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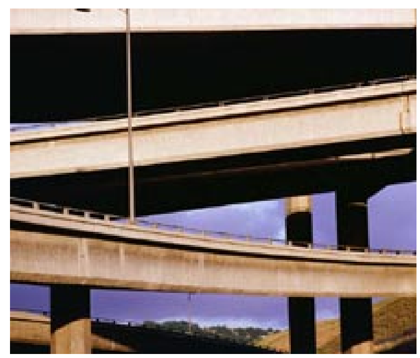

POLICY STUDY

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Executive Summary

Today's High-Occupancy Vehicle (HOV) lanes represent a valiant but largely unsuccessful effort to reduce traffic congestion in America's large metropolitan areas. Evidence is growing that, despite billions of dollars worth of capital investment, and many years of rideshare promotion, HOV lanes have not changed Americans' driving habits. Instead of gradually gaining strength, carpooling has been slowly eroding. The fraction of commuters sharing the ride to work declined in the decade of the '90s from a nationwide average of 13 percent in 1990 to 11.4 percent in 2000 according to the *2000 Census*. Although HOV lanes reduce travel time for the remaining small percentage of commuters who are able to carpool, a vast proportion of the traveling public does not benefit from them.

Meanwhile, the traffic congestion which HOV lanes were supposed to alleviate has continued to mount. Congestion in America's largest 75 urban areas cost travelers $68 billion in lost time and wasted fuel in 2000, an all-time high. In just the eight most congested metropolitan areas (excluding New York), the congestion cost totaled $30.7 billion—and there is no relief in sight. But America's investment in HOV facilities is too great and their potential too valuable for these facilities to be ignored.

HOV lanes, we believe, could be transformed into a more effective component of the urban transportation system by turning them into premium lanes that would serve as high-speed guideways for express buses, while providing a faster and more reliable travel option to individual motorists traveling in personal automobiles. Buses and vanpools would use the premium lanes free of charge, while other motorists would pay a variable toll. Tolls would be debited electronically from users' smart cards, thus doing away with tollbooths and cash transactions. In effect, our proposal marries two promising transportation innovations receiving growing attention in the transportation community: High Occupancy Toll (HOT) lanes and Bus Rapid Transit (BRT).

HOT lanes are limited-access lanes reserved for buses and other high-occupancy vehicles but open to single occupant vehicles upon payment of a toll. The number of cars using the reserved lanes can be controlled through variable pricing (via electronic toll collection) so as to maintain free-flowing traffic at all times, even during the height of rush hours. California's two HOT lane projects, which have been in operation for

several years, have demonstrated convincingly the ability of electronic variable pricing to maintain congestion-free conditions even during peak hours. Moreover, surveys in California have shown widespread public acceptance of the HOT lane concept. People of all income levels use the HOT lanes when saving time is an important consideration. Indeed, utility vans and delivery trucks are a far more common sight on California's HOT lanes than the proverbial Lexus.

Bus Rapid Transit (BRT) refers to frequent bus service operating in special lanes. BRT aims to provide performance and service qualities comparable to those of rail transit but at a cost that is considerably lower than that of light rail systems (an average of $9 million/mile versus $34.8 million/mile for light rail transit according to U.S. General Accounting Office estimates). Because of its favorable economics, BRT is receiving increased attention from the U.S. Department of Transportation and is picking up support in the transit community. Transit officials realize that the federal New Starts program can only fund a small fraction of the rail candidate projects currently in the pipeline. They see BRT as offering a new generation of less costly transit systems that would extend the benefits of rapid transit to a much larger number of communities.

However, to fully realize the potential of these two innovative concepts, the fragmented and unconnected HOV facilities that already exist in metropolitan areas today must be extended, linked and interconnected so as to create seamless region-wide networks of unobstructed lanes. Only then would transit riders and motorists be able to take full advantage of the benefits of time savings and increased travel reliability of premium lanes.

In one sense, our proposal calls for a return to an earlier concept, in which special reserved lanes were developed primarily as uncongested guideways for regional express bus service. But instead of offering the significant remaining capacity of these premium lanes to carpool vehicles at no charge, our proposal would open these lanes to all personal vehicles that choose to pay a fee. Charging such vehicles serves two purposes: it generates the funds needed to pay for the network and it manages traffic flow to preserve the time-saving advantages necessary for high-quality express bus service.

We believe there is a way to accomplish this vision without drawing heavily on public sector funds. Experience with California's two HOT lane facilities has shown that motorists are willing to pay tolls to save time even if there is a free highway alternative. These facilities have further demonstrated that tolls paid by motorists can generate a significant annual revenue stream. Our proposal is to use these revenues as the basis for issuing tax-exempt toll revenue bonds to finance the build-out of the HOT Networks.

In this report we define potential HOT Networks for eight of the most-congested metropolitan areas (Miami, Atlanta, Dallas/Ft. Worth, Houston, Seattle, Washington, D.C., the San Francisco Bay Area, and Los Angeles/Orange County). Using current engineering cost data, we develop the estimated cost of each network. And based on demand data from California's two operational HOT lanes, we estimate the annual premium toll revenue that each would produce, and translate that into hypothetical toll revenue bond issues. Overall, our estimates show that toll revenue bonds could cover about two thirds of the $43 billion in construction costs. The balance would come from the federal aid transportation program.

To implement this plan we recommend that Congress authorize a multi-year program of HOT Network development to be jointly implemented by the Federal Highway Administration and the Federal Transit Administration. Specifically, the program would aim to encourage states and metropolitan jurisdictions to:

1. Incrementally create networks of premium toll lanes (HOT Networks) by extending, linking, interconnecting and filling in gaps in existing metropolitan HOV systems;

2. Implement Bus Rapid Transit services on the completed parts of the HOT Networks as soon as practicable; and

3. Develop innovative public-private financing arrangements involving tax-exempt toll revenue bonds to help fund a significant portion of the capital cost of these projects.

Funds to support the federal portion of the program would come from special fund allocations drawn from the FHWA's National Highway System or Surface Transportation Program. The FTA's New Starts program would provide funds for bus acquisition and related BRT system components. The proportion of funds to be contributed by each agency would be determined by congressional action in the authorizing legislation.

In sum, the HOT Networks concept is an approach by which nearly everyone would win. Transit riders would win because many cities that could not afford to build a large-scale rail system would be able to implement effective region-wide express transit service. Individual motorists would benefit by having the option of faster and more reliable travel on a network of congestion-free lanes when saving time is really of importance to them. Users of regular lanes would gain because regular lanes would become less congested as some motorists switched to the toll lanes. And, importantly, HOT Networks could be built without the need for major new public funds by utilizing the revenue stream from toll charges paid by individual motorists.

In the 2003 surface transportation reauthorization, Congress will have an opportunity to make this vision a reality. A congressionally authorized program of HOT Networks—built to benefit motorists and transit users alike—would constitute a powerful expression of the increasingly intermodal nature of our federal surface transportation program. And at a time when the need for transportation capital investment greatly exceeds traditional sources of funding, HOT Networks would give America's metropolitan areas a new option—both congestion relief and improved transit service without the need for major new tax revenues.

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Figures and Tables

Part I

Introduction

Urban traffic congestion remains one of America's biggest problems, despite decades of efforts by federal, state, and local governments to address it. In 2000, according to the most recent annual Urban Mobility Report from the Texas Transportation Institute, American motorists in the largest 75 urban areas lost $67.5 billion in wasted time (3.6 billion hours of delay) and fuel (5.7 billion extra gallons) due to traffic congestion.[1] This was an all-time high for the nearly two decades during which TTI has been measuring the extent of congestion. The average annual amount of time an urban motorist lost to congestion during peak hours grew from 16 hours in 1982 to 62 hours in 2000.

One reason for the increase in congestion is that driving increased far more than road capacity over the past three decades. TTI found a strong relationship between the extent to which congestion was kept more-or-less under control and the extent of capacity growth. As the TTI report explains,

> *"[T]he more that travel growth outpaced roadway expansion, the more the overall mobility level declined. The urban areas with significant capacity additions had their congestion levels increase at a much lower rate than those areas where travel increased at a much higher rate than capacity expansion."*

However, the high cost and political difficulty of adding significant highway capacity in congested urban areas was also noted by TTI's researchers. Only six of the 75 urban areas were able to keep highway capacity growth within 10 percent of traffic growth. The vast majority that could not do so suffered considerably greater reductions in mobility due to congestion.

Federal, state, and metro-area governments have focused considerable efforts and funding over the past two decades on providing commuters with alternatives to driving alone. The two principal thrusts were to invest significant sums on (1) adding high-occupancy vehicle (HOV) lanes to urban freeways, and (2) expanding transit systems, especially by adding new rail systems. During the past 20 years or so, American taxpayers paid for the creation of 2,119 lane-miles of HOV lanes, according to the Federal Highway Administration.[2] At an estimated $4 million per lane-mile, that represents an $8.5 billion investment. American taxpayers also spent over $70 billion on transit capital investment during the past decade.[3]

Data from the 2000 Census provides a measure of how effective this two-part strategy has been in reducing congestion. Unfortunately, the conclusion is: not very effective. Nationwide, despite the major expenditure on HOV lane additions, carpooling to work declined from 13.4 percent in 1990 to 11.2 percent in 2000—a drop of 16 percent. Carpooling's mode share decreased in 36 of the 40 largest metro areas. Transit's commuting mode share declined from 5.27 percent in 1990 to 4.73 percent in 2000—a decline of 10.3 percent (although transit mode share did increase in 12 of the 40 largest metro areas). Meanwhile, driving alone actually increased nationwide, rising from 72.7 percent of all work trips in 1990 to 75.7 percent in 2000. And driving alone's share increased in 36 of the 40 largest metro areas.

For purposes of analysis in this report, we will focus primarily on the 10 most-congested urban areas, as measured by TTI's latest report. While TTI provides several different measures of the extent of congestion, we have chosen annual hours of delay per peak road traveler as the best measure of the comparative severity of congestion. Table 1 lists the resulting 10 metro areas, in rank order, along with their drive-alone, HOV, and transit mode shares in 1990 and 2000.

As can be seen, even in these 10 highly congested metro areas, driving alone increased its mode share in seven out of 10. Correspondingly, carpooling lost market share over the past decade in seven of the 10. Transit lost commuting market share in half of these most heavily congested areas. These results came about despite large-scale efforts to expand HOV and transit capacity and to promote both carpooling and transit use.

Thus, the stage is set for the question to be explored in this policy study. As a nation, we have continued to lose ground against urban traffic congestion for several decades. To make meaningful progress, we may need to try new approaches. Can we make better use of the nation's investment in HOV capacity, and can we make transit more effective, while at the same time acknowledging the reality that for a complex set of reasons, driving (including driving alone) will continue to be the majority's mode of choice?

Table 1: Changes in Commuter Mode Choice in the Most-Congested Metro Areas

			Drive-alone %**		HOV %**		Transit %**	
Name	Person-hrs delay per peak traveler*	Rank*	1990	2000	1990	2000	1990	2000
Los Angeles-Orange County	136	1	72.3	72.4	15.5	15.2	4.6	4.7
San Francisco-Oakland	92	2	68.3	68.1	13.0	12.9	9.3	9.5
Washington DC-MD-VA	84	3	66.1	70.4	15.5	12.8	11.0	9.4
Seattle-Everett	82	4	73.1	71.6	12.1	12.8	6.1	6.8
Houston	75	5	76.1	77.0	14.6	14.2	3.8	3.3
Dallas-Ft. Worth	74	6	78.6	78.8	13.9	14.0	2.3	1.8
San Jose	74	6	68.3	68.1	13.0	12.9	9.3	9.5
New York-NE NJ	73	8	55.4	56.3	10.4	9.4	24.8	24.9
Atlanta	70	9	77.9	77.0	13.0	13.6	4.5	3.7
Miami-Hialeah	69	10	75.3	76.6	14.5	13.4	4.4	3.9

* Source: TTI *2002 Urban Mobility Report*, Exhibit A-2, 2000 Urban Mobility Conditions.

**Source: U.S. Census Bureau, "Journey-to-Work Trends for Selected Metropolitan Areas, available at www.census.gov. Note that the Census figures are based on the MSA, a larger geographic unit than used by TTI. Thus, for example, the Census defines a single MSA encompassing the entire San Francisco Bay Area, while TTI uses a separate urbanized area for San Francisco-Oakland and San Jose.

Part 2

Origins of the Concept

The premise of this policy study is that HOV lanes can be transformed into a more effective component of our urban mobility system. By changing the access requirement from vehicle occupancy to willingness to pay a market price (for cars) but allowing super high-occupancy vehicles (buses and vanpools) to use the lanes at no charge, we can accomplish three important goals:

Generate significant new revenue to pay for building out today's fragmented HOV lanes into a seamless network;
Provide a congestion-free alternative on every congested freeway in the metro area; and
Provide a congestion-free guideway for Bus Rapid Transit service that can make this form of transit significantly more competitive with driving.

Two key transportation innovations need to be combined to create these proposed HOT Networks: High-Occupancy Toll (HOT) lanes and Bus Rapid Transit (BRT). In this section, we provide an overview of both innovations. We also summarize several precursor proposals, which have not been implemented but which suggest parallel thinking among others in the transportation community.

