morning and afternoon rush. Yet, even with the many policies that are designed to increase vehicle occupancies for those commuting to and from work, occupancy rates are actually lowest for work trips. Meanwhile the highest occupancy trips are for social and family purposes, which suggests a high likelihood of fampooling (Figure 4).

That fampooling does not take cars off the street is particularly evident when HOV lanes are used by drivers whose passenger is someone who, for a variety of reasons, would not be driving anyhow. For example, it is certainly convenient for a parent driving with a son or daughter to use the carpool lane, but as long as the son or daughter is under the legal driving age, this sort of carpool does not spare the road from an extra car.

Figure 4: Mean Occupants by Trip Purpose

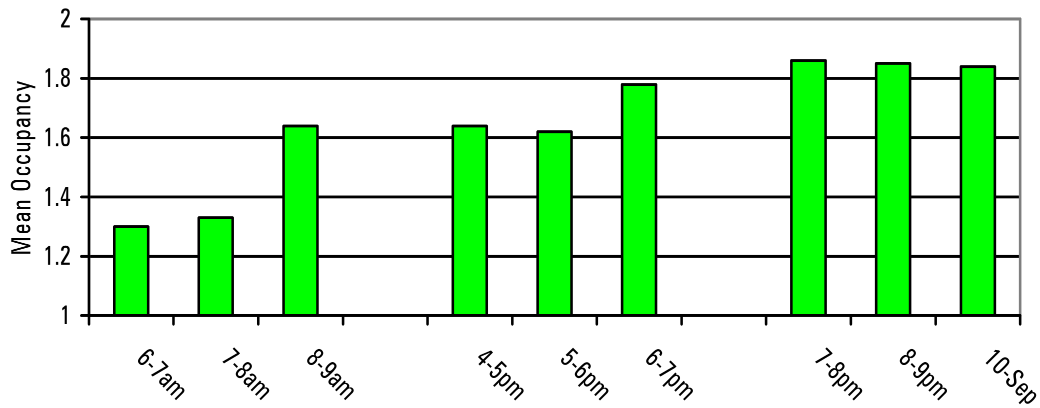


Source: The 2001 National Household Travel Survey, daily trip file, U.S. Department of Transportation.

We see a similar trend by noting *when* vehicle occupancies are at their highest. Occupancy rates do not peak during the morning and afternoon rush, but in the evening. The highest occupancy occurs between 7:00 and

10:00 PM when many people head to restaurants, movie theaters and social events. Vehicle occupancy rates are highest during weekends, when travelers are even more likely to be headed to social and family events, and when they are least likely to encounter congestion.[42]

Figure 5: Weekday Vehicle Occupancy Per Vehicle by Time of Day



Source: 2001 National Household Travel Survey

In most areas traffic congestion is not a constant problem. It strikes with most severity during weekday mornings and afternoons, and during other periods most commuters enjoy relatively good driving conditions. Although policymakers intend for carpooling to ease peak hour congestion, carpooling is most prevalent during periods when commuters are least in need of congestion relief. This suggests that, in its present form, carpooling's ability to relieve congestion continues to shrink.

D. Has Carpooling Hurt Vanpooling?

During recent decades the concept of "high occupancy" has evolved to fit an ever-looser definition. Exclusive busways gave way to mixed traffic, and HOV requirements dropped from four occupants per vehicle to three, and from three to two, where most stand today. Meanwhile, the watering down of the definition of "high occupancy" has hurt a particularly efficient form of transit, vanpools.

A vanpool is a midsize transportation mode (between a car and a bus), and generally consists of between 8 and 15 people who travel together on a regular basis by van. Shifts of population and employment toward the suburbs and the rise of urban areas with multiple business districts, have made it increasingly difficult for transit agencies whose service aims at bringing people to and from one dominant employment center. Vanpooling offers the kind of flexibility that can continue to make transit relevant.

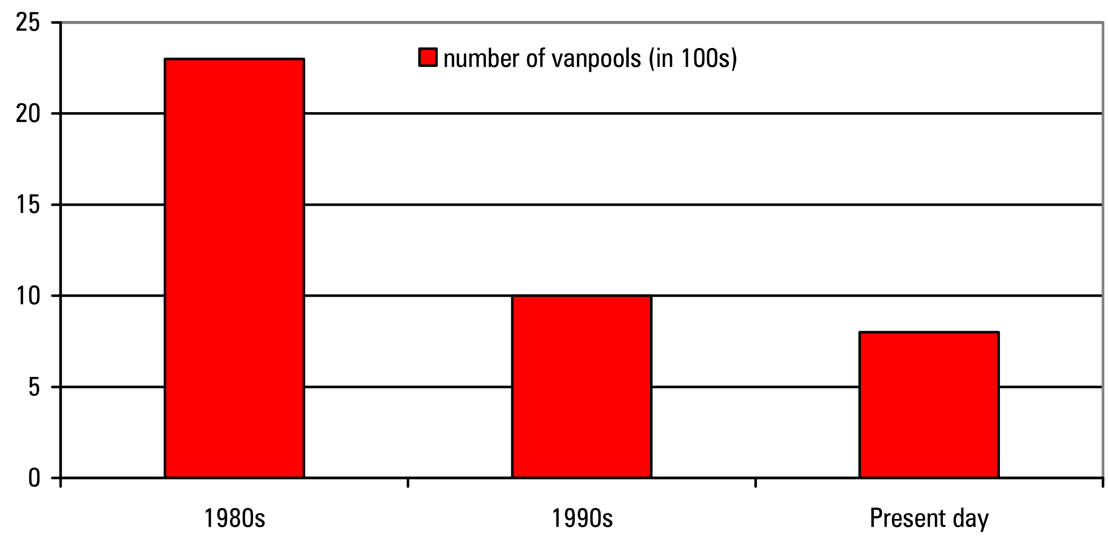
However, as HOV lanes filled up with lower-occupancy vehicles, vanpooling's time- saving advantage has dwindled. Two of the seven obstacles to vanpooling cited in a recent nationwide study centered directly on congestion:

- lowering of HOV requirements (crowds HOV lane with too many cars);

- severe congestion, if vanpools have no travel-time advantage (HOV lane or other priority travel) over SOVs.[43]

Nationwide, the number of vans participating in vanpools peaked in the mid-80s (23,000 vans). But by the end of the 90s, the number fell to 10,000, a 56 percent decline.[44] The Vanpool Council estimates that today there are roughly 8,000 commuter vanpools on the road each work day (Figure 6).[45]

Figure 6: Vanpooling's Decline Nationwide



Source: Washington State DOT and The Vanpool Council

Some figures complicate the trend somewhat. For example, according to a Federal Transit Administration survey, the number of agencies offering vanpooling services doubled from 1991 to 2002. Still, simply noting that an agency offers a service does not explain how widespread the service is, how many vans participate or how many people use it. Further, the total number of agencies offering vanpooling (42) represents a tiny portion of the over 600 agencies included in the FTA analysis.[46] Most fundamentally, most vanpooling occurs via private operators, not transit agencies.

Local examples also show how congested HOV lanes hamper vanpools:

Washington, D.C.

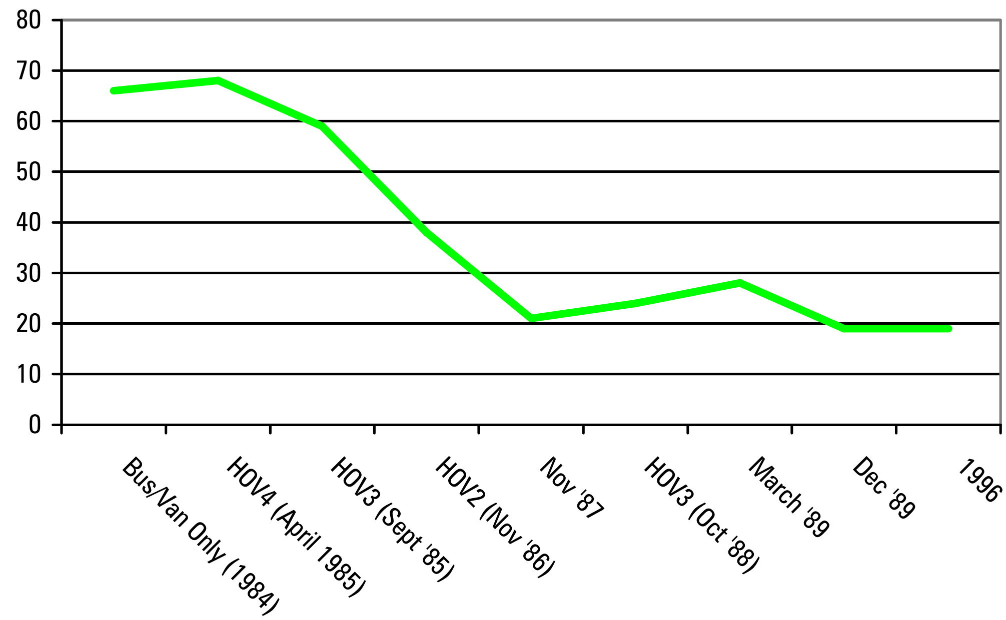
Vanpooling's decline in the Washington, D.C. metro area mirrored national trends. Morning vanpools traveling to the D.C. employment core fell from 1,020 in 1996 to 720 in 2002, and outbound afternoon vanpools have declined from 970 to 930 during the same time period.[47]

In a 2002 survey of D.C.-area vanpoolers, respondents cited "Congestion in HOV lanes" as their second-greatest issue of concern. (That congestion has been increased in recent years by the influx of hybrid vehicles into the Virginia HOV lanes.) The top issue of concern, "Finding new riders," is also likely related to HOV lane congestion since would-be vanpoolers may see little value in joining a vanpool if the HOV lanes are frequently gridlocked.[48] Also, it's much easier to find one or two other riders than it is to find and maintain a group of 8 or 10.

Houston

Figure 7 shows how vanpooling declined in Houston as the Katy facility evolved from allowing buses and vanpools only, to HOV-4, and finally HOV-3. Chuck Fuhs, one of the nation's leading HOV experts and a key figure in planning Houston's first transitways, thinks the rise of carpooling contributed to the decline in vanpooling. Even so, he cites dwindling corporate sponsorship as a more significant contributor to vanpooling's dwindling numbers.[49]

Figure 7: Vanpooling's Decline on the Katy Freeway



Source: Richard H. Pratt, et al, "Traveler Response to Transportation System Changes, Interim Handbook," Transit Cooperative Research Program, Washington, D.C. 2000.

Los Angeles

The El Monte Busway began as an exclusive busway, but it too gave way to lowering occupancy requirements. In January 2000 Senate Bill 63 took effect, lowering the vehicle-occupancy requirement from HOV-3 to HOV-2. The move was part of a six-month long demonstration project which required Caltrans to monitor the effect of the lowered occupancy requirement. Caltrans did not like the result.

Although morning peak-hour Busway vehicle volumes increased from 1,100 to 1,600, the facility carried fewer people (from 5,900 to 5,200). Busway morning peak-hour average speeds plummeted from 65 mph to 20 mph. Peak-hour travel times on the Busway increased by 20 to 30 minutes, and bus riders flooded the transit agencies with complaints of delays and poor schedule adherence.

Although the figures do not treat vanpools separately, the increased congestion degraded travel conditions for all vehicles that had fit the earlier definition of “high occupancy.” Many bus riders, as well as vanpool patrons and 3+ carpoolers, pointed out that the degraded service destroyed the incentive to use these modes of travel. In order to help frustrated bus riders make connections, Foothill Transit provided extra buses and operator in the downtown area, at a cost of approximately $1,250 per day.

Transit officials and policymakers saw all they needed to see. The demonstration project ended in July 2000, when Assembly Bill 769 overrode SB63, reinstating HOV-3 during peak hours.[50]

The busways of the ‘60s and ‘70s only emerged in a handful of metro areas. In most cases, a metro area’s first and only HOV facilities have been built as HOV-2, which means that it is not possible to provide a before-and-after view of how lowered occupancy requirements affected vanpools. Here we must consider the issue in reverse: wouldn’t raising HOV occupancy requirements make vanpooling more attractive?

Part 3

The Potential for Rubber-Tire Transit

Canada and South America have long-standing examples of rubber tire transit's ability to offer flexible, cost-effective service that appeals to large numbers of patrons. The surge in interest in U.S. bus rapid transit (BRT) systems is a recognition of the success other nations have enjoyed.

A. Capacity of Busways

Bus transit can operate with headways as short as five seconds. At 40 to 120 passenger spaces per bus (including standees), theoretical busway capacity is between 28,800 and 86,400 people/lane/hour—exceeding the capacity of light rail and even some heavy rail systems. At its busiest hour the nation's busiest busway, the Lincoln Tunnel Express Bus Lane (XBL), carries over 30,000 passengers/lane. Ottawa's busway system is used by 40 percent of those within its service area, a much greater proportion than San Francisco's BART heavy rail system or the light rail system of Portland, Oregon.[51]

South America's highly productive busways actually approach the total transit ridership of major U.S. metro areas like Washington, D.C. and San Francisco. Several South American busways exceed the total transit ridership of Seattle and Portland .

Bogotá's TransMilenio system operates under a public-private partnership and has a daily ridership of 630,000, carrying up to 45,000 passengers per hour per direction. At 1,100 buses, Curitiba has the world's most extensive BRT system. It carries an astounding 1.3 million passengers per day.[52]

B. Cost-Effectiveness

Rail transit has certain operational advantages over rubber-tired transit, perhaps the most significant being that rail cars' greater capacity and ability to be coupled into trains allows for more passengers per consist. Of course, there is a significant difference between available passenger space and space actually used by passengers. And, unlike bus transit, rail typically requires a separate repair facility and specialized staff. In addition, the much longer stopping distance required by trains requires much greater headways, which permits busways to make up in frequency what they lose in lower capacity per consist.

The GAO examined six cities that operate both BRT and light rail, and then measured operating costs in three categories: operating cost per vehicle hour, per revenue mile, and per passenger mile. For each category, the large majority of cities experienced lower operating costs with BRT[53].

Ironically, the cost-effectiveness of bus transit can often work against it. Because it is comparatively cheap to add bus service, buses are used in all kinds of different settings, from high-traffic corridors to lightly traveled areas on the outskirts of town. On the other hand, the placement of a rail line is very precise. It will generally only be located in the most highly trafficked corridors. The result is an unequal comparison, with ridership comparisons made between high-volume rail lines and bus ridership averaged over a multiplicity of types of bus routes. These skewed comparisons then show operating costs per passenger that are often lower for rail than for bus. This can well reflect the nature of the comparison, rather than any inherent costliness of the kind of bus service that is a realistic alternative to rail.

C. Flexibility

Another advantage of buses operating on HOV lanes or exclusive rights of way is greater flexibility than rail transit. As the booklet "High Quality Transportation" (on BRT and managed lanes) points out:

> *The flexibility of BRT allows combinations of different running ways and operating conditions. For instance, a BRT service could begin with a local circulation route in mixed traffic on local streets, proceed on an exclusive guideway, and then circulate once again on a transit priority system in the downtown.*[54]

The authors go on to point out that four different types of routing systems can make use of the same BRT guideway for the long-haul portion of the trip: shuttle, express, local, and feeder. For shuttle and express services, that begin and end their trips in circulation on local streets, these services offer many riders a long-haul trip without having to change vehicles or modes: from a residential neighborhood bus stop all the way to an employment area. Much transportation research shows that such "single-seat rides" are significantly more attractive to passengers than trips involving transfers.