A. HOT Lanes

1. Definition

HOT lanes are defined as specialized lanes open to both qualifying high-occupancy vehicles (carpools and transit) and paying customers (typically solo drivers). The term and concept of High-Occupancy toll (HOT) lanes was first set forth in a 1993 policy study by the Reason Foundation,[4] and subsequently endorsed by the Federal Highway Administration, under its Value Pricing Pilot Program. HOT lanes are being embraced by transportation planners for several reasons:[5]

1. First, by adding a controlled number of (paying) vehicles to under-utilized carpool lanes, the HOT lane concept keeps HOV lanes at their optimum utilization and relieves political pressures to decommission them (i.e., convert them back to general-purpose lanes).

2. Second, by diverting some solo drivers from the adjoining general-purpose lanes, HOT lanes help to reduce congestion in the general-purpose lanes.

3. Third, HOT lanes generate increased revenues for transportation corridor improvements, both highway and transit.

4. Fourth, HOT lanes provide a premium travel option for SOV drivers who have a special need to reach their destination on time and are willing to pay for better service.

In short, all user groups would benefit from HOT lanes. There should be no "losers" in the implementation of HOT lanes on a congested freeway.

The Federal Highway Administration (FHWA) fully supports HOT lanes. The 1991 Intermodal Surface Transportation Efficiency Act (ISTEA) created a Congestion Pricing Pilot Program, offering modest federal grant support to metropolitan planning organizations (MPOs) willing to experiment with the use of pricing mechanisms to improve highway operations. Projects to convert under-used HOV lanes to HOT lanes were embraced by FHWA beginning in 1995, and the agency has provided funding to assist with feasibility studies, implementation projects, and evaluations of operational projects.

In 1998 the federal transportation program was reauthorized as TEA-21. Under Section 1216(a) of TEA-21, the Congestion Pricing Pilot Program was broadened and renamed the Value Pricing Pilot Program (VPPP). Pricing of lanes otherwise reserved for high-occupancy vehicles is explicitly authorized. However, in order to protect the integrity of HOV programs, priority will be given by FHWA to "those HOT lane proposals where it is clear that an HOV lane is under-utilized."

2. HOT Lane Implementation

Thus far, HOT lanes have been in operation for a number of years in three metro areas in two states, California and Texas. There is sufficient operational experience to be able to draw some preliminary conclusions about the lanes' performance and acceptability. Houston has converted two HOV-3 facilities to a limited form of HOT lane in which HOV-2 vehicles can purchase access during peak periods, but solo drivers are not allowed. In San Diego, an under-utilized reversible HOV facility on I-15 was opened to solo drivers willing to pay a price that varies every six minutes (based on the volume of traffic in the HOV/HOT lanes) And in Orange County, California, a private developer financed, built, and operated new HOT lanes in the median of a congested commuter freeway, managing traffic flow via a price schedule that charges different prices at different hours of the day.

Houston's QuickRide program began on the I-10 West (Katy) Freeway in 1998. The increase in HOV requirement from HOV-2 to HOV-3 had solved the previous congestion problem in the HOV lanes, but had led to significant under-utilization. Permitting HOV-2s to purchase access for a $2.00 toll, paid via transponder, did reduce the extent of under-utilization. The program was extended to a similar HOV facility on the Northwest Freeway in 2000. Unfortunately, the market for paying HOV-2 customers has been modest. Despite the sale of over 1,500 transponders, the average daily number of paid transactions on the two facilities is only 160, of which 90 are on the Katy and 70 on U.S. 290.[6]

San Diego converted the grade-separated, reversible HOV-2 lanes on I-15 to HOT lanes in two steps, first offering access to solo drivers who purchased a monthly permit in 1996. The plan shifted to per-trip charging, via transponder, in 1997. Introduced at that time was dynamic variable pricing, under which the price charged is varied every six minutes based on observed traffic levels in the lanes. The program is required to maintain level of service (LOS) C[7] or better, and variable pricing is the tool used for this purpose.

Under normal conditions, the toll for the eight-mile drive ranges from 50 cents to $4.00. Although carpools still make up the majority of vehicles, the I-15 Express Lanes have been very successful in attracting paying solo drivers, who as of 2002 constitute 25 percent of all vehicles in the lanes.[8]

Orange County's 91 Express Lanes project represents a distinctly different application of HOT lanes, since this project involved the addition of two such lanes in each direction in the median of a heavily congested commuter freeway, SR 91. Furthermore, a basic rationale for the project was to use toll revenue to recover the costs of construction and operation, via a public-private partnership. Based on the strength of traffic and revenue projections, the company was able to finance the $135 million project via long-term toll revenue bonds. Traffic demand has been close to original projections, and the project is generating sufficient revenue to cover the debt service on the bonds, as well as all operations and maintenance costs. The variable toll structure has been adjusted upwards more than once a year since the lanes opened in December 1995, so as to limit the number of vehicles using the lanes and maintain free-flow conditions at 65 mph even during the busiest peak hours. (As of mid-2002, tolls ranged from $1.00 to $4.75 for the 10-mile facility.) HOV-3s use the lanes at half-price, while HOV-2s pay the regular rate. HOV-3s constituted about 13 percent of vehicles in the Express Lanes, as of 1999, the last year for which detailed data were available.[9]

3. Proposed and Planned HOT Lanes

Although HOT lanes are currently operational in only three urban areas, serious efforts are under way on HOT lane projects in quite a few other localities with serious congestion problems. Here is a brief overview.

Atlanta: The Georgia Regional Transportation Authority and its Atlanta Task Force in October 2001 announced a year-long study that will review possible conversion of HOV lanes to HOT lanes and/or the addition of new HOT lanes to the metro area's freeways.

Dallas: The recent Major Investment Study for expanding the most congested 18.5-mile section of the LBJ Freeway (I-635) calls for adding one, two, or three HOT lanes in each direction, depending on the section of the freeway. The North Central Texas Council of Governments has recently embarked on a study of adding value-priced toll lanes to all congested freeways.

Denver: Colorado DOT has completed a feasibility study on converting the under-used eight-mile HOV lane on I-25 to a HOT lane. It is also reviewing an unsolicited proposal from a private consortium to add HOT lanes to 10 miles of I-70 between Denver International Airport and downtown. And it is has solicited proposals to add 10 to 13 miles of HOT lanes to the C-470 beltway.

Houston: The local tollway authority is moving forward with the addition of tolled express lanes on an 11-mile section of the Katy Freeway (I-10), as part of a major expansion, to begin in 2003.

Los Angeles: The Southern California Association of Governments is carrying out feasibility studies on the addition of truck toll lanes (essentially, HOT lanes for trucks) on four freeways heavily affected by truck traffic to and from the ports of Long Beach and Los Angeles: 20 miles of the Long Beach Freeway (I-710), 37 miles of the Pomona Freeway (SR-60), 41 miles of the Golden State Freeway (I-5), and 35 miles of I-15.

Miami: Florida DOT has completed a feasibility study on converting the HOV lanes on I-95 in Miami-Dade County to a variable-priced HOT lane facility. Studies are under way by the Miami-Dade Expressway

Authority on adding tolled express lanes to SR 836 and SR 874. And value-priced express lanes are also being studied for the Homestead Extension of Florida's Turnpike (SR 821).

Phoenix: The Maricopa Association of Governments has recently completed a feasibility study on adding a system of interconnected HOT lanes to the Maricopa County freeway system.

San Diego: The San Diego Association of Governments (SANDAG) and Caltrans are beginning a major expansion of the existing I-15 HOT lanes, adding two additional lanes and lengthening the eight-mile facility by another 12 miles. And SANDAG now plans to add HOT lanes to three other freeways: I-5 and I-805 and SR 52.

San Francisco Bay Area: A number of HOT lane projects have been proposed in this highly congested region. In Alameda County, voters in November 2000 approved a ballot measure that includes adding a 14-mile HOV or HOT lane on I-680, a major commuter route to and from Silicon Valley. A feasibility study on adding HOT lanes to 11 miles of US 101 in Sonoma County was completed in 1998, and another has been conducted regarding US 101 in Marin County. Feasibility studies have also been done for possible HOT lanes on SR 1 in Santa Cruz County and I-880 in Alameda County.

Seattle: In November 2001 the I-405 Executive Committee recommended a major expansion of this congested freeway, with the addition of two lanes in each direction. To help cover the estimated $7 billion cost for this 33-mile project, the committee voted to consider "use-based pricing" for the new lanes.

Washington, D.C.: In summer 2002 a private consortium proposed adding two HOT lanes in each direction on 14 miles of the Washington Beltway in Virginia, from the Springfield interchange to the American Legion Bridge. The project would be developed and operated under the provisions of Virginia's Public-Private Transportation Act.

4. HOT Lanes' Potential

A recent presentation about Orange County's 91 Express Lanes provided some powerful evidence about their potential for managing traffic flow.[10] During the busiest peak hours, which are Wednesday through Friday afternoons, the two peak-direction HOT lanes carry more than 40 percent of the total SR 91 traffic, even though they constitute only 33 percent of the freeway's capacity (two lanes out of six). In other words, their throughput (vehicles/hour) is greater at 65 mph than that of the congested regular lanes, which operate in stop-and-go conditions averaging 10-20 mph. These results suggest that HOT lanes may be significantly more effective than HOV lanes at relieving freeway congestion.

That empirical finding gets analytical support from a recent UCLA Ph.D. dissertation.[11] Eugene Kim used a travel-demand model to estimate the comparative travel times that would come about by converting an existing HOV lane on a congested freeway to either (a) a general-purpose (GP) lane, (b) a HOT lane, or (c) a toll lane. He also estimated long-term (20-year) costs and benefits of each alternative, as well as environmental impact. In almost all cases, HOT or toll lanes provided a greater degree of fiscal benefits consumer welfare, and environmental benefits than any other expressway investments. In most cases, Kim concludes, society would be better off if the lanes were converted. Converting to GP lanes is most defensible when HOV use is less than 7 percent of all corridor trips, and there are under 700 vehicles/hour in the HOV lane. But in almost all cases, converting to a toll lane produces greater benefits, primarily because doing so can preserve free-flow conditions as traffic continues to grow and freeway congestion worsens. Another benefit is that toll lanes generate substantial revenues for the transportation system.

Whether to convert only to HOT (carpools still go for free) or go all the way to toll receives detailed attention in Kim's work. Intuitively, one might expect that conversion to toll would produce less delay-reduction than conversion to HOT, because fewer people will continue to carpool if those vehicles have to pay. But the modeling shows that conversion to toll produces large delay-reduction benefits "regardless of whether the conversion . . . results in a significant increase or decrease in the initial proportion of HOVs." As Kim points out, tolling indirectly preserves economic incentives to ride-share, by (1) spreading the toll over more than one person, and (2) by providing insurance against travel time uncertainty in the event that a carpool participant unexpectedly cancels—an effect already observed on the I-15 HOT lanes. Toll lanes would continue to serve large numbers of people in high-occupancy vehicles if express buses are allowed to use the toll lanes at no charge—as in our HOT Networks concept.

B. Bus Rapid Transit (BRT)

1. Definition

As its name implies, Bus Rapid Transit (BRT) is intended to mimic rail transit. BRT service typically involves high-capacity buses operating on specialized rights of way, offering frequent service. In its ultimate form, BRT makes use of enclosed stations equipped with high platforms to facilitate rapid loading and unloading of passengers. Fares are collected upon entering the station, not on entering the bus, in order to speed up boarding and reduce time spent at stations. The overall intent is to give bus service some of the qualities it frequently lacks: faster operating speeds, greater service reliability, and increased comfort and convenience, matching the quality of rail transit service—but at lower cost.

BRT guideways can be either totally separated *busways*, i.e. roadways reserved exclusively for bus operation, or *managed lanes* where free-flowing traffic is maintained at all times by controlling and constraining the volume of traffic -- and hence the level of congestion. The control is maintained by applying eligibility criteria (as in HOV lanes, reserved for "high-occupancy vehicles") or through pricing (as in HOT lanes). The best examples of large-scale high-capacity BRT systems are those of Curitiba (Brazil), Bogota (Colombia), Lima (Peru), Ottawa (Canada), and Paris (France). All five systems employ separate busways reserved exclusively for express buses. (Further details on several of these systems will be found in the Appendix.)