As noted previously, because bus headways can be much shorter, frequency of service can be much greater with a busway system. It is easier for buses to overtake one another than for rail cars, and because of their smaller unit size, it is easier to fill a bus with passengers going from a common origin to a common destination. Hence, is easier to organize express bus service than express train service. Buses can deviate from routes to avoid accidents or traffic jams. And rail trains are always run by a single monopoly operator, whereas a busway can be open to competing bus and van operators.

D. Vanpools

High occupancy travel has evolved to fit the extremes of the concept. On the low end of vehicle occupancy are carpool lanes, the vast majority of which allow access to vehicles with as few as two people. On the high end, there is the standard city bus or rail car, each with the capacity to carry roughly 100 people. Most transit agencies have forgotten about the choice found in the middle, vanpools.

Vanpools typically carry between 8 and 15 passengers, and do so very efficiently. Recovery ratios measure the degree to which a mode of travel is reliant on subsidies. If a transit agency has a recovery ratio of 40 percent, that means revenue generated from fares, advertisements, and so on covers 40 percent of the cost of operating the service. The other 60 percent is covered by subsidies from taxpayers. Although it is a very politically popular mode of transit, light rail's average recovery ratio is stands at 28 percent.[55]

By way of comparison, vanpool recovery ratios often exceed 70 percent and sometimes they do something nearly unheard of in public transit—make a profit.

Washington State is the nation's vanpool leader in terms of market share, and the impressive financial performance shows the sort of cost-effectiveness vanpooling can offer. The state's transit-agency-operated vanpools have an average recovery ratio of 80 percent (see Table 2).

Table 2: Vanpool Recovery Ratios in Washington State

Agency	Recovery Ratio
Ben Franklin Transit	89%
C-Tran	94%
Intercity Transit	111%
King County Metro	70%
Kitsap Transit	30%
Pierce Transit	64%
Community Transit	69%
Spokane Transit Authority	77%
Yakima Transit	117%
AVERAGE	80%

Source: Federal Transit Administration, National Transit Database 2002, Table 26

The reason behind vanpooling's cost-effectiveness lies in several factors, including capital costs, load factors and energy use. Because vans are mass-produced, in contrast with buses and rail cars, vans' cost per seat is less than that of the average transit bus and much less than that of the average light rail car. Like bus transit, vanpooling typically makes use of existing infrastructure (the road), so the costs associated with, for example, building and maintaining transit-only infrastructure, are absent.

Load factors measure how filled or empty a rail car, bus, or van is. It is very expensive to operate any kind of transit if there are many empty seats, since empty seats represent fare revenue not received. Compared to other modes of transit, vanpooling uses its fleet very efficiently.

Vanpooling also saves on energy costs, for, as Table 3 demonstrates, it is more energy-efficient than any transit mode. For example, vanpooling uses less than one-third the energy per passenger mile as rail transit.

Table 3: Urban Transportation Energy Use	
Mode	**BTU/passenger-mile**
Demand response (dial-a-ride)	13,271
Transit bus	4,124
Personal truck	4,063
Automobile	3,588
Rail transit (heavy/light)	3,172
Commuter rail	2,717
Motorcycle	2,049
Vanpool	1,273

Source: Transportation Energy Data Book http://www-cta.ornl.gov/data/tedb23/Spreadsheets/Table2_11.xls

E. The Appeal of Rubber Tire Transit

Officials often assume that most people are simply turned off by the bus. Indeed the bus does suffer from a poor reputation. However, this reputation has less to do with the physical form of a bus and more to do with decades of slow and spotty city bus service. Note that musicians ride buses from performance to performance, and buses often take wealthy Manhattanites from the Upper East Side to the Hamptons. The GAO and others have noted that patrons value service characteristics (speed, convenience, cleanliness, etc.) most of all, and they will gladly use any transportation mode that offers them those qualities.

Vanpooling may have an even greater advantage. Because vanpools offer features such as door-to-door service and guaranteed seating, commuters tend to prefer this mode to any other alternative to single occupancy driving.[56] Vanpooling is even more popular than rail transit, and survey respondents say they would be willing to pay more for vanpooling:

> *The same people, using the same rating scale, who express a 36 percent interest in rail at 50-cent fare, express a 91 percent interest in paying $1 for door-to-door service with a guaranteed seat.*[57]

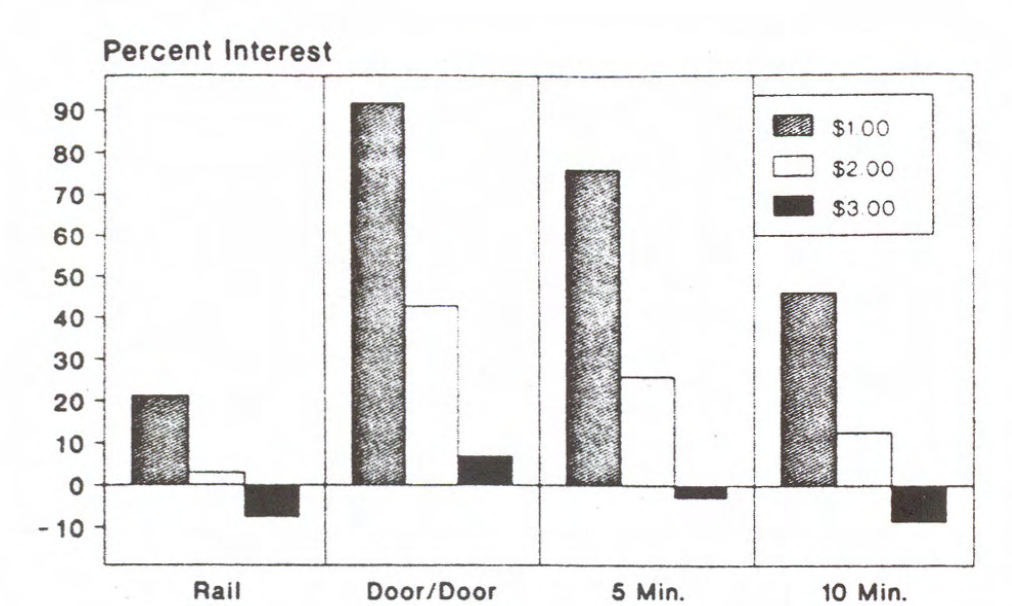
Even when service is not door-to-door but instead requires passengers to walk to their pick-up and destination locations, vanpooling still enjoys more appeal than rail transit (see Figure 7).

Vanpooling is also "capable of attracting those same commuters that most strongly resist using other alternatives," which makes for impressive congestion relief potential:

> *These results suggest that if paratransit [i.e. vanpooling] served the same area as a rail system, it could take at least two to four times more cars off the road than rail would.*[58]

Couple its appeal with flexibility and low cost, and we find that vanpooling offers perhaps the most underappreciated alternative to single passenger driving.

Figure 7: Interest in Rail vs. Van Options



Source: Flannelly, et al "Direct comparison of commuters' interests in using different modes of transportation"

Part 4

The Virtual Exclusive Busway Concept

A. Exclusive Busways—the Impossible Dream

In the previous sections of this report, we have seen that there is great potential for rubber-tire transit modes, including bus rapid transit and vanpools, especially when they can operate on exclusive busways. But we have also noted how few exclusive busways actually exist in this country. And most of those that were built in the 1970s and '80s got opened up, over time, to vehicles with fewer and fewer occupants, evolving from transitways to HOV lanes, a large fraction of whose users are actually fampools.

Yet if we could somehow afford to put in exclusive busways on a larger scale, their capacity could easily rival those of most urban rail systems. We saw in Part 1 that the Lincoln Tunnel XBL averages 16,000 persons/lane/hour during peak hours. During its busiest hour, with 735 buses, it has been observed to carry 32,600 passengers.[59] At its highest performance level, that is a 4.9-second headway (time between buses). With some engineering improvements, the Port Authority of New York & New Jersey estimates it could achieve a four-second headway, which would increase its peak-hour throughput to as much as 39,600. And that is with express buses carrying an average peak load of just 44 passengers.