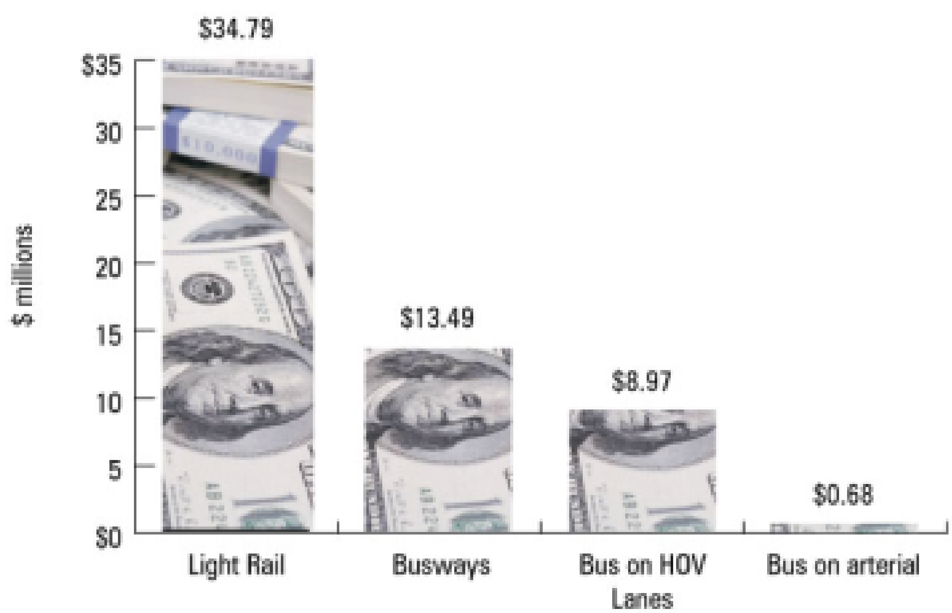
In the United States, the BRT concept, as currently interpreted by the Federal Transit Administration (FTA), includes (in addition to busways) express buses operating in dedicated bus lanes on arterial streets and freeways, and buses operating in dedicated lanes on city streets, using traffic signal preemption. Exclusive busways currently exist in Pittsburgh and Miami. Buses on HOV lanes operate in Dallas, Denver, Houston, Los Angeles, the San Francisco Bay Area, Seattle, Northern New Jersey, and Northern Virginia. A 10-city Bus Rapid Transit Demonstration Program was launched by the FTA in December 1998. Demonstrations are currently under way in Boston, Charlotte, Cleveland, Eugene, Hartford, Honolulu, Miami, San Jose, and San Juan. The demonstration program does not provide funding for construction but rather focuses on obtaining and sharing information on projects being pursued by local transit agencies. A 2001 General Accounting

Office (GAO) review of Bus Rapid Transit systems found at least 17 U.S. cities planning to implement some form of BRT.[12]

2. Bus Rapid Transit Economics

The FTA has begun to actively promote BRT as a lower-cost alternative to building light rail systems. Carving out a bigger role for BRT is seen by the FTA as potentially improving the return on federal investment in transit. Recent studies by the GAO have found that, on a capital cost per mile basis, BRT systems average from 26 to 39 percent less than light rail systems. Specifically, the GAO has found that capital costs averaged $13.5 million per mile for busways and $9.0 million per mile for buses on HOV lanes, while light rail capital costs ranged from $12.4 million to $118.8 million per mile (all figures adjusted to 2000 dollars).[13] Figure 1 graphically illustrates the difference.

Figure 1: Capital Costs of Light Rail and Bus Rapid Transit



Notes: Cost escalated to fiscal year 2000 dollars.

Average Light Rail capital costs are for 13 cities that built 18 Light Rail lines since 1980. Busway capital costs are for nine busways built in four cities; in two cities these facilities were subsequently opened to private vehicles as HOV lanes. Capital costs for buses using HOV lanes are eight HOV facilities in five cities. Capital costs for buses on arterial streets are for three lines in two cities.

Source: "Mass Transit: Bus Rapid Transit Shows Promise," Washington, D.C.: General Accounting Office, GAO-01-984, September 2001.

According to the GAO, the higher per-mile capital costs for light rail systems are attributable to several factors. First, the light rail systems contain elements not required in the BRT systems, such as track bed, signalization, communications, and an overhead electrical power distribution system. Light rail vehicles, while having higher carrying capacity than most buses, also cost more—about $2.5 million each. In contrast, bus vehicles range from $280,000 for a typical 40-foot transit bus to $420,000 for a high-capacity bus.

GAO's findings on operating costs were mixed. On the one hand, it found lower BRT operating costs per vehicle revenue hour and per revenue mile. Operating cost per passenger trip was lower on four BRT systems and higher on two others, leading to no clear conclusion on that point.

3. BRT Performance

Bus Rapid Transit may also include certain features that further improve its performance and service quality. For example, many BRT systems have enclosed bus stations where passengers pay prior to boarding the bus, thus speeding up the boarding process. Extra- wide doors facilitate prompt boarding and disembarking of riders. Intelligent transportation system (ITS) technologies maintain more consistent headways between buses and inform passengers when the next bus is coming.

The operating performance and level of service provided by BRT can thus be comparable to that of light rail transit. Indeed, in the six cities reviewed by the GAO that had both types of service (Dallas, Denver, Los Angeles, Pittsburgh, San Diego and San Jose), BRT generally operated at higher speeds. In addition, light rail was found not to have a capacity advantage over BRT. The highest ridership on a light rail line was found on the Los Angeles Blue Line, with 57,000 riders per day, while the highest BRT ridership, also in Los Angeles, was on the Wilshire-Whittier Metro Rapid line with 56,000 riders per day. Most light rail lines in the United States carry less than half the Los Angeles Blue Line's ridership.[14]

BRT and light rail each have their merits and drawbacks. BRT generally has the advantage of greater operational flexibility than light rail. BRT's flexibility may be a potentially valuable feature for many communities with sprawling patterns of development. Light rail has the potential capability of stimulating joint development around transit stations and improving community image. Transit users also may prefer light rail service because they perceive it as faster, quieter, and less polluting. Proponents of BRT maintain that BRT can overcome this image by offering a high service quality that competes with private autos for discretionary riders.

4. Federal Support of BRT

Bus Rapid Transit is a relatively new concept. As of March 2002, only one of the Federal Transit Administration's 29 New Starts projects with "existing, pending or proposed" grant agreements is a BRT project. Of the five New Starts projects nearing approval, again only one involves Bus Rapid Transit. Some BRT projects do not fit the exclusive right-of-way requirements of the federal New Starts Program and thus are not eligible for funding under the present federal guidelines. The BRT Demonstration Program, which involves the 11 projects noted in subsection 1, does not provide funding for construction but rather focuses on obtaining and sharing information on projects being pursued by local transit agencies.

BRT is picking up substantial support within the transit community. Transit officials realize that the federal New Starts program can only fund a small fraction of the rail candidate projects currently in the pipeline. They see BRT as offering a new generation of less costly transit systems that would extend the benefits of rapid transit to a larger number of communities. The FTA expects to enter the period covered by the next reauthorization (fiscal years 2004 through 2009) with over $3 billion in outstanding New Starts grant commitments. In addition, FTA has identified five projects estimated to cost $2.8 billion that will likely be ready for grant agreements in the next two years. Even assuming that the total authorization for New Starts in the next program is higher than the current TEA-21 level ($6 billion), most of the New Starts funds will be committed early in the reauthorization period. The remaining funds would go further supporting BRT projects than costly rail projects, some of which are anticipated to require multi-billion dollar federal grants.[15]

C. Precursors of HOT Networks

While this report is the first full-length presentation of the HOT Networks concept under this name[16], the concept has several precursors in the U.S. transportation community. The first of these was a proposal submitted to the Arizona Department of Transportation (ADOT) in May 1992 by a joint venture of Kimley-Horn and Lockheed called the Arizona Tollroad Company. It called for converting existing HOV lanes on I-10 in Phoenix to HOT lanes (though the term "HOT" was not yet in the lexicon) and using the revenues from charging solo drivers to add new HOT lanes to additional stretches of I-10 and US 60, the principal east-west freeways in Phoenix at the time. A proposed future phase would have added HOT lanes to I-17, the principal north-south freeway. Included in the concept was express bus service using the HOT lanes, possibly subsidized via surplus revenues from tolls. The proposal ultimately died because of a lack of state legislation to permit charging tolls on existing lanes.

Interestingly, 10 years later ADOT and the local metropolitan planning organization (MPO), the Maricopa Association of Governments (MAG), completed a study evaluating the feasibility of what amounts to a HOT Network for the Phoenix metro area. Conducted by Parsons Transportation Group, the study evaluated Value Lanes (defined as "HOT lane facilities that use dynamic variable pricing"). The Recommended HOT Case involved a network of HOT lanes on the region's core freeways, with direct-access connectors at several key interchanges. All five candidate corridors were judged to be financially feasible.[17]

A more comprehensive network of HOT lanes was proposed in a 1998 study by the Minnesota Department of Transportation and the Metropolitan Council of the Twin Cities.[18] The proposal called for existing HOV lanes on I-394 and I-35W to be converted to HOT lanes. Together with new HOT lanes to be added to a number of other freeways, the result would be 273 lane-miles of mostly interconnected HOT lanes. They would use variable pricing, based on distance and time of day. A peak toll rate of 13 cents/mile was found to maximize revenue. The study concluded that the HOT lane system concept would be "technically feasible and could generate ample revenue to operate and maintain the system and provide for modest transit enhancements."

In 1999, the Maryland Department of Transportation (MDOT) launched a major study of variable pricing to determine whether peak period pricing would be an appropriate means to help manage congestion and provide travelers additional transportation choices in the highly congested metropolitan Washington/Baltimore region. The study included I-270, I-495 (The Beltway), MD 210, US 50, I-95 (north and south of Baltimore), Chesapeake Bay Bridge and the three Baltimore Harbor Crossings. The aim of the study was to assess the fiscal, environmental and public acceptance feasibility of the concept. It was not intended to resolve all of the technical and engineering design issues associated with implementation.[19] Phase I considered a broad range of variable pricing strategies, while in Phase II three alternative HOT lane network configurations were evaluated. Public involvement (including educational and outreach components, as well as work sessions with stakeholders and focus groups) was an integral part during both phases of the study. The study was prematurely terminated by order of Gov. Parris Glendening in June 2001. Glendening cited egalitarian concerns and smart-growth considerations for his decision.

In October 2000, the Texas Transportation Institute began an ongoing project on what it calls “Managed Lanes.” This is a general term that “encompasses a variety of facility types, including HOV lanes, high-occupancy toll (HOT) lanes, single-occupancy vehicle (SOV) express lanes, special use lanes, and truck lanes.”[20] According to researchers at TTI, the term and concept originated in discussions between TTI and HOV expert Chuck Fuhs of Parsons Brinckerhoff in 1999.[21] TTI’s recent policy paper states that “The theory behind managed lanes is to set aside certain freeway lanes and to use a variety of operating strategies to move traffic more efficiently, providing travelers with more choices than driving alone on a congested freeway.” Among the potential benefits of managed lanes, the TTI paper includes:

- Revenue generation (for those that charge prices);
- Time savings;
- Safety (especially in the case of managed lanes for trucks only);
- Environmental benefits (thanks to reduced emissions due to free-flowing traffic); and
- Community acceptance (to the extent that a managed-lanes approach reduces the need to acquire additional right of way).

The managed lanes term is becoming widely used in Texas, where projects are in the planning and/or study phase in Austin, Dallas, Ft. Worth, Houston, San Antonio, and Waco. The TxDOT Project Monitoring Committee defines the term as follows: “A managed lane facility is one that increases freeway efficiency by packaging various operational and design actions. Lane management operations may be adjusted at any time to better match regional goals.”[22] The term is beginning to be used elsewhere as a general term for other than general-purpose highway lanes. The HOT Networks proposed in this policy study are one form of managed lanes.

Part 3

HOT Network Specifics

A. Defining the HOT Network

For purposes of this policy study, we are defining a HOT Network as an interconnected set of limited-access lanes on an urban freeway system. These lanes may be used by buses and vanpools at no charge and by automobiles and light trucks (SUVs, pickups, etc.) upon payment of a variable toll. The prices would be varied so as to limit the number of vehicles per lane per hour to the maximum consistent with free-flow conditions. Tolling would be all-electronic, using dashboard-mounted transponders to debit pre-paid toll accounts. Enforcement would be via video camera imaging of the license plates of vehicles either lacking a transponder, having an insufficient account balance, or whose accounts had expired.

Like HOV lanes, HOT Networks would be designed for relatively long-haul travel. Thus, they would have far fewer ingress and egress points than the freeways themselves. In most cases, the HOT Network would be composed of existing freeway HOV lanes (converted to operate as HOT lanes) linked with additional lanes planned as HOV but now built as HOT instead. Most of these lanes would be at-grade, like the freeway of which they are a part. But in some core portions of metro areas where right of way is very expensive (and where land takings would be politically difficult) those portions requiring lane additions would be built as elevated sections. The majority of initial HOT Networks would be configured as a single lane in each direction, separated from each other by a concrete Jersey barrier (and from adjacent general-purpose lanes by plastic pylons, as used on the 91 Express Lanes). But some portions would include two lanes in each direction and other portions—where commuting is heavily directional—would use reversible lanes.

Key to the definition of a HOT Network is its being a *network*. Unlike most of today's freeway HOV lanes, which do not make the transition from one freeway to another, our approach would provide for seamless connections at interchanges. Only a handful of transportation agencies (e.g., Orange County, California) have given priority to HOV-to-HOV connectors, because these elevated flyovers are very costly to build. But it is only these connectors that make a true network possible.

We expect that HOT Networks will attract more patronage than HOV lanes, for several reasons. First, precisely because they will be (1) uncongested and (2) networks, they will provide much greater time-saving (congestion-avoidance) benefits than today's mostly fragmentary HOV lanes. Second, they will be open to all motorists (except heavy trucks), not just to those who can arrange their lives so that they can carpool. Third, if implemented as we recommend, with strong participation by the Federal Transit Administration, they will bring about greatly increased use of such lanes by local transit agencies for express bus service. That will dramatically increase their overall person throughput compared with typical HOV lanes today.

A quantitative example will illustrate this point. Table 2 provides numbers illustrating the performance of what we might call typical HOV lanes in large metro areas. These are compared with an idealized high-performing HOV lane and our hypothetical HOT Network. First note the relatively good performance of the "typical" large-metro-area HOV-2 facility: 950 vehicles per hour but a person throughput of 2,275 per lane per hour (compared with perhaps 1,800-1,900 persons/lane/hour in a general-purpose lane). But note two other things about this typical case. First, there is still considerable unused vehicular capacity in this lane, of perhaps 750 vehicles/hour. This under-utilization—even for what are considered well-performing HOV lanes—is a source of political opposition to HOV lanes, and is a genuine waste of capacity. Second, note the low use of the lane by express buses. In most metro areas (except Houston), it has not been a high transit-agency priority to run express buses on these lanes.

The second case is a "typical" HOV lane whose requirement has been increased to three or more persons/vehicle. Because assembling three people to carpool together on a regular basis is difficult for most people, most HOV-3 lanes are greatly under-utilized. One of the handful of exceptions is the El Monte Busway on I-10 in Los Angeles County, the inspiration for the "ideal HOV-3" shown in the third column. Congestion is so bad in this corridor that a relatively large number of 3+ carpools can be maintained. But what really makes the difference in throughput in this case is the large number of express buses operated by Los Angeles County MTA and Foothill Transit using this facility.

The last column shows that nearly as great throughput can be achieved by the proposed HOT Network in high-demand corridors. With a comparable commitment of express bus service, the cost-sharing among carpoolers to split the toll, and active patronage by single-occupant vehicles, a full 1,700 vehicles/lane/hour can be accommodated, with passenger throughput 80 percent as high as the ideal HOV-3 case.

Table 2 : Comparative Throughput of HOV Lanes and HOT Network

	Typ. HOV-2	Typ. HOV-3	Ideal HOV-3	HOT Network
SOVs (avg.1.1 person/veh.)	0	0	0	1100
HOV-2s (avg. 2.1 person/veh.)	788	0	0	300
HOV-3s (avg. 3.2 person/veh.)	150	350	1200	200
Vanpool (avg. 7.0 person/veh.)	10	20	20	60
Express bus (avg. 35 persons/veh.)	2	3	40	40
Vehicles/hour	950	373	1260	1700
Persons/hour	2275	1365	5380	4300

At this point, the question may be asked: Wouldn't it be better to seek to replicate the ideal HOV-3 case rather than shifting to the HOT Network model? The first rejoinder is that the latter model brings with it the huge benefit of toll revenue, which can help pay for the costly build-out of the system into a seamless network. (Both the costs and revenues are estimated in Part 5.) Even if the ideal HOV-3 were better in principle, since it is unaffordable during the next two decades, when our metro areas are choked with traffic congestion, it is of more theoretical than practical interest. Furthermore, HOV-3s are becoming a rarity. According to *Commuting in America II*, "Carpooling in America is now, fundamentally, a two-person phenomenon."[23]

Another point in favor of the HOT model is that very few transit agencies have made good use of existing HOV lanes for bus service, and there is little sign of this changing. But if Congress were to embrace the HOT Network model as an important step forward for urban transit (as we suggest in Part 6), then the use of such networks for region-wide express bus service would be more than just a nice-sounding idea; it could well become the reality within a decade.

Another very practical advantage of the HOT Network as we have defined it is ease of enforceability. The first generation of HOT lanes in California, which lets carpools use the lanes at no charge (I-15) or at a reduced rate (91-Express) must combine electronic enforcement (transponders and video license-plate imaging) with visual inspection and deterrence by the highway patrol, as is done for HOV lanes. Enforcing one or the other is relatively straightforward, but enforcing both simultaneously is far more complicated. Patrol officers must distinguish between single-occupant vehicles legally in the restricted lanes (those with valid transponders) and those who are HOV violators. If the rules of the game are that only buses and vanpools go free—and that those vehicles, too, must have transponders—then enforcement can be almost entirely electronic, reducing both cost and operational problems (e.g., pulling over violators on what is supposed to be a high-speed express lane).

B. Acceptability of HOT Networks

The HOT Networks concept represents something of a departure from the past 20 years' focus on HOV lanes. HOT lanes themselves are still a relatively new idea, but those lanes still give special standing to carpools. Can this somewhat different approach to managed lanes gain enough acceptance to be implemented? We believe it can, for several reasons.

1. The public already supports HOT lanes

Commuters in the congested I-15 corridor in San Diego have had over four years to experience or observe a HOT lane in the peak direction on that route. The project's sponsor, SANDAG, and the California DOT (Caltrans) plan to expand this project, quintupling its size from two lanes and eight miles (16 lane-miles) to four lanes and 20 miles (80 lane-miles). As part of the planning process, they carried out a major public-opinion effort, including focus groups, stakeholder interviews, intercept surveys (at bus and carpool locations), and household telephone surveys. What they found was overwhelming support, both for the existing HOT lanes and for expanding the project as the best way of dealing with congestion in the corridor. Over 88 percent of current paying customers support the existing project, as do two-thirds of other I-15 users. And majorities nearly that large support the proposed expansion.[24] This support extends, with only minor variations, across all income levels, ethnic groups, and age groups.

Strong user support has also been measured for the 91 Express Lanes.[25] In its early years, when the new capacity provided by that project led to reduced congestion in the adjacent general-purpose lanes, support among paying customers exceeded 80 percent, and general-purpose lane user support was nearly 70 percent. By 1999, after congestion had returned to the general-purpose lanes, support among non-customers in the corridor declined to 49 percent, but 72 percent of paying customers continued to express strong support.

These examples suggest that commuters understand and appreciate having the option of shifting from congested lanes to express lanes for those trips when their value of time is especially high. This support is often seen in stated-preference surveys about hypothetical HOT or express-toll lanes, generally in the 55-60 percent range.[26] But the acid test is not what people say they might do when presented with a hypothetical, but what they actually do when that possibility becomes a reality. By that standard, the two California HOT lanes have demonstrated strong public support.

2. HOT Networks will provide a significant increase in high-quality transit service at modest cost.

Part 2 summarized GAO and FTA findings that Bus Rapid Transit on uncongested guideways can provide transit service of a quality comparable to that of light rail. And BRT is inherently less costly than light rail, according to these studies.[27] The beauty of the HOT Networks approach is that the uncongested guideway can be provided at little or no cost to the transit agency, because paying auto customers will provide the toll revenue stream needed to pay off the revenue bonds for building the network. Instead of devoting hundreds of millions of dollars to exclusive light-rail infrastructure, the transit agency can spend capital funds on a much larger fleet of express buses and related facilities. Furthermore, since the HOT Network will be built along existing freeway right of way, major controversies over land acquisition for rail right of way can be avoided. And large-scale capital investment in the HOT Network can be carried out over the span of a decade or so, rather than the 20 to 30 years needed to build out either HOV systems or rail systems under conventional, fiscally constrained long-range transportation plans. Thus, HOT Networks promise significantly more transit, much sooner, for far less transit capital expenditure.

3. Equity perceptions are not justified; nearly everyone stands to gain from HOT Networks.

To many people, a troubling aspect of HOT lanes or HOT Networks is the idea that they are elitist (Lexus Lanes is a common epithet). Careful thought, as well as data from the California HOT lanes, presents a rather different picture.

First, consider that all people—not just those at upper income levels—may place a higher value on their travel time under some circumstances than others. For example, a single mother with a child in day care may consider it worth paying a $4 toll on a day she is running late after work, to avoid paying a $10 late fee. A plumber trying to get in one last appointment on a busy day may be quite happy to pay a toll to bypass congestion so as to get there in time to do the work. A family running late to catch a plane may also prefer to pay the toll rather than risk missing their flight. To presume that only the wealthy could value their time enough to pay to use a HOT Network is disrespectful of individuals' ability to make such tradeoffs for themselves. The denial of choice in transportation is discriminatory and regressive with respect to lower-income people. Those with the lowest income are the most severely harmed when they are denied such choice. The consequences of late fees or lost work are more severe for those with the lowest income.

Second, from the standpoint of social policy, consider the alternative to paying for large-scale HOV expansions via tolls. Such projects today are paid for primarily via gasoline taxes, and to an increasing degree (especially in California) by special sales taxes devoted to transportation. Both, especially the latter, are regressive taxes. By contrast, market-based tolls are a prime example of user pays. Only those who value time savings highly will voluntarily choose to pay this price. And yet in the HOT Network context, it is these people who will disproportionately be paying for the extensive new guideway for Bus Rapid Transit. To the extent that higher-income people make greater use of HOT Networks than lower-income people, this is a win-win public policy solution. In what other area of public infrastructure do we find a small fraction of the population willingly paying extra to provide a greatly improved public service?

Third, let's look at the actual data from the California HOT lanes. Evaluations of usage patterns on both the I-15 and 91 Express Lanes do show that propensity to use the lanes is roughly proportional to income quartile.[28] But the university-based evaluators in both cases noted that significant numbers of paying customers were found in every income quartile, supporting the first point noted above. Moreover, survey research data in both cases finds strong support for the idea that being able to choose, voluntarily, to pay more to bypass congestion when you decide it's worth it, is "fair." In the San Diego case, 78 percent of the lowest-income commuters in the corridor agree that "SOV drivers should be allowed to use the Managed Lanes for a fee," and 82 percent of this group favor the proposed extension of the I-15 lanes.[29]

Finally, it should be noted that while not all HOT *lanes* ensure bus service as part of the package, the HOT *Networks* concept features express bus (BRT) service as an integral part. Thus, the concern about those who cannot afford to pay the market-priced toll is misplaced. In the first place, they will still have just as many general-purpose lanes to use as before, since our proposal takes away none of these lanes. But more important, they will gain a whole new option in most metro areas—BRT on a high-speed, uncongested managed lane.

4. HOT Networks are the only urban transportation improvement that can be largely self-supporting.

While the cost and revenue estimates that we develop in Part 5 are very preliminary, we believe our calculations have been made conservatively; they are certainly in the right ballpark. And those calculations suggest that HOT Networks can be self-supporting to a significant degree. We know of no other large-scale planned or proposed urban transportation improvement that can make this claim. At a time when every reputable study suggests that the need for transportation capital investment greatly exceeds existing, traditional sources of funding, this is certainly good news. It means that America's largest and most congested metro areas have a new option available that offers both meaningful congestion relief and significantly improved transit service—and without the need for major new tax revenues. The funding will be largely volunteered by a subset of auto users, willing to pay for a higher quality of transportation than is now available to them.

But the financial viability of the HOT Networks approach depends critically on a majority of the vehicles being paying customers. Of the two successful HOT lanes in California, the I-15 is able to focus primarily on HOVs because it did not have to pay for its construction costs out of toll revenues. The grade-separated lanes were built using conventional fuel-tax funds and only later converted to HOT operation. Thus, they can afford to have 75 percent HOV users and 25 percent paying customers. By contrast, the 91 Express Lanes had to be built from scratch using toll revenues. In order to cover those costs, it's no surprise that the operating policy charges regular tolls to HOV-2s and half-price tolls to HOV-3s. And only 13 percent of its vehicles are HOV-3s.

These two contrasting cases illustrate the choice facing transportation policymakers. If we want to implement seamless networks of premium lanes on our major urban freeway systems--not "maybe someday, somehow" but realistically, within the current transportation improvement plan—billions of dollars in new transportation revenues must be found and dedicated to this purpose. The HOT Networks approach is the only way we can imagine of actually achieving that result.

Part 4

Applying HOT Networks

In this section we illustrate the application of the HOT Networks concept in a number of America's most congested urban areas. For this purpose, we have relied on the rank-ordering presented previously in Table 1 of the 10 most-congested metro areas as measured by TTI, using annual person-hours of delay per peak traveler as our metric. For this exercise, we have elected to omit the New York/Northeastern New Jersey metro area, because its greater population density and very high transit usage make it unique among U.S. urban areas. We have also chosen to combine the two urbanized areas in the San Francisco Bay Area (San Francisco/Oakland and San Jose) into one, since its freeway system is better thought of as a single, integrated system. Thus, we will apply the HOT Networks concept to the following eight metro areas: Los Angeles, San Francisco, Washington, Seattle, Houston, Dallas/Fort Worth, Atlanta, and Miami.

In each case, we describe the current extent of freeway HOV lanes and HOV-HOV connectors at freeway interchanges, and planned additions to the HOV system, whether funded or unfunded. Where possible, we also identify any other additions needed to link these components together into a seamless network over the principal freeways in the system. After sketching out the proposed HOT Network in Part 4, we will use this definition of each system to estimate its capital costs and revenue potential in Part 5.

A. Miami

Miami-Dade County has only one HOV facility in service, approximately 10 miles of concurrent-flow (one lane each direction) striped-off HOV lanes on I-95, the area's busiest north-south artery. FDOT has a feasibility study under way on the possible conversion of these lanes to HOT lanes, including their extension southward to I-395.

Planned or potential HOV/HOT lane projects include the HOV lanes on the Palmetto Expressway (SR 826) planned by the Florida DOT. The Miami-Dade Expressway Authority has in its Five Year Work Program the planning and design of express toll lanes for its Don Shula Expressway (SR 874) and Dolphin Expressway (SR 836). These new lanes are being planned to include BRT service that will link the western part of the metro area with Miami International Airport. These lanes will connect with the proposed HOT or tolled express lanes on the Homestead Extension of Florida's Turnpike (SR 821) and a possible new north-south, all-electronic tollroad—the Central Parkway from SR 112 to SR 924. With the addition of some connector links, especially at key interchanges, Miami-Dade could have a seamless HOT Network depicted in Figure 2.

Figure 2: Miami HOT Network

B. Atlanta

The Atlanta metro area currently has 128 lane-miles of HOV facilities including sections of I-20, I-75, I-85, and the I-75/I-85 central section. The approved 2025 Regional Transportation Plan (RTP) for the Atlanta Metro Area includes approximately 262 miles of additional HOV lanes and 55 HOV ramps and connectors, adding additional HOV lanes on I-20, I-285, I-575, I-75, I-85, SR 316, SR 400, and U.S. 78. The development of the HOV system is currently the subject of a major study by the Parsons Transportation Group. Total cost at build-out is estimated at $3.4 billion. To this we have added 96 lane-miles worth ofmissing links, indicated by the dotted lines. As depicted in Figure 3, these additions would produce a reasonably complete HOT Network for the greater Atlanta area.