Transit consultant Thomas Rubin believes that with Intelligent Transportation System (ITS) technology, buses on busways could operate safely at three-second headways. With more typical rush-hour loads of 58 passengers per bus (including standees), the resulting 1200 buses per hour could carry up to 70,000 passengers per lane per hour.[60]

The upper limit of potential passenger throughput is derived from the Transportation Research Board's *Highway Capacity Manual*. It recognizes a bus in an express lane as the equivalent of 1.5 cars, and puts the maximum capacity of an express lane at 2,000 cars/lane/hour.[61] That equates to 1,333 buses/lane/hour. Using a range of from 40 to 80 passengers per bus, we get a theoretical maximum of 53,000 to 107,000 passengers/lane/hour.

Obviously, there are very few real-world corridors where the demand for bus travel is anywhere near those numbers. But they do illustrate the potential carrying capacity of exclusive busways.

With more typical real-world headways like 60 seconds (one bus per minute) on a highly used busway, 60 buses per lane per hour is very low utilization of expensive right of way and concrete. It's completely understandable that taxpayers would object to the "empty lane syndrome" when they see the vast majority of the lane's capacity going unused, even during peak hours. That suggests we need to look for second-best alternatives to the impossible dream of exclusive busways.

B. The Limits of HOV Lanes as Busways

The approach taken by most metro areas has been to employ HOV lanes as their alternative to exclusive busways. One of the best examples of this kind of system is in Houston, where what began as transitways (for buses and vanpools) evolved over time to largely HOV-2 lanes with extensive express bus service. But the problem with HOV lanes as busways is that they are not sustainable for the long-term.

To be sure, in some metro areas where carpooling has never really caught on, the HOV lanes themselves suffer from empty-lane syndrome, and the buses operate in relatively uncongested conditions. But as Houston has found on the Katy and Northwest Freeways, two-person carpooling can overwhelm the available lane capacity during peak periods, resulting in congestion for buses and carpools alike. That led to Houston's current Quick-Ride program, with occupancy put back to HOV-3 but HOV-2s able to buy their way in. Unfortunately, few two-person carpoolers have opted to pay, and these lanes operate with significant excess capacity.

This illustrates a general problem with HOV lanes. Where carpooling is popular, it's only a matter of time until the HOV-2 lane gets filled up and loses much of its time-saving advantage over regular lanes. Yet at HOV-3, in most metro areas, there is nowhere near enough demand to make full use of their capacity. In a handful of areas (like Washington, D.C., where HOV-3 use is unusually high), the same dilemma would exist with a shift from HOV-3 to HOV-4. Thus, the HOV model is caught between extremes of too much demand and too little demand. Changing occupancy requirements by whole-number amounts (two, three, four, etc.) is too blunt an instrument. What would be desirable for HOV lanes, in mathematical terms, is a continuously variable occupancy requirement. But there is no such thing as 2.7 occupants.

C. Managing Lanes via Value Pricing

The goal of more precisely managing traffic flow to use all the lane capacity but without recurrent congestion has actually been achieved in recent years. Two high-occupancy toll (HOT) lane facilities in California, on I-15 in San Diego and SR 91 in Orange County, both employ variable pricing to limit the number of vehicles using their lanes during any given time period, in order to keep traffic flowing at close to the speed limit. Limiting the volume of vehicles in this way keeps traffic flow from breaking down into stop-and-go conditions. And that, in turn, means that throughput (vehicles/lane/hour) on these managed lane facilities can be higher than throughput on the general-purpose lanes during peak periods. The latest (2004) figures from the 91 Express Lanes show that during the busiest peak hours, those two peak-direction lanes (representing just 33 percent of total peak-direction lane capacity) handle 49 percent of total peak-direction traffic.[62]

In both cases the pricing is done entirely via electronic toll collection; all vehicles must open an account and acquire a transponder in order to use these managed lanes. In the case of Orange County, the pricing is based on a pre-published fee schedule, with more than a dozen different prices reflecting projected demand at different hours of the day and days of the week. The Orange County Transportation Authority (OCTA), which owns and operates the lanes, has a pricing policy that automatically adjusts the rates upward during any peak-period hour during which traffic has exceeded free-flow norms for more than 12 weeks[63]. The Express Lanes' business model is to offer people a faster and more reliable trip in exchange for paying a premium toll. Hence, in order to make good on this offer, OCTA must be able to adjust the prices as required so as to maintain free-flow conditions. They also offer a money-back guarantee should a customer experience congested conditions.

The pricing approach on San Diego's managed lanes is both more and less advanced. Technologically, it is more advanced, in that the system measures traffic flow in real time and adjusts the price every six minutes to ensure that it matches the level of traffic so as to prevent overloading the lanes. But this adjustment takes place within a pre-defined range, from a minimum to a maximum amount. This floor and ceiling have not been changed since the pricing system began in 1997, and the responsible agency, SANDAG, has not announced what it will do when rates begin to routinely bump up against the maximum. In this regard, OCTA already has in place a long-term sustainable pricing approach, which SANDAG does not.

The success of these managed lane projects in providing improved mobility by means of variable pricing has been noted far and wide. In both cases, detailed academic reports have documented every aspect of these projects and their performance, with reports from San Diego State University[64] and California Polytechnic[65], respectively. The Federal Highway Administration's Value Pricing Pilot Program has featured them at national and regional conferences, and assisted transportation planners from other metro areas in learning more about these projects. As a result, projects to convert existing HOV lanes to HOT lanes, or to develop new HOT or managed lane systems, are under way in such metro areas as Atlanta, Dallas, Denver, Houston, Miami, Minneapolis/St. Paul, the San Francisco Bay Area, Seattle, and Washington, D.C.

D. The Virtual Exclusive Busway

The demonstrated ability of value pricing to manage traffic flow, offering reliable high-speed travel during peak periods, suggests that lanes managed with value pricing could become the second-best alternative to the exclusive busways that transit planners would like to have. If priority is given to bus transit usage, a managed lane can become the *virtual equivalent* of an exclusive busway, from the transit agency's standpoint.

Thus, transportation planners studying the possibility of a whole network of HOT or managed lanes should look upon them not merely as an alternative for drivers and carpoolers. Such a network of managed lanes is also the infrastructure for an area-wide bus rapid transit system—a *virtual exclusive busway* (VEB).

To elaborate a bit further, although the highway capacity manual may report that a lane can handle 2,300 vehicles per hour, to ensure uncongested flow and prevent traffic-flow breakdown into unstable stop-and-go conditions, a managed lane is generally limited to about 1,700 vehicles/hour. Depending on how much demand for BRT service exists, some pre-defined amount of this capacity can be reserved on a long-term basis for bus service for each corridor of the managed lane network. With peak-period bus service at one-minute headways, for example, that would be 60 buses/hour, the equivalent of 120 cars/hour. The balance of the capacity (1,580 vehicles/hour) would be available for other vehicles, some operating at no charge (e.g., vanpools, and possibly some other HOVs) and the rest as paying vehicles. As long as overall traffic is kept within these limits, the buses can operate at the speed limit, as unconstrained as if they were on an exclusive busway. Yet because a significant fraction of the other vehicles will be paying for access, a large fraction of the cost of this busway infrastructure will be paid for, willingly, by those purchasing a premium-service auto trip.

This concept was first suggested in Reason's HOT Networks policy study in 2003[66], and subsequently elaborated upon by Wilbur Smith Associates in their booklet on High Quality Transportation.[67] As the latter document puts it,

> *HighQ is a unique combination of supply-side (transit services) and demand-side (managed lanes) strategies. . . .[It] is the next logical step in the development of mobility improvement strategies. . . . HighQ offers a strategy to expand the capacity of the transportation network more efficiently than either adding general purpose lanes or investing in high capacity transit improvements such as fixed guideway transit. . . . HighQ projects have been found to enjoy greater public support than HOV, toll, or BRT projects individually because together they increase traveler choices, are multimodal, are paid for by the user, and improve reliability and speed.*

With the basic concept now set forth, we will explore its ramifications in the next three sections.