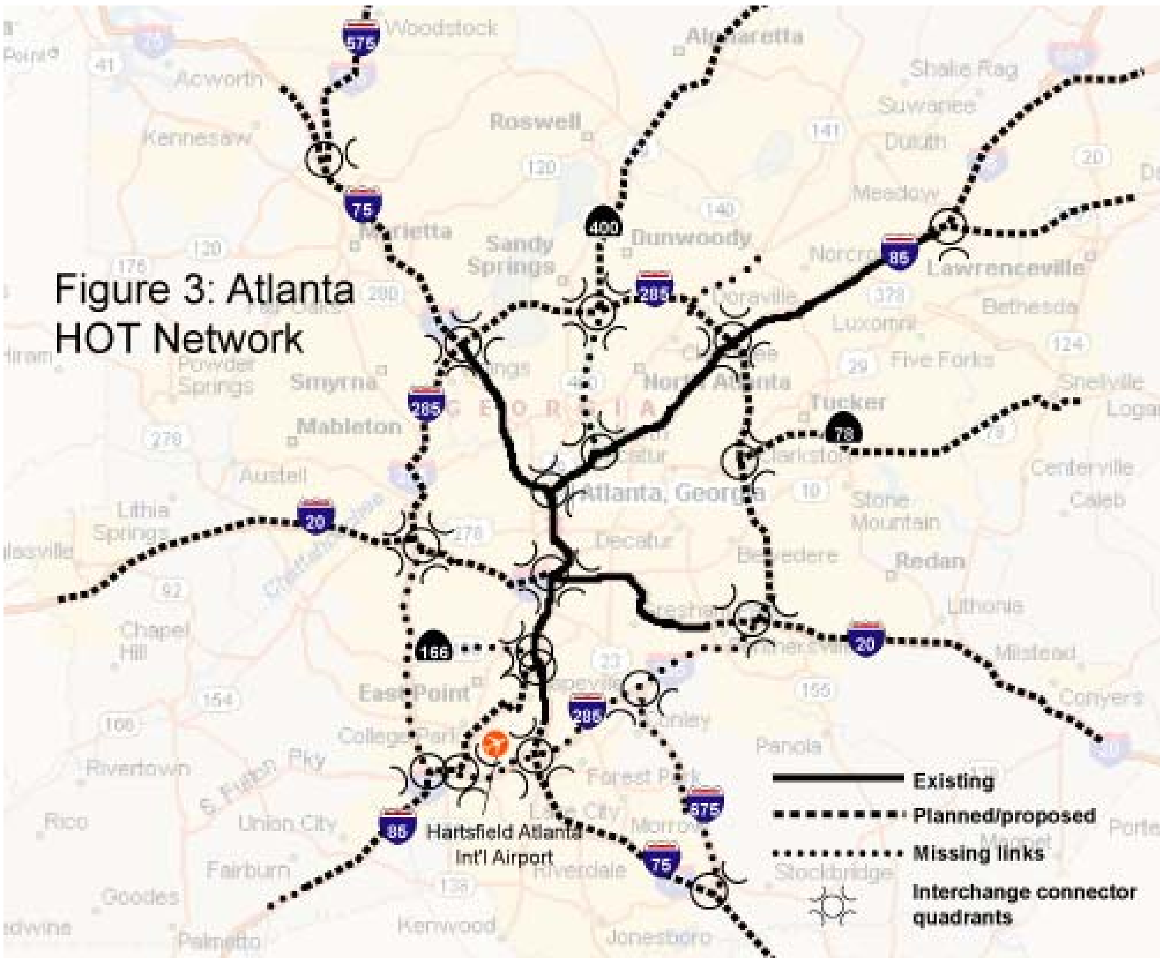


Figure 3: Atlanta HOT Network

C. Dallas/Fort Worth

The current extent of Dallas HOV facilities totals just under 80 lane-miles. It includes the Southwest Texas Medical Center Busway, plus HOV lanes on the Love Freeway (I-35E and US 67), Stemmons Fwy (I-35E), LBJ Freeway (I-635) and I-30. The Dallas Metropolitan Transportation Plan, *Mobility 2025*, outlines a major expansion of HOV facilities for the Metroplex. The Plan identifies 397 lane-miles of new HOV lanes. Many of these HOV facilities are reversible. In several corridors, such as Interstate 635 (LBJ) and Interstate 35E (Stemmons), traffic flow is sufficiently strong in both directions to warrant two-way HOV lanes. In addition to dedicated HOV lanes, the Plan also identifies future corridors likely to be built as toll roads where HOV lanes are also needed. In these corridors, the plan calls for HOV users to travel on the toll roads free or at discounted rates. *Mobility 2025* also recommends multi-lane peak-HOV lanes with off-peak express service. These facilities will be reversible in most corridors and designed to serve as express lanes for all traffic in the off-peak travel periods. The Plan includes recommendations from the recently completed I-635 (LBJ

Freeway) Major Investment Study, which calls for a combination of HOV, toll, and express lanes in the corridor. Other detailed HOV recommendations are pending on-going and future major investment studies.

For purposes of this study, we have added missing links on US 75 and US 45 and on I-30, as well as a number of interchange connectors. The resulting HOT Network is shown in Figure 4.

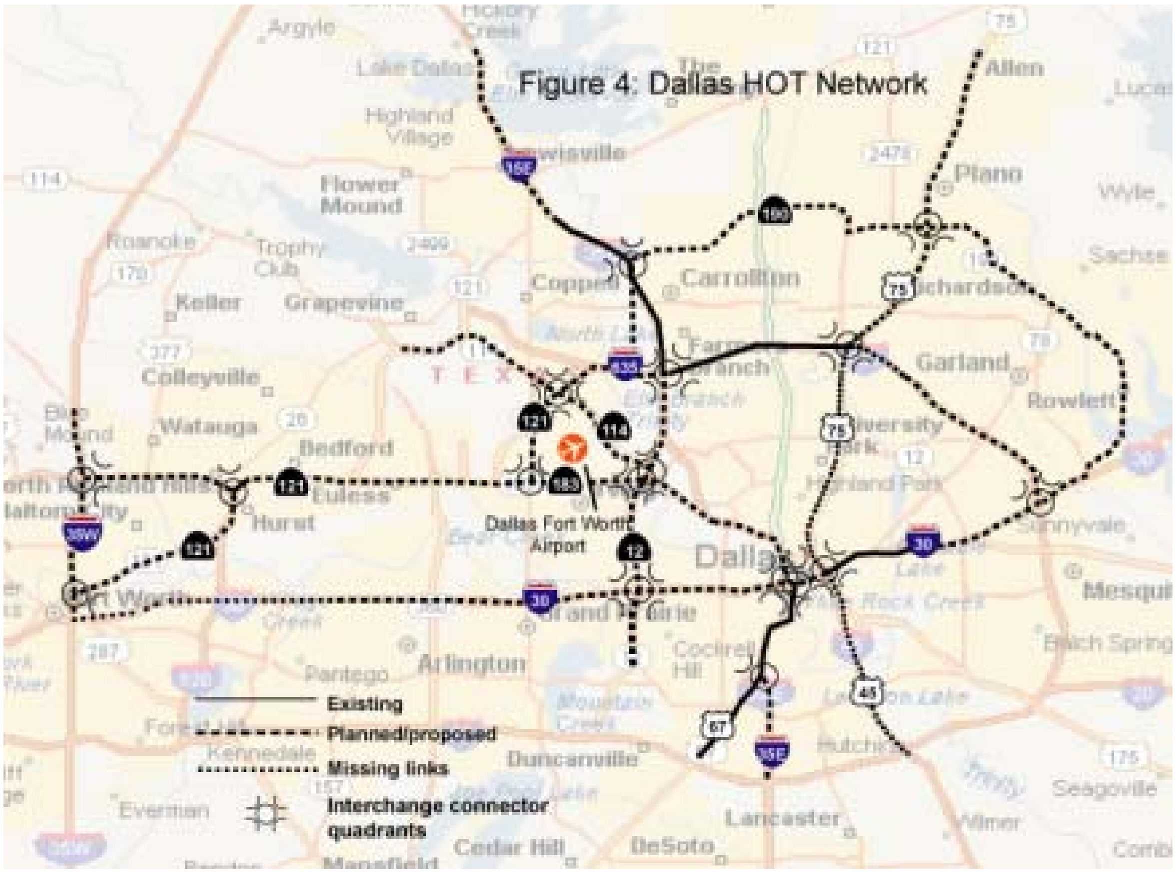


Figure 4: Dallas HOT Network

D. Houston

Houston's current HOV facilities comprise 133 lane-miles of barrier-separated HOV lanes. Major facilities are on the Katy Freeway (I-10), Gulf Freeway (I-45), Northwest Freeway (US 290), North Freeway (I-45), and the Eastex/Southwest Freeways (US 59). The 2022 Metropolitan Transportation Plan/2002 Regional Mobility Update for the Houston metro area calls for an expansion of this system by 226 lane-miles, to 359 lane-miles. Major additions include extensions to the I-45, US 59 and US 290 HOV lanes and gap closures and extension on US 59. To this we have added missing links on the I-610 loop, the Katy (I-10) through downtown, and US 59 and I-45 through downtown. The downtown additions would be elevated. The resulting network is depicted in Figure 5.

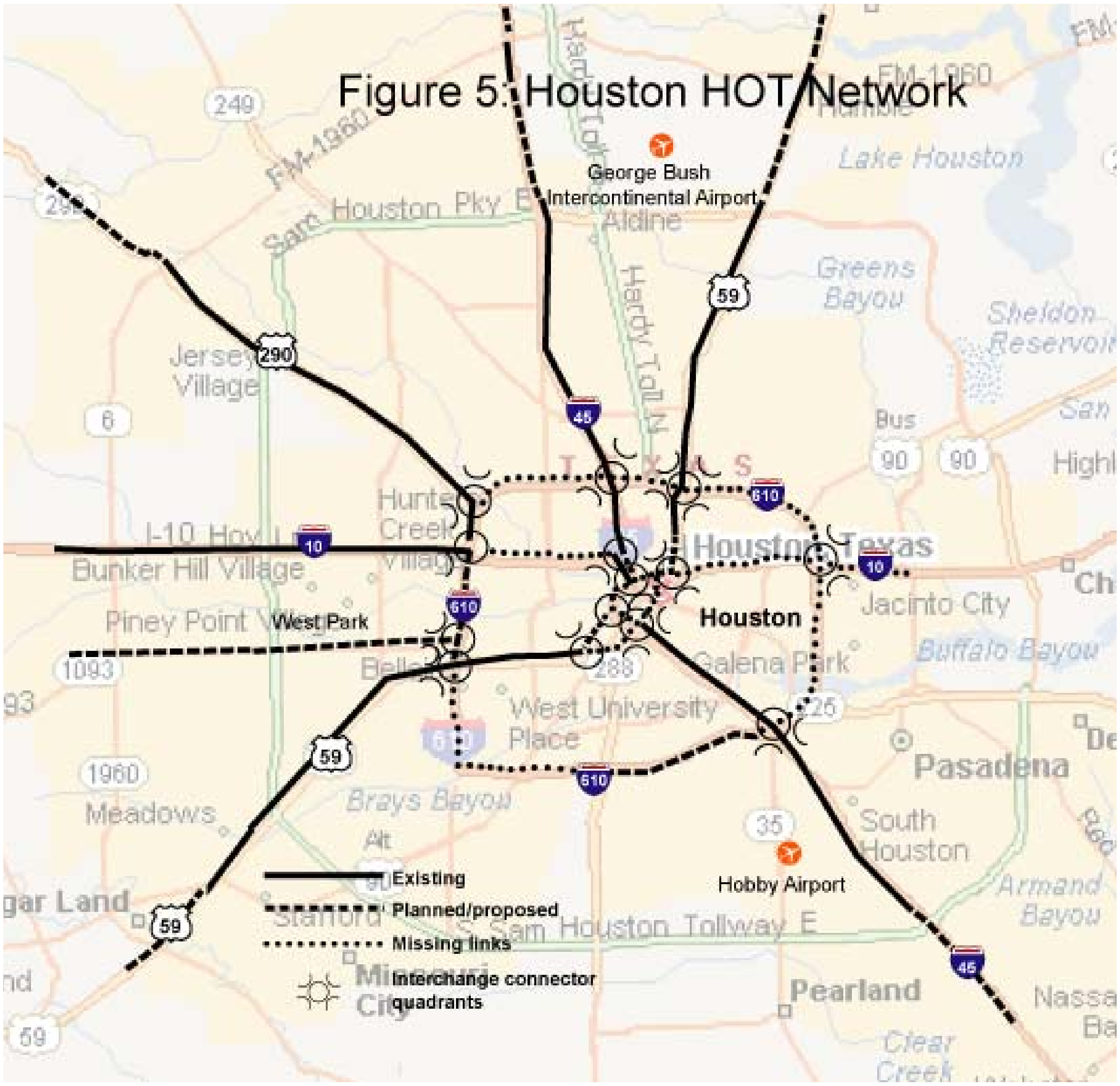


Figure 5: Houston HOT Network

E. Seattle

The Puget Sound region has an extensive core HOV system in place, with some 205 lane-miles on the region's most congested freeways including I-5, I-405, I-90, and SR 520 and SR 167.

Destination 2030 is the region's long-range transportation plan. It calls for adding additional HOV capacity to bring the total lane-miles to 329 by 2010 and to 505 by 2030. Included would be important missing links, including the SR 520 bridge, and major extensions into the Tacoma area to the south and Everett on the north. We have added a few more missing links and interchange connectors. For the additional lanes to be added to I-405, we have assumed costs equivalent to adding these lanes as elevated rather than at-grade. The resulting system is depicted in Figure 6.

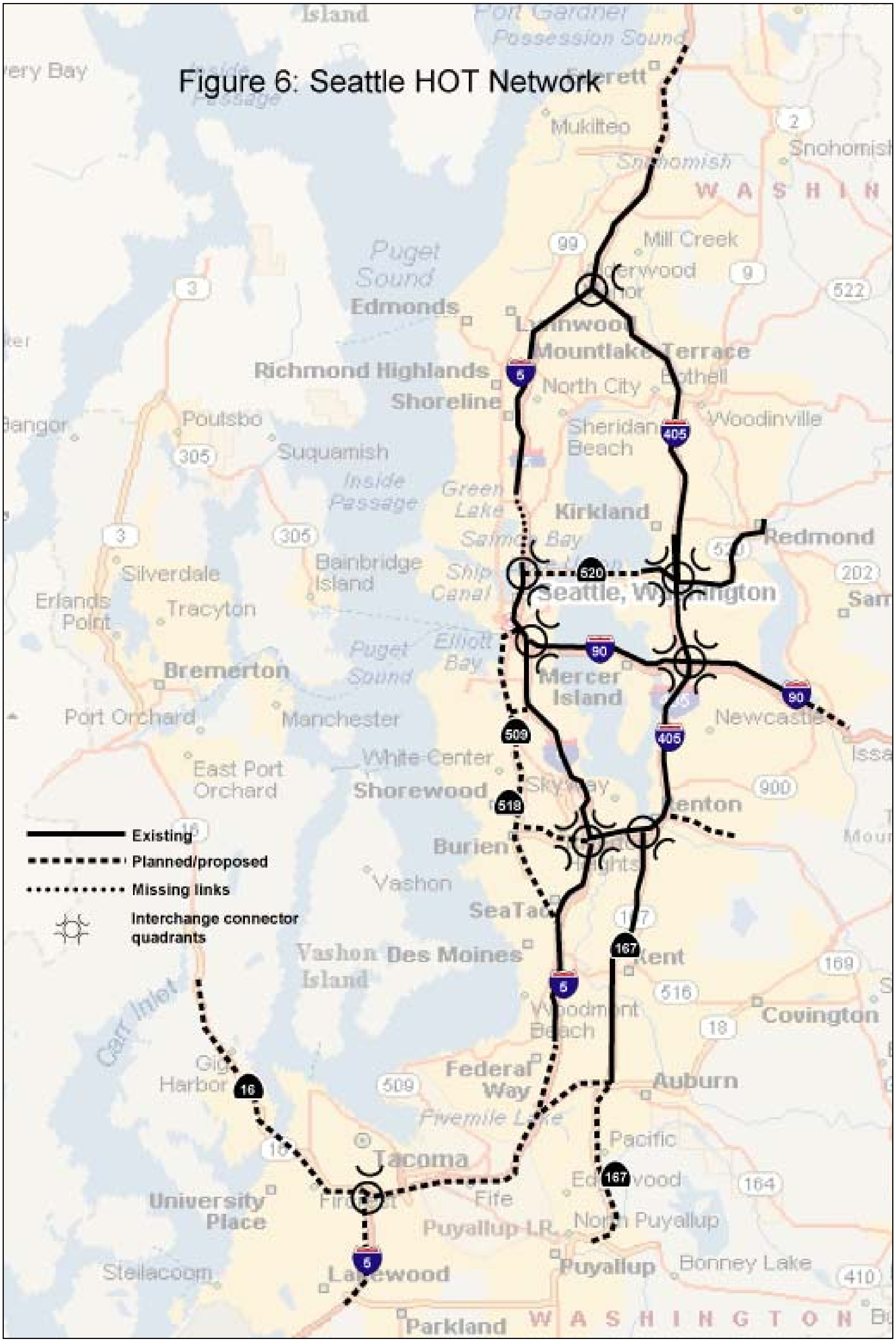


Figure 6: Seattle HOT Network
Existing
Planned/proposed
Missing links
Interchange connector quadrants

F. Washington, DC

The Washington metropolitan area's current HOV facilities comprise a total of 170 lane-miles, 134 of which are in Northern Virginia and 36 miles in Maryland. The HOV lanes are in four radial commuter corridors. They include Northern Virginia's I-95, I-66, and the Dulles Toll Road, plus Montgomery County's I-270 and U.S. 50. The I-95 HOV facility is one of the oldest in the nation, having originally been built as a busway in the late 1960s.

The current Constrained Long Range Plan for the Washington metropolitan region includes 66 additional HOV lane-miles in Northern Virginia and 40 more lane-miles in Maryland. Major projects in Northern Virginia include widening the existing I-95 HOV lanes (27 miles) from 2 to 3 lanes, extensions to the I-95 and I-66 lanes and HOV lanes on the Beltway (I-495), from I-95 to the American Legion Bridge (which is the Virginia-Maryland boundary). In Maryland, major HOV projects include HOV lanes on MD 210. We have added additional lane-miles to fill in missing links in this system, which includes HOT lanes on the entire Beltway (two each way) and on I-95 all the way to Columbia, MD.

The proposed HOT lanes on the Beltway have been the subject of a recent proposal by Fluor Daniel, one of the world's largest engineering and construction companies. The company has proposed to widen the Beltway between the Springfield Interchange (I-95) and the American Legion Bridge with four HOT lanes, two in each direction. The project would be financed primarily with bonds underwritten by HOT lane revenue. Local and state officials reacted "cautiously" according to press reports.

Figure 7 depicts the potential HOT Network for the Washington, DC metro area.

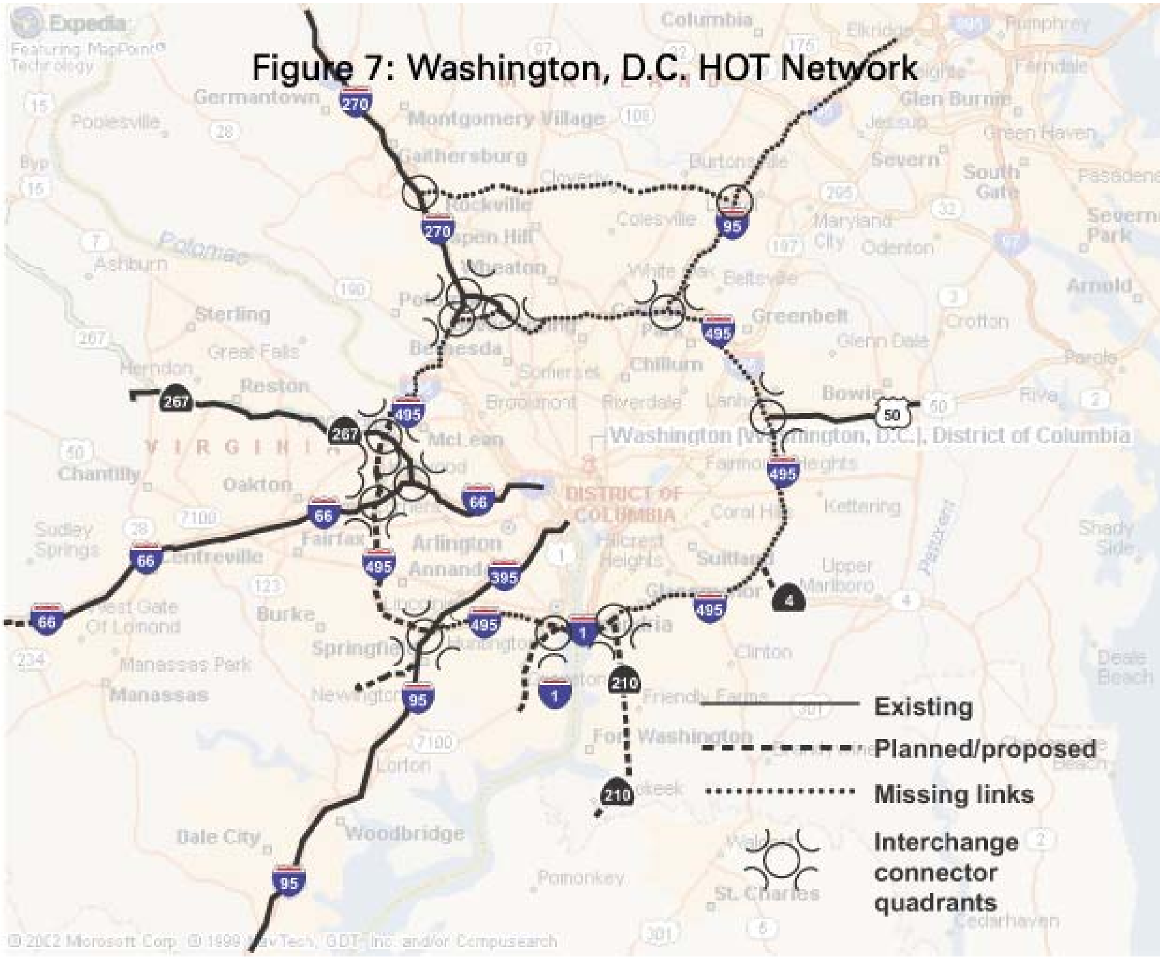


Figure 7: Washington, D.C. HOT Network

G. San Francisco Bay Area

The San Francisco Bay Area has 285 freeway lane-miles of HOV facilities in service at present (plus another 50 lane-miles of expressway HOV lanes in Santa Clara County, which are not included in our calculations). The 2001 Regional Transportation Plan calls for adding 140 more lane-miles, and the 2003 Transportation Improvement Plan adds another 100 lane-miles of HOV.

This set of plans still leaves some key links without HOV facilities. We have filled these in, including 58 lane-miles of elevated capacity in such inner corridors as US 101 in San Mateo County and I-880 in Oakland. Because several major bridges (Golden Gate, San Francisco-Oakland Bay Bridge, San Mateo Bridge, etc.) constitute critical links in the freeway system and the proposed BRT network, we have also designated 47.4 lane-miles of existing bridge lanes as part of the HOT Network. Figure 8 depicts the completed network. That system would total 630 lane-miles.

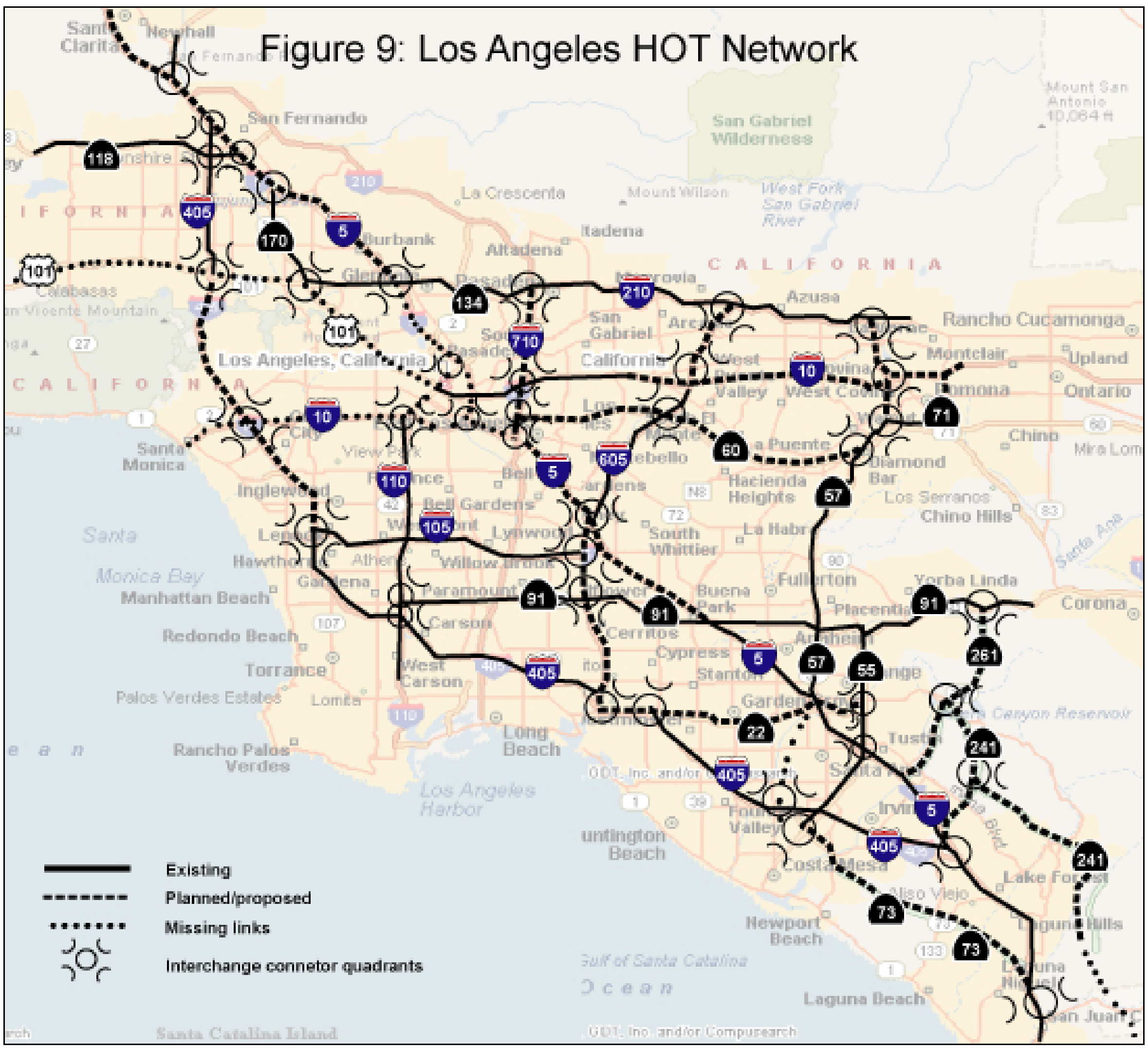
The Bay Area's Metropolitan Transportation Commission is committed to making use of the expanded HOV network for BRT service. The $177 million initial implementation phase of the BRT system focuses on East Bay rapid bus connections to BART in the I-580 and SR 4 corridors. The initial BRT phase also includes North and East Bay routes using US 101 in Sonoma and Marin Counties, I-680 from the Benicia Bridge in the north to San Jose in the south, I-80 from Solano County to the East Bay and San Francisco, I-880 from

San Leandro to San Jose, area-wide services in Santa Clara County along its freeway network, the I-280 corridor in San Mateo, and upgraded express services across most of the region's bridges. Needless to say, the much larger HOT Network proposed in Figure 8 would facilitate a much larger and more comprehensive BRT service than currently planned.