Part 5

The Houston Prototype for VEBs

A. The Katy Freeway Managed Lanes Project

The metro area with the most extensive system of express bus operations on HOV lanes has a project under way that amounts to the country's first Virtual Exclusive Busway. Houston is adding four value-priced managed lanes to the median of the Katy Freeway (I-10), as part of a major expansion of that freeway.

The Katy is Houston's busiest and most congested freeway. The existing configuration in its most congested section (from I-610 to SH 6) is three general-purpose lanes in each direction plus a reversible HOV lane in the center. In addition, as is standard Texas practice, there are three-lane frontage roads alongside the freeway in each direction. A Major Investment Study of the Katy got under way in the late 1990s. A managed lanes approach, adding four such lanes in the middle of an expanded freeway (replacing the single reversible HOV lane) emerged as the preferred option, though tolling was apparently not considered initially.

As recounted in a Federal Highway Administration study,[68] however, during the environmental review process, the local toll agency, Harris County Toll Road Authority (HCTRA), proposed that the managed lanes be tolled. Toll revenues could pay for their capital cost, and value-priced tolls would manage traffic flow. The environmental impact statement (EIS) was revised to include this option, and after further public involvement activities, this approach was adopted.

Two multi-agency agreements were crucial factors in creating the "public-public partnership" that made this project possible. The Tri-Party Agreement between FHWA, TxDOT, and Harris County deals with roles and responsibilities in design, funding, and construction of the managed lanes project.[69] HCTRA agreed to pay for the construction cost (up to $250 million), design the toll-related elements, and carry out any additional public-involvement activities needed. Toll revenues are specified to be used for debt service, a reasonable return on investment, and operation and maintenance of the managed lanes. TxDOT will secure needed federal funds, obtain right of way for the overall freeway expansion, and handle construction. And FHWA authorizes tolling of these lanes on the Interstate system under the federal Value Pricing Pilot Program.

The other agreement is the historic Memorandum of Understanding (MOU) between TxDOT, METRO, and Harris County.[70] This MOU sets forth the respective roles of these three parties as to how the managed lanes will be operated. In general, HCTRA is responsible for operation of the lanes, as it is for its other toll roads in the Houston metro area. Thus, HCTRA deals with operations and maintenance, enforcement, and incident management. METRO is responsible for operating bus services on the lanes, with various key protections built in. Since the Katy is part of the state highway system, TxDOT makes sure the managed lanes are properly integrated with the rest of the freeway and other facilities.

The previously mentioned High Quality Transportation report points out the real significance of the MOU:

> *A key provision of the [MOU] is a commitment by the toll operator [HCTRA] to price the lanes to assure free-flow conditions for bus operations in the managed lanes. As a result, the new lanes can function as a form of high-speed dedicated busway in addition to always providing high quality transportation for motorists.*[71]

To meet this goal, the MOU defines Level of Service C (LOS C) as the acceptable level of traffic flow. METRO is guaranteed the right to operate up to 65 buses per hour, 24 hours a day, seven days a week at no charge. Its smaller METROLift and support vehicles may also operate without paying tolls. Carpools and vanpools with three or more occupants (HOV-3) may travel at no charge in the peak direction during peak hours, but HOV-2s and SOVs must pay the value-priced toll at all times (as must HOV-3s in non-peak directions and during all non-peak hours).

What happens when conditions start to worsen, below LOS C? The MOU says that all parties will meet and review the options to restore LOS C. The options include increasing peak toll rates, increasing the HOV requirement, restricting the number of non-charged support vehicles, and expanding the managed lanes. Unless the facility is expanded, what happens next depends on the level of METRO-related traffic. If buses, support vehicles, and HOV-3 vehicles exceed 25 percent of the facility's capacity, then METRO will give first priority to buses, by increasing the HOV requirement beyond HOV-3. But if METRO is not using its full 25 percent of capacity, then HCTRA will increase peak toll rates to restore LOS C conditions. (Note: the full text of the MOU is provided in the Appendix.)

To sum up, the transit agency is guaranteed up to 25 percent of the managed lanes' capacity for transit and HOV uses. And the toll agency guarantees to use its value pricing authority to limit paying traffic to an amount consistent with LOS C traffic flow. The transit agency gives first priority to buses, since their passenger capacity is far greater than those of vanpools or carpools.

The Katy reconstruction, with the four new managed lanes, is under way as of this writing. Thus, Houston will be the nation's first metro area to implement a Virtual Exclusive Busway.

B. Implications of the Houston VEB

A number of the features of the MOU that made Houston's first VEB possible are worth discussing in more detail.

Transit Funding

As HOT lanes have begun to catch on among transportation planners, the transit community has begun to appreciate their importance as a way of providing infrastructure for express bus or bus rapid transit service. In particular, transit organizations have begun to advocate for using net toll revenues from managed lanes for both transit-related facilities as part of the project (e.g., bus stations, park-and-ride lots) and transit operating subsidies anywhere in the region.[72] Such uses are only possible in situations where there are net toll revenues. That is generally the case for projects that convert an existing HOV lane to a HOT lane (as is being done currently in Denver and Minneapolis). But in cases like the Katy project, where significant new lane capacity is being added (four managed lanes replacing a single HOV/HOT lane), the likelihood of any "net" revenues being left over after debt service, return on investment, and operating and maintenance costs are covered is very small. That is why no such commitments are included in the Katy MOU.

But even though METRO is not receiving any net toll revenues to subsidize its bus operations or build park-and-ride lots, it is still getting a very good deal from this project. On the Katy today it must make do with a single, reversible HOV lane, which it must share with carpools and vanpools. A single-lane facility is far more vulnerable to incident-related congestion (e.g., when a vehicle breaks down) than a multi-lane facility like the managed lanes that will replace it. And a bi-directional facility makes possible reverse-commute bus service, which will be increasingly important as Houston grows and the central business district accounts for a smaller percentage of all jobs. And especially important, thanks to value pricing, the managed lanes will be sustainable long-term as a reliable, high-speed facility.

Busway Capacity

It was noted previously that Houston has one of the nation's most extensive systems for express bus service on HOV lanes. So the question arises whether the Katy MOU provides a reasonable level of capacity for METRO, at 25 percent of total vehicles and a guarantee of 65 buses per hour. Data from Table 2 of the FHWA Houston managed lanes case study show that as of 2003, the Katy HOV lane served 40 buses during its busiest AM peak hour. (The other freeway HOV peak bus levels ranged from 4 to 43.) Thus, the Katy's allocation of 65 buses per hour represents a 62.5 percent increase over its maximum rush-hour bus service today. There is nothing magic about 65 per hour, nor about 25 percent of total capacity. But given the actual level of demand for such bus service today, those numbers appear reasonable.

Remember, a *virtual* exclusive busway provides the equivalent of an exclusive busway in terms of accommodating, under uncongested conditions, the level of bus service the transit agency needs. That appears to be what METRO is getting under the MOU.

FTA Approval

HOV lanes in U.S. metro areas have been developed using federal, state, and local funding sources. Federal sources in some cases are exclusively highway (FHWA) funds and in other cases exclusively transit (FTA) funds. The Katy HOV lane received some of each; hence, the FTA had to concur in the decision to change the nature of this facility. In the past, the FTA has had a mixed record on HOV to HOT conversions. It approved San Diego's pioneering project on I-15, but initially raised objections to Denver's plans for a similar conversion on I-25 North. But the FTA seems to have come to terms with HOT lanes, as long as transit service is maintained and suffers no degradation in service quality (i.e., reduction in LOS). Managed lanes using value pricing to maintain LOS C or better meet this test.

HOV Occupancy Changes

The vast majority of U.S. HOV lanes are operated as HOV-2 facilities.[73] The most successful become congested over time, dropping below LOS C. But transportation officials are often reluctant to increase the occupancy requirements, for fear of backlash from existing (mostly two-person) carpoolers. Yet Houston had already been willing to bite the bullet on both the Katy and Northwest Freeways, increasing peak-period occupancy to HOV-3. This very likely made it easier to make the across-the-board change from HOV-2 to HOV-3 for the Katy managed lanes project.

It should also be noted that although federal approval is required for "significant" changes to HOV lanes that have received federal funds, that term appears reserved for major changes in operating hours and converting from HOV to HOT or to general-purpose lanes. Minor changes in operating hours and changing the occupancy requirements do *not* require federal approval.

Being able to change the occupancy requirements over time is one of the two keys to making a VEB sustainable on a long-term basis. METRO has clearly recognized that a bus is more productive than a van, and a vanpool is more productive than a carpool as a user of expensive-to-produce managed lane capacity. It has made the tough decision to favor greater overall throughput.

Pricing Sustainability

The other key to a VEB's long-term sustainability is pricing flexibility. Paying customers are the key factor in providing the funds for building, operating, and maintaining these managed lanes. But allowing too many to crowd onto the lanes during rush hour would completely defeat their dual purpose of facilitating high-quality transit and providing a reliable, higher-speed trip for those opting to pay for premium lanes. Therefore, the ability to increase value-priced toll rates as high as is needed to maintain LOS C conditions is essential.

But since future toll levels might grow to quite high levels, if rush-hour demand in the corridor continues to grow, there is always concern about whether future price increases might be politically constrained. We saw in Part 4 that OCTA has adopted a managed lanes pricing policy for the 91 Express Lanes that is essentially on automatic pilot; whenever incipient congestion appears during a 12-week period, a toll increase goes into effect for that hour of the day.

The Houston MOU commits the three parties—HCTRA, METRO, and TxDOT—to use pricing in a comparable way to maintain LOS C conditions on the Katy managed lanes. This represents important institutional support for long-term use of value pricing to manage traffic flow. All three agencies have a lot at stake in the performance of the managed lanes. In particular, from METRO's standpoint, they will only function as a Virtual Exclusive Busway if HCTRA increases toll levels when necessary to maintain the free-flow conditions it needs for reliable, high-speed express bus service.

Part 6

Prospects for VEB Networks

A. Network Benefits

The previous section made the case that an individual managed lanes facility can function as a Virtual Exclusive Busway. In this section, we extend the discussion to entire networks of managed lanes, some or all of which can be operated as VEBs.

From the standpoint of drivers who will pay to use premium lanes, either regularly or occasionally, to bypass congestion, the existence of an interconnected network of such lanes offers obvious benefits. Viewed in terms of a commuting-time budget, a network of reliable, high-speed lanes opens up a much larger radius of job opportunities within any individually determined maximum commute period (be that 30 minutes or 90 minutes). To the extent that a larger range of job opportunities increases both personal wealth and economic productivity (thanks to better matching of people with jobs), the economic benefits could be very large for a metro area with such a network as part of its transportation system.

From the standpoint of the transit system, similar network benefits apply. A region-wide express bus system is far more feasible if it can operate on a region-wide infrastructure that is the functional equivalent of a network of exclusive busways. Yet such a network would be highly unlikely to come about if it had to be developed with existing federal, state, and local transit system resources. Conceptual designs of HOT Networks for Atlanta, Dallas/Ft. Worth, Houston, Seattle, and Washington, D.C. consist of about 500 lane-miles apiece.[74] At today's urban freeway construction costs, such systems would cost $4-5 billion each. (This would cover the roadway infrastructure but not bus-related elements such as park-and-ride lots or bus stations.)

A rail transit system encompassing 500 miles (two tracks, 250 miles each) would cost over $30 billion, based on recent experience. Table 4 lists current light rail and heavy rail projects supported by Full Funding Grant Agreements under the FTA's New Starts program. As can be seen, the expected capital costs of light rail systems range from $44 million per mile to $237 million per mile, with an average among the nine projects of $124 million per mile. Applying those unit costs to a 250-mile system (equivalent to a 500 lane-mile managed-lanes network, with one lane per direction) shows that it would cost an average of $31 billion. If built as heavy rail, the 250-mile system would cost an average of $38 billion.

Even though the VEB network would cost considerably less, neither a 250-mile rail system nor a 500-mile VEB network would be affordable out of transit system funding sources. But the VEB network's capital costs would be largely paid for by drivers paying to bypass congested freeway lanes, so this kind of network would be far more affordable, in practice.

Table 4: Current FTA-Supported Light and Heavy Rail Projects						
Metro Area	**Project**	**Type**	**Route miles**	**Capital Cost ($M)**	**Cost/Mile ($M)**	**250-mi. system cost ($B)**
--- Light Rail ---						
Los Angeles	Gold Line	Light	5.9	$899	$152.4	$38.1
San Diego	Mission Valley	Light	5.9	$431	$73.0	$18.3
Denver	T-REX	Light	19.1	$879	$46.0	$11.5
New Jersey	Hudson-Bergen	Light	5.1	$1210	$237.2	$59.3
Portland	MAX	Light	5.8	$350	$60.3	$15.1
Seattle	Sound Transit	Light	13.9	$2440	$175.5	$43.9
Phoenix	East Valley	Light	19.6	$1400	$71.4	$17.9
Charlotte	South Corridor	Light	9.6	$427	$44.5	$11.1
Pittsburgh	North Shore	Light	1.5	$381	$254.0	$63.5
Average		Light			$123.8	$30.95
--- Heavy Rail ---						
San Francisco	BART-SFO	Heavy	8.7	$1550	$178.2	$44.5
Chicago	Douglas Branch	Heavy	6.6	$483	$73.2	$18.3
San Juan	Tren Urbano	Heavy	10.7	$2250	$210.3	$52.6
Average		Heavy			$153.9	$38.5

Source: Federal Transit Administration (www.fta.dot.gov/news/press_release/16282_16385_ENG_HTML.htm)

A possible criticism of a VEB network, from a bus-transit standpoint, is that to serve its function of offering congestion relief to drivers, it would have to encompass beltway-type freeways as well as radial freeways. Many urban areas have concentrated their HOV lane efforts on radial freeways, on the grounds that such routes are the ones best suited to transit and carpooling because they feed the densest employment concentration—the central business district. Historically, there is some validity to this point, but the overall trend in urban land use patterns over the past 50 years has been the decentralization of employment.[75] In response, transportation planners in a growing number of large metro areas are now adding (or planning to add) HOV and/or HOT lanes to circumferential freeways such as the LBJ Freeway (I-635) in Dallas and the Beltway (I-495) in Washington, D.C. And if the fraction of buses and HOV-3s on these portions of the network is lower than on radial freeways (e.g., the Katy's planned 25 percent), that just means a larger fraction of all network vehicles will be paying customers, improving the degree to which the network can be self-supporting from toll revenues.

B. Current Steps Toward Managed Lane Networks

There has been a flurry of activity around the country on the subject of networks of HOT or managed lanes. This is a brief recap, as of early 2005.

Atlanta

The Georgia State Road and Tollway Authority released a draft HOT lanes feasibility study report in February 2005, prepared by Parsons Brinckerhoff.[76] The study reviewed alternative operating philosophies for such lanes, and concluded that the region's planned HOV system would be overloaded by 2030, that a network of HOT lanes would provide greater benefits, and that a network of HOT lanes would be most feasible if buses and vanpools went at no charge but all other vehicles paid. It identified feasible corridors to begin implementing what would evolve into a network of HOT lanes.