Figure 8: San Francisco Bay Area HOT Network

H. Greater Los Angeles

With the greatest amount and intensity of traffic congestion, as measured by TTI, Los Angeles (defined as Los Angeles and Orange Counties) also has the most extensive set of HOV facilities in the nation. The existing set of HOV facilities suggests the beginnings of a real network, especially in the Orange County portion of the region. The current long-range transportation plan's constrained version would fill in a small portion of the system's missing links, focusing primarily on the addition of interchange connectors in Orange County. The unconstrained LRTP adds many more missing links and connectors, but even that plan still leaves a number of freeways without HOV lanes and over a dozen connectors unbuilt. Figure 9 includes all planned (constrained plus unconstrained) additions, as well as the additional links needed to complete the system as a seamless network on all but a few outlying freeways. The completed system would include 1,009 lane-miles and 93 interchange connector quadrants.



Part 5

Costs and Revenues for Proposed HOT Networks

A. HOT Network Capital Costs

What would a complete HOT Network cost? In this section we make order-of-magnitude estimates of the additional capital cost of building out the existing HOV facilities into the complete network shown for each of the eight metro areas in Part 4. Our cost model contains four elements:

- New lanes added, at grade;
- New lanes added, elevated;
- New HOV-HOV connectors at interchanges;
- Conversion of entire system from HOV to HOT.

We first derive generic cost figures for each of these. Please note that we have not attempted to estimate capital costs for BRT components such as express buses or stations. The cost figures below are solely for the HOT Network guideway.

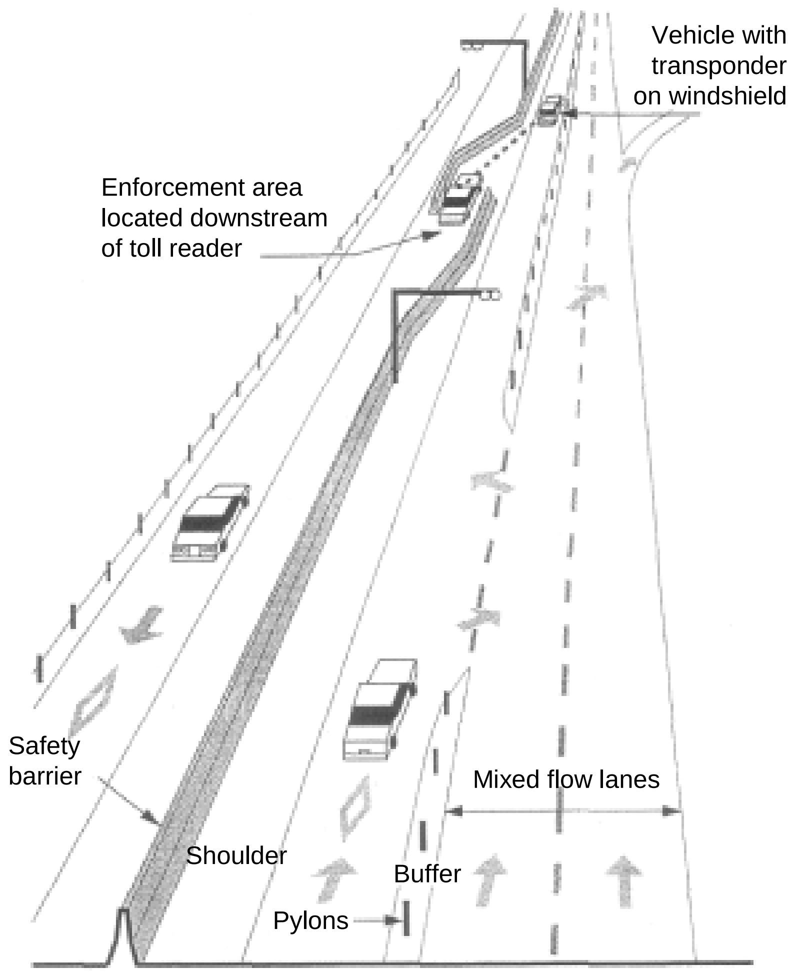
1. New, At-grade HOV/HOT Lanes

Generally, MPOs and state DOTs have tended to build the easier HOV projects first. When resources are scarce (as they generally are), an agency can have a greater sense of accomplishment if it can get a number of facilities up and running, rather than waiting many years to accumulate enough funds and overcome whatever obstacles there may be for more costly and difficult projects. For this reason, we were advised by several experts to ignore historic HOV lane costs, which have often been in the vicinity of $2-3 million per lane-mile. Three highway transportation experts we consulted—at a federal agency, a nonprofit research institute, and a major engineering/consulting firm—provided going-forward estimates of $10 million, $7.5 million, and $10 million per lane-mile, respectively. (These figures include the cost of right of way acquisition.) From the long-range transportation plans of the eight metro areas, enough projects carried cost estimates that it was possible to derive average costs per lane-mile for HOV projects planned for near-term implementation. These metro-area averages ranged from a low of $2.1 million (Houston) to a high of $10.1 million (Washington, DC). Averaging all 10 of these figures (three expert and seven metro area), our overall average for new, at-grade HOV projects was $7.37 million per lane-mile, which we rounded off to $7.4

million. It should be remembered that the costs of individual projects may vary considerably, both above and below this average.

A typical at-grade stretch of a HOT Network is shown in Figure 10, taken from a Parsons Brinckerhoff feasibility study of adding HOT lanes to US 101 in Sonoma County, California.

Figure 10: Typical AT-Grade HOT Network Lanes



Source: Parsons Brinckerhoff, 1998.

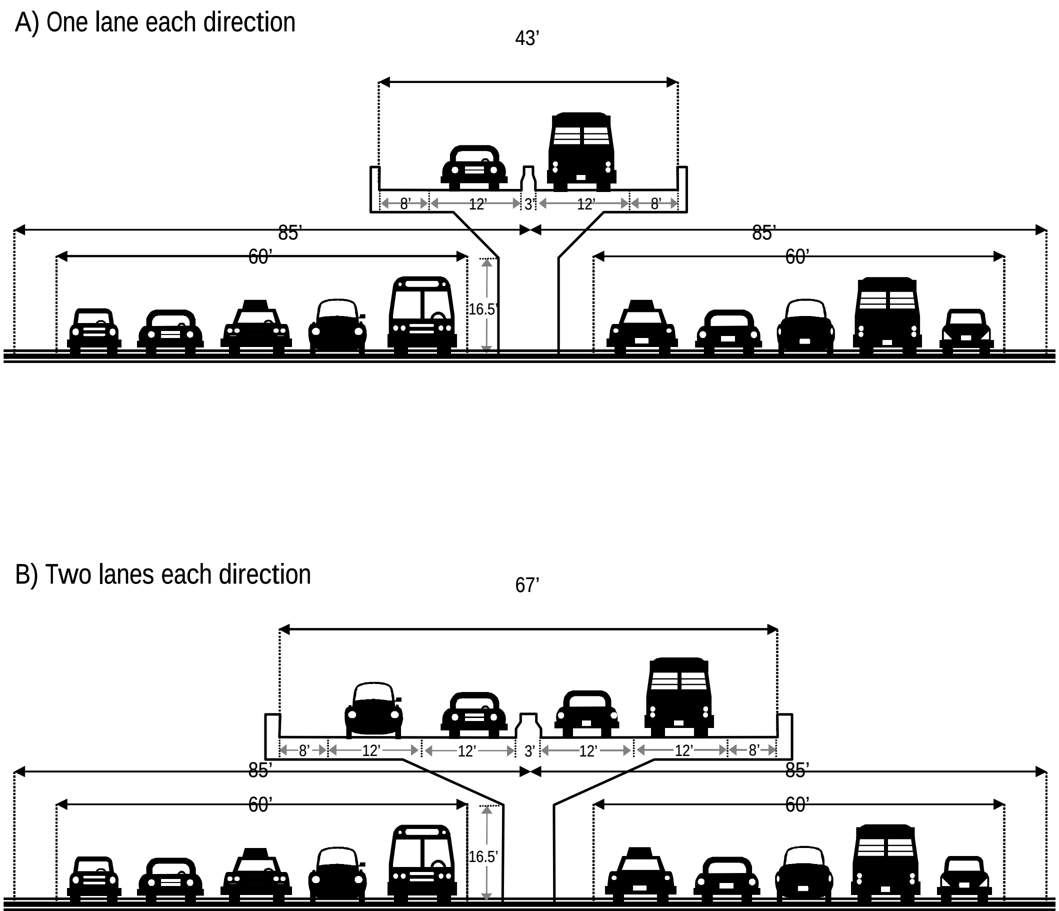
2. New, Elevated (or Tunneled) HOV/HOT Lanes

In some corridors, there is simply no room to add additional lanes, without condemning significant high-value land alongside the existing right of way. In some of cases, the more viable alternative is to build elevated (or tunneled) HOV lanes above (or below) the median, with limited ingress and egress, consistent with the usual HOV design concept. One example of such lanes is the Harbor Transitway in Los Angeles, added to the Harbor Freeway (I-110) during the 1990s.

Only very limited examples of actual or proposed elevated lanes were available. From these cases, we estimate a cost of $25 million per lane-mile. That would make an elevated two-lane project (one lane per direction) $50 million per mile, while an elevated four-lane project would be $100 million per mile.

These two variants of elevated HOT network structures are illustrated in Figure 11.

Figure 11: Typical Elevated HOT Network Sections



3. Interchange Connectors

HOT-to-HOT interchange connectors are commonly referred to as "flyovers." They are elevated ramps that make connections from the HOT lanes of one freeway to those of another. Depending on the configuration of the interchange and the directionality of traffic flow, anywhere from one quadrant (e.g., North to East and East to North) to all four quadrants may be required. Our data from the eight metro areas showed a considerable range of estimated costs, ranging from a low of $14.6 million for one quadrant to as much as $164 million for four quadrants. We settled on $40 million per quadrant as a conservative figure for planning purposes.

4. HOV to HOT Conversion

Only a handful of HOV lanes have been converted to HOT lanes, but the cost elements are fairly straightforward. The difference between the two is primarily in signage and electronic toll collection equipment. Assuming (as we do) the use of variable pricing, the HOT lane will require changeable message signs to inform potential users of the price in effect at the point of use (or rather, at each decision point about use). It will also require overhead gantries with radio-frequency transceivers and video-enforcement equipment, as well as computers and fiber-optic lines linking the various elements together. For estimating purposes, we draw on a feasibility study of converting a conventional 25-mile (50 lane-mile) continuous HOV lane in Sonoma County, California into a HOT lane.[30] The added cost of doing this project as HOT instead of HOV was in the $5-7 million range. Using $6 million and dividing by 50 lane-miles gives us $.12 million per lane-mile. It should be noted that this estimate assumes the use of plastic pylon lane-separation treatment (as in Figure 10), rather than a concrete Jersey barrier. It is also not strictly accurate to estimate HOV-HOT conversion costs on a per-mile basis, because there are significant fixed costs, such as the computer systems and other back-office costs. However, for the large HOT lane networks we are talking about here, a per-mile figure derived from a small system should be conservative.

5. Estimated System Costs

Table 3 pulls all of these cost elements together for our eight metro areas. In each case, we use the totals from the analysis underlying Figures 2 through 9 for existing, new at-grade, and new elevated lane-miles, plus the number of connector quadrants involved. Using the average cost factors discussed above, we then calculate the cost of each proposed HOT Network. As can be seen, these costs range from a low of $1.9 billion in Dallas/Ft. Worth to $8.9 billion in Los Angeles. While these numbers are large, they are in the same size range as actual or proposed rail transit projects in these and other metro areas. The difference from those projects is that HOT Networks can generate significantly more revenues.