Dallas/Ft. Worth

All the principal transit, highway, and toll road agencies in the Dallas/Ft. Worth metro area are cooperating on a HOT lanes region-wide study, with the assistance of consultant URS Corporation. The study seeks to identify a set of managed lanes projects for inclusion in the next long-term transportation plan. Dallas has already included HOT lanes in the planned reconstruction of the LBJ Freeway (I-635), is now considering HOT lanes on I-30, and has received private-sector proposals for managed lanes on the Airport Freeway between Dallas and Ft. Worth.

Denver

The relatively new Colorado Tolling Enterprise is completing a major study, with consultant Wilbur Smith Associates, on corridors where tolled express lanes would be most feasible.[77] The preliminary study identified a potential network of such lanes, and estimated that toll revenues could fund the majority of its cost.

Houston

Texas DOT (in conjunction with Houston METRO and HCTRA) has received a federal Value Pricing grant to study the possible conversion of all six current HOV facilities in Houston to HOT lanes and their development into a HOT Network. HCTRA has agreed to let METRO buses operate without charge on its new Westpark Tollway, which opened in 2004. And discussions are under way on a managed lanes MOU similar to that of the Katy for the Northwest Freeway corridor.

Miami

Three agencies—Florida DOT, Miami-Dade Expressway Authority, and Florida Turnpike Enterprise—are working together on managed lane feasibility studies for major freeways and toll roads in Miami-Dade County. A network of such lanes is one possible outcome. Detailed traffic and revenue studies have been done for two corridors, and a third corridor study (I-95) is under way.

Minneapolis/St. Paul

Minnesota DOT and the Metropolitan Council are sponsoring a region-wide study on the potential of managed lanes and bus rapid transit. The MnPASS Toll Lane System Study is being conducted by Cambridge

Systematics.[78] It is evaluating individual corridors as well as one or more possible networks of managed lanes.

San Diego

The metropolitan planning organization (MPO) for this region, the San Diego Association of Governments (SANDAG), sponsored the I-15 HOV to HOT lanes conversion project that demonstrated the feasibility of quasi-real-time variable pricing. In addition to greatly expanding the I-15 managed lanes, SANDAG has included in its 2030 long-range transportation plan the addition of similar managed lanes on three other freeways: I-5, I-805, and SR 52.

San Francisco Bay Area

In February 2005 the Metropolitan Transportation Commission of the nine-county San Francisco Bay region adopted its year 2030 long-range transportation plan. Included in the plan is a proposal to consider a $3 billion HOT Network. In justifying this project, the MTC explicitly cites its role in providing the infrastructure for region-wide express bus service, a long-sought Bay Area goal. The Bay Area has begun the addition of a HOT lane (the region's first) to I-680 on the Sunol Grade, an important commuter route from the East Bay to Silicon Valley. And Santa Clara County is conducting feasibility studies of several possible HOT lane projects.

Washington, D.C.

In 2004, the Transportation Planning Board for the greater Washington metro area completed a Regional Mobility and Accessibility Study that proposed an extensive HOT Network for the metro area.[79] In parallel with this study, the private sector has proposed adding HOT lanes to the southwest quadrant of the Beltway (I-495) and to I-95 and I-395 approaching the District of Columbia from the south. The Maryland State Highway Authority is actively studying express toll lanes for a number of freeways, including the Maryland portion of the Washington Beltway and I-270.

* * *

These studies have several features in common. All are examining the trade-offs between HOV occupancy requirements (for free passage) and toll revenue, since all would involve extensive construction of new managed lane capacity. All are examining the possibility of going beyond individual managed lane facilities to consider the possibility of a complete network. And all are including a significant role for bus transit operations. Hence, all have the potential to lead to VEB networks.

Part 7

Potential Obstacles and Needed Policy Changes

What will it take to make Virtual Exclusive Busways a reality? As is often the case, the devil is in the details. Even if a Metropolitan Planning Organization and state and local transportation agencies wish to proceed with VEBs, there are uncertainties at the federal level that need to be clarified by the Federal Transit Administration and potentially other federal agencies. Some of these changes will require statutory change by Congress.

A. Federal Transit Policy Changes

The most important federal policy changes involve the FTA's policy toward HOT lanes and managed lanes generally, especially in the context of the agency's growing support for Bus Rapid Transit.

As noted previously, FTA has become comfortable with conversions of HOV lanes to HOT lanes, so long as transit remains an important use of the facility and transit service quality is not degraded (generally meaning at least LOS C conditions). Since this condition is easy to satisfy by using value pricing, such conversions are increasingly being approved.

But for transit agencies, an important issue arises when new HOT lanes are added to a set of converted HOV lanes. In calculating federal transit aid, FTA's formula funds (under Sec. 5307 of Title 49) and New Starts funds (under Sec. 5309) count the number of miles of "guideway" used by the transit agency. HOV lanes qualify as "guideway" for this purpose, and recent FTA policy on HOV to HOT conversions allows the resulting HOT lanes to qualify, as well. But there is no statutory or policy statement on the status of new HOT lanes that get added to a region's system. While a clarifying policy statement from FTA would help, transit agencies should have the certainty of a statutory change to the term "fixed guideway" in Sec. 5302 of Title 49, so as to include value-priced lanes operated in partnership with transit agencies.

A second issue arises in connection with the alternatives analysis that a transit agency must carry out in applying for capital funding under FTA's New Starts program. Given the great benefits of a Virtual Exclusive Busway for transit, as documented in this report, a VEB or a VEB Network should be one of the alternatives studied in such analyses.

The third issue concerns New Starts funding itself. This report has made the case that a VEB is a very cost-effective fixed guideway for high-volume, high-speed, highly reliable express bus service. As such, it ought to be eligible for New Starts funding. Since as we have seen, toll revenues can support a significant fraction of the capital costs of VEBs and VEB Networks, and local, state, and federal highway funds can be justified for the remainder of the basic highway infrastructure portions of such facilities, FTA New Starts funds should be available for the bus-related infrastructure portions, namely:

- Park and ride lots;
- Direct-access ramps (from stations and other high-traffic entry and exit points);
- On-line and/or off-line stations; and
- Buses.

Eligibility for a project to be considered a VEB for New Starts purposes should be conditioned on a multi-agency agreement such as the MOU in Houston (see Appendix) which spells out the amount of capacity dedicated to transit-type uses and the commitment of all parties to use value pricing and occupancy-level adjustments to maintain acceptable level of service conditions on a long-term basis.

B. Paying for HOV Trips

As discussed previously, there is an inherent trade-off between the financial viability of managed lanes such as VEBs and the extent to which certain categories of vehicles (e.g., HOV-2s) are exempted from paying the value-priced tolls. In general, this report has favored making such projects as close as possible to self-supporting from toll revenues, by limiting exemptions to super-HOV categories such as buses and pre-authorized vanpools. But there is another way to approach this issue, one which could avoid taking on the existing HOV constituency.

Several transportation experts have suggested to the authors that instead of continuing (and perhaps expanding) the "HOV entitlement," transportation policy should instead charge all vehicles using the managed lanes—but reimburse commuter HOVs for the toll. One expert suggested that this be the form in which a state agency would contribute to the capital costs of the project. It would be paying only to the extent that the VEB was successful in attracting commuter HOV trips, rather than paying a portion of the costs of the infrastructure, regardless of the amount or nature of the use.

Such an approach would have several advantages over today's HOVs-go-free policy. First, it would greatly simplify enforcement, since every vehicle would be required to have a transponder and an account, and there would be no need for on-the-road checking of the degree of vehicle occupancy. Second, it would limit the HOV entitlement to genuine commuter carpools and vanpools, excluding most of the fampools now taking advantage of what was supposed to be a means of changing commute behavior during rush hours. Third, it would make the cost of favoring HOVs an explicit item in somebody's transportation budget, where it could receive periodic scrutiny in competition with other uses of transportation funds.

Simply listing these advantages does not answer the question of where the funds to pay for these toll reimbursements would come from. One possibility is the various Transportation Demand Management (TDM) programs that exist in large urban areas. These agencies work with employers to provide ride-matching services for commuters, make available transit information, and related tasks. TDM programs get funds from a variety of sources, including local, state and federal governments, but also in some cases from developers and large employers. Obviously, if a TDM program becomes responsible for reimbursing the toll payments made by thousands of carpoolers every day, it would have to find increased funding from various sources. While we do not have a ready source to suggest, we simply point out that, over time, assisting with carpooling may be more cost-effective than some forms of transit expansion.

Another way of addressing the same problem has been proposed recently by Patrick DeCorla-Souza and William G. Barker.[80] They suggest a form of public-private partnership for managed lanes in which value-priced tolls are paid by most vehicles (buses and HOVs excepted), and those tolls are paid to the government entity sponsoring the managed lanes project. The actual lanes would be developed and operated by a private firm, which would be paid a flat "shadow toll" by the government entity for every vehicle using the lanes. Firms would bid to become the managed lanes developer/operator on the basis of the level of shadow toll they would need, and the qualified firm bidding the least would be selected. The firm would minimize its traffic risk, since it would price the managed lanes to operate at maximum throughput (vehicles/lane/hour) in order to maximize the revenue from its agreed-upon shadow toll. Hence, it would be indifferent to whether any particular vehicle was an HOV or a SOV.

C. Air Quality Conformity

One other problem that a full-sale VEB Network would have to confront is an air quality conformity determination. Federal transportation law and the Clean Air Act amendments require that significant highway expansion projects demonstrate conformity with the approved State Implementation Plan (SIP) for air quality. While the impact of converting an existing HOV lane to a HOT lane is so small as to be insignificant, the development of a complete $3 billion network of managed lanes, much of it new capacity, would clearly have to pass a conformity test in order to get approval for development.

In principle, we know that free-flowing traffic at speeds of 40-50 mph emits significantly less reactive organic gases (ROG) and carbon monoxide (CO) than stop-and-go traffic, though somewhat more nitrogen oxides (NOx). In his Ph.D. dissertation on HOT lanes, Eugene Kim modeled the conversion of an HOV lane to either a general-purpose lane or a HOT lane. Using the EMFAC 2000 model, at the time the principal transportation emissions model used in California, Kim found that the HOT lane conversion would reduce emissions of all three pollutants.[81]

What Kim did not model, however, was the addition of large amounts of HOT lane capacity. This is where the issue becomes more difficult, because the standard of comparison must be: compared to what? An alternatives analysis might compare developing a network of VEBs with the addition of the same amount of capacity as conventional HOV lanes and with a no-build alternative. If the analysis is carried out over a realistic planning horizon (e.g., a typical 30-year toll revenue bond financing period), both the no-build alternative and the HOV lanes expansion are likely to show higher levels of congested travel than the VEB alternative. And if transit mode share is shown to be significantly higher for the VEB alternative, that should be positive for air quality, as well.

Most conformity modeling is shifting from EPA's MOBILE5 model to MOBILE6. The latter builds in the significant reductions in emission rates expected over the next 20 years as the vehicle fleet turns over and cars that meet today's much tougher emission standards come to predominate in the fleet. Since no large-scale VEB network would come into operation for at least 10 years, it is important that the conformity modeling take into account the vehicle fleet as it will exist during the time period following completion of the network, rather than today's far more polluting fleet.

Appendix

Houston's Katy Managed Lanes MOU

A MEMORANDUM OF UNDERSTANDIN BY AND AMONG THE STATE OF TEXAS (STATE), THE COUNTY OF HARRIS (COUNTY), AND THE METROPOLITAN TRANSIT AUTHORITY OF HARRIS COUNTY (METRO) FOR THE OPERATION OF TRANSIT ALONG THE KATY FREEWAY

8-20-02

Texas Department of Transportation (STATE) is currently planning to reconstruct the portion of the IH 10 from the city of Katy, Texas east to just east of the interchange with IH 610. The reconstruction will include building two managed lanes in each direction in the median area, from just west of SH 6 to just west of IH 610 that will be used by Harris County (COUNTY) as a toll road.

As part of the effort to develop an agreement with COUNTY to operate a toll road in the median of the Katy Freeway, issues impacting METRO operations need to be clarified. These issues, as listed below, will be made part of the construction agreement. The MOU will then be incorporated into an Operating Agreement that will be executed between the STATE, COUNTY, and METRO.

The issues are:

1. A Level of Service (LOS) C is the target level for determining acceptable system operation.
2. Enforcement and incident management of the toll lanes will be the sole responsibility of the COUNTY. TranStar may be used as the base of operations for County Toll Road operations personnel.
3. STATE, COUNTY, and METRO will agree upon an Operations Plan.
4. COUNTY will have sole responsibility for the maintenance of the toll facility.
5. The number of access points to the managed lanes for transit vehicles will be as shown on the approved schematic.
6. METRO reserves the right to provide future light rail transit in the highway corridor. STATE will consider adding provisions into the current highway construction to facilitate this future operation in the median of the highway. The implementation of light rail transit may require the STATE to reimburse COUNTY for certain capital expenditures.
7. METRO will be responsible for providing the STATE with any special signage and equipment to be installed along the toll lanes to support their transit operations.

Initially, the operating agreement envisions the following:

- METRO can operate, on a toll free basis, a maximum of 65 buses per hour, in each direction, 24 hours per day, 7 days a week (24/7). METRO can operate METROLift vehicles on the same basis as buses.

- High Occupancy Vehicles with three or more occupants (HOV3) will be allowed to operate toll-free from 6:00 AM to 11:00 AM eastbound and from 2:00 PM to 8:00 PM westbound, 7 days a week.

- In support of its transit operations, METRO non-revenue (support) vehicles will be allowed toll-free use 24/7. All such support vehicles shall bear readily recognizable METRO logos. Support vehicles include METRO police cruisers, wreckers, maintenance trucks, pickup trucks, sedans, and service vans. A limit of 300 toll tags will be issued for use by support vehicles and Metrolift vehicles.

- Single Occupancy Vehicles and HOV2, commercial vehicles (trucks, non-METRO buses, including school buses) shall pay tolls at all times.

- Vans with at least three occupants shall be considered as HOV3.

At such time that the LOS C is not being maintained, all parties will meet to review and decide among various options to restore the system to an acceptable level. These options include, but are not limited to: adjusting variable pricing (tolls); adjusting occupancy levels of HOVs (initially established at HOV3) using the facility toll-free; restricting the number of support vehicles using the facility toll-free; expansion of the managed lanes to include a transit lane in each direction in addition to the two toll lanes initially provided; or other measures.

Unless the facility is expanded, it is recognized by all parties that if LOS C is not being maintained and that if the actual combined number of toll-free buses, METROLift, support, and HOV3 vehicles exceeds 25% of the calculated facility capacity in either direction, toll-free HOV occupancy requirements will be adjusted to restore LOS C. METRO will allocate its 25% share of facility capacity in the following order: 1) buses and other revenue vehicles, 2) HOVs and 3) non-revenue vehicles. In the event that the combination of toll-free buses, METROLift and support vehicles and HOVs does not exceed 25% of the calculated facility capacity in either direction, variable pricing or facility expansion options would be employed to restore system operations to LOS C.

IN WITNESS WHEREOF, the STATE, COUNTY AND METRO have caused this Memorandum of Understanding to be duly executed, to be effective as of the date executed by the STATE.

About the Authors

Robert W. Poole, Jr. is Director of Transportation Studies at Reason Foundation. He received his B.S. and M.S. in engineering from MIT and worked in aerospace before launching Reason Foundation in 1978. He has advised the U.S., California, and Florida departments of transportation, as well as the Reagan, Bush, Clinton, and Bush White Houses on transportation policy issues. He was a member of California's Commission on Transportation Investment in 1995-96.

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Balaker is currently writing (with Samuel Staley*) The Road More Traveled: Improving Mobility and Reducing Congestion in American Cities* (Rowman & Littlefield 2006).

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