Table 3: Estimated Capital Costs of Proposed HOT Networks

	Miami	Atlanta	Dallas/Ft. Worth	Houston	Seattle	Washington	San Francisco	Los Angeles
Existing Lane-Miles	20	128	80	133	205	170	332	624
New Lane-Miles, At-Grade	183	358	416	307	231	230	240	154
New Lane-Miles, Elevated	34	--	4	7	69	210	58	231
Total Lane-Miles	237	486	500	447	505	610	630	1009
New Connector Quadrants	11	55	40	27	19	26	32	93
HOV-HOT Conversion	$28	$58	$60	$54	$61	$73	$76	$121
At-Grade Construction	$1,354	$2,649	$3,078	$2,272	$1,709	$1,702	$1,776	$1,140
Elevated Construction	$850	$0	$100	$175	$1,725	$5,250	$1,450	$5,775
Connector Construction	$440	$2,200	$1,600	$1,080	$760	$1,040	$1,280	$3,720
Total Cost	$2,673	$4,908	$4,838	$3,580	$4,255	$8,065	$4,582	$10,756

B. HOT Network Revenues

Estimating the revenues from a HOT Network is challenging. In conventional toll traffic and revenue studies, the problem to be addressed is how much traffic can be attracted to the facility, given that it will be charging a toll. By contrast, in the highly congested freeway systems of interest here, there appears to be a very large unrealized demand for time savings. In the eight metro areas we are concerned with, TTI estimates the value of lost time and wasted fuel to be $30.7 billion per year. While not every rush-hour driver will be willing to pay a large toll to avoid congestion, a fraction will be.

On the 91 Express Lanes at the busiest peak times (eastbound on Friday afternoons), the two peak-direction HOT lanes attract more than 40 percent of the vehicles, despite having only 33 percent of the lane capacity (two out of six total peak-direction lanes).[31] And those paying customers are able to travel at 65 mph, while the adjacent lanes are operating under typical stop-and-go conditions. The HOT lanes operate under free-flow conditions, handling 1,700 to 1,800 vehicles per lane per hour.

Thus, we will assume that the problem for our proposed HOT Networks is to set the toll high enough that it will limit peak-hour usage to no more than 1,700 vehicles/lane/hour.[32] And because we want to ensure ample capacity for express buses and other super-HOV vehicles, we will assume a maximum of 1,600 paying vehicles/lane/hour in the peak direction during peak hours. On average, we will also assume that tolls in the non-peak direction will be low enough to attract 1,100 vehicles/lane/hour in the non-peak direction during peak hours. Thus, our average (both-direction) peak-period volume of paying customers is 1,350 vehicles/lane/hour.

The next question is what peak-hour/peak-direction toll can be charged. In a recent *Transportation Quarterly* paper, the head of the Value Pricing Pilot Program at FHWA modeled the addition of HOT lanes to a congested freeway, using peak-hour tolls of 49 cents per mile.[33] This number is at the upper end of our limited experience with HOT lanes. The highest current rate on the 91 Express Lanes (peak-hour, peak-direction) is $4.75 for this 10-mile facility (47.5 cents/mi.), while the maximum peak-hour, peak-direction toll on the I-15 HOT lanes is 50 cents/mile (but the average is 33 cents/mi.[34]).

For purposes of revenue estimation, however, we must take into account not the highest (variable) rate charged during peak hours, but the average across all the hours defined as peak hours. And as noted above, we must also take into account that most urban freeways are at least somewhat “tidal” in nature, with much heavier traffic in one direction than the other during morning and afternoon rush hours. On 91 Express, the non-peak-direction toll during peak hours tends to be about half the peak-direction toll during those hours. Our analysis of 91 Express’s toll schedule indicates that the average peak-hour, peak-direction toll is about 40 cents/mi. A recent study of proposed HOT lanes on Miami’s SR 836 East-West Expressway proposed peak-period, peak-direction tolls averaging 35.2 cents/mile.[35]

It is reasonable to expect that willingness to pay a HOT-lane toll to avoid congestion would vary in proportion to the intensity of that congestion. We have used TTI’s measure of delay-hours per commuter as our measure of congestion intensity. We have actual or proposed average peak-period, peak-direction tolls for HOT lanes in three metro areas: Los Angeles (Orange County), San Diego, and Miami. If we use those as markers for the upper and lower ends of the range of peak tolls for our eight metro areas, we can fill in intermediate values for the remaining metro areas, proportional to the intensity of congestion, as is done in Table 4. Note that we have also assumed, conservatively, that the average toll charged during peak hours in the non-peak direction is 50 percent of the rate charged in the peak direction in the two most congested cities, 40 percent as high in the next two cities, and 30 percent as high in the remaining cities. Since some of the freeways in our eight metro areas are congested in both directions during peak hours, our assumptions will tend to understate actual revenue.

Table 4: Proposed HOT Lane Peak-Period Tolls

Metro Area	Annual Delay-hours per Commuter	Number of Peak Hours per Weekday	Peak Direction Peak Toll per Mile	Non-Peak Direction Peak Toll per Mile	Average Peak Period Toll per Mile
Los Angeles	136	7	$.40	$.20	$.30
San Francisco	92	6	$.38	$.19	$.285
Washington	84	6	$.37	$.148	$.259
Seattle	82	6	$.37	$.148	$.259
Houston	75	5	$.36	$.11	$.235
Dallas	74	5	$.36	$.11	$.235
San Jose	74	5	$.36	$.11	$.235
Atlanta	70	5	$.35	$.10	$.225
Miami	69	5	$.35	$.10	$.225
San Diego	51	5	$.33	$.10	$.215

Using the number of peak hours per weekday, the average peak period toll that applies across those hours, and the number of lane-miles in the HOT Network, we can compute the revenues generated during peak hours on weekdays for each of the HOT Networks. This is done in Table 5. Multiplying by 250 weekdays per year gives us annual revenue from peak operations. Like 91 Express, our proposed HOT Networks would also operate at non-peak times, charging much lower rates but offering a perceived higher quality of service for longer-distance trips. The 91 Express lanes generate between 20 and 25 percent of their revenue from non-peak period trips, on weekdays plus weekends and holidays.[36] Using 22.5 percent for non-peak revenue, we can then derive the total annual revenue for each network.

The revenue number for each system is the *baseline* annual revenue. This is the annual revenue several years after the complete network is opened and the initial user-familiarization period has transpired (sometimes called the “ramp-up” period for a new toll facility). Since we are proposing prices which will vary in accordance with demand, so as to manage the flow of traffic in these lanes, as overall traffic on the metro area’s freeway system continues to grow, the prices on the HOT Network would increase, accordingly. The increased revenues would provide a source of funding for *operating costs* and ongoing maintenance, to the extent that they are more than needed to service the debt on toll revenue bonds issued to pay for build-out of the network.

As a very rough rule of thumb, based on observation of toll revenue bond issuance on other projects, it seems safe to estimate that a baseline annual toll revenue stream can support a toll revenue bond issue of approximately 10 times the amount of that baseline annual toll revenue. We have used that rule of thumb in Table 5. Comparing the size of the bond issue with the estimated cost of each system (from Table 3), we see that they generally could not be fully supported by toll revenue bonds. The San Francisco and Los Angeles networks come the closest to being self-supporting. At the low end of self-support, both Miami and Atlanta still have to build the large majority of their systems, and their smaller populations mean less toll-paying traffic. Overall, the fraction that we estimate could be paid for via toll revenue bonds ranges from a low of 43 percent (Miami) to a high of 93 percent (San Francisco). Over the eight metro areas combined, we estimate that toll revenue bonds could pay for about 67 percent of the cost of creating the networks.

In actual practice, each metro area's HOT Network would be unlikely to come about as a single huge project. Rather, individual projects would be developed, each with its own capital costs and potential toll revenues (even though the whole network would operate as an integrated system, once completed). Hence, even in those metro areas where the overall network could ultimately be self-supporting from toll revenues, a very meaningful role could be played by start-up and supplemental funding (and credit support) from the federal highway and transit agencies, as discussed below in Part 6.

Table 5: Estimated Revenues of Proposed HOT Networks

	Miami	Atlanta	Dallas/Ft. Worth	Houston	Seattle	Washington	San Francisco	Los Angeles
Vehicles/lane/hour	1350	1350	1350	1350	1350	1350	1350	1350
Average peak toll	$0.2250	$0.2250	$0.2350	$0.2350	$0.2590	$0.2590	$0.2600	$0.3000
Peak hours/day	5	5	5	5	6	6	6	7
Lane miles	237	486	500	447	505	610	630	1009
Peak revenue/day	$359,944	$738,113	$793,125	$709,054	$1,059,440	$1,279,719	$1,326,780	$2,860,515
Peak revenue/year	$89,985,937.50	$184,528,125	$198,281,250	$177,263,438	$264,859,875	$319,929,750	$331,695,000	$715,128,750
Off-peak revenue	$26,095,922	$53,513,156	$57,501,563	$51,406,397	$76,809,364	$92,779,628	$96,191,550	$207,387,338
Total revenue/year	$116,081,859	$238,041,281	$255,782,813	$228,669,834	$341,669,239	$412,709,378	$427,886,550	$922,516,088
Size of bond issue	$1,160,818,594	$2,380,412,813	$2,557,828,125	$2,286,698,344	$3,416,692,388	$4,127,093,775	$4,278,865,500	$9,225,160,875
Cost of Network	$2,673,000,000	$4,908,000,000	$4,838,000,000	$3,580,000,000	$4,255,000,000	$8,065,000,000	$4,582,000,000	$10,756,000,000
Percent Covered by Revenue Bonds	43%	49%	53%	64%	80%	51%	93%	86%

Summary Data:

Total Annual Revenues	**$2,943,357,041**
Total Bonds	**$29,433,570,413**
Total Cost	**$43,657,000,000**
Percent Covered	**67.42%**

Part 6

Policy Changes Needed

The approach recommended in this report is to combine two innovative concepts—High-Occupancy Toll (HOT) lanes and Bus Rapid Transit (BRT)— to create seamless metropolitan-wide networks of HOT lanes. They would serve as guideways for Bus Rapid Transit and provide a faster congestion-free travel option to toll-paying motorists. To implement this vision, we recommend that Congress authorize a multi-year program of HOT Network development to be jointly implemented by the Federal Highway Administration and the Federal Transit Administration. Specifically, the aim of the program would be to encourage states and metropolitan jurisdictions to:

1. Incrementally create networks of premium toll lanes (HOT Networks) by extending, linking, interconnecting and filling in gaps in existing metropolitan HOV systems;

2. Implement Bus Rapid Transit services on the completed parts of the HOT Networks as soon as practicable; and

3. Develop innovative public-private financing arrangements involving tax-exempt toll revenue bonds, to help fund a significant portion of the capital cost of these projects.

Funds to support the federal portion of the program would come from special allocations from the FHWA's National Highway System (NHS) program (or, alternatively from the Surface Transportation Program), and from the FTA's Section 5309 New Starts program. The proportion of funds to be contributed by each agency would be determined by congressional action in the authorizing legislation. Eligible expenses under this program would include right-of-way acquisition (where needed); planning, design and construction of premium toll lane facilities and ancillary bus stations; and acquisition of BRT rolling stock. The Section 5309 funds could only be used for transit-related expenses (such as BRT stations and rolling stock). The federal grant support could be supplemented, as needed, by long-term Transportation Infrastructure Finance and Innovation Act (TIFIA) loans.

Up to eight candidate metropolitan areas would be selected from among applicants for participation in the program. Candidates would be chosen according to a set of criteria established jointly by FHWA and FTA. The criteria would include the level of congestion (as measured by the TTI index), the ability to develop a meaningful area-wide network of premium toll lanes, the existence of a sound financial plan, and local political consensus.

Full Funding Grant Agreements (FFGA), modeled after those used in the FTA's New Starts Program, would be negotiated with each successful candidate jurisdiction. A Full Funding agreement would represent the federal government's commitment to participate financially in a HOT Network project up to an agreed dollar amount. The federal commitment would be subject to annual congressional appropriations. Each grant agreement would establish the terms and conditions of federal financial participation in the project including the maximum level of federal financial assistance and the minimum level of service (LOS) to be maintained in the premium lanes. (The setting of toll rates would thus be governed by the requirement to maintain the specified LOS). The grant agreement would also define the project's scope, its schedule, timetable for completion, costs, and disposition of any excess toll revenues. Since the full funding grant agreement limits the maximum federal funding for a project, the grantee would be responsible for any project increases that might occur after the agreement is signed, unless the agreement was amended.

Existing law and agency regulations would need to be carefully reviewed in order to make them consistent with the proposed program. Specifically, the following actions would appear to be necessary:

1. Expanding the existing provisions in Sec. 1012(b)(4) of ISTEA as amended, to allow the use of tolls on any federal aid highway segments, including Interstate highways, that might form part of a HOT Network. (The current provision allows the use of tolls only on those Interstate segments that are part of the Value Pricing Pilot Program.)

2. Amending Sec. 1012(b)(1) of ISTEA, as amended, to authorize the Secretary to enter into full funding grant agreements with up to eight state and local governments or public authorities to design, construct, and operate HOT Networks. (The current provision authorizes the Secretary to enter into "cooperative agreements" with up to 15 state or local governments to conduct Value Pricing projects.)

3. Expanding Sec. 1012(b)(6) of ISTEA as amended (by Sec. 1216(a)(6) of TEA-21) to permit single-occupant vehicles to operate in former HOV lanes that become part of a HOT Network. (The current provision permits single-occupant vehicles in HOV lanes "if such vehicles are part of a value pricing pilot program.") Level of service C or better must be maintained in such lanes, to ensure adequate access for buses and vanpools.

4. Amending FTA rules to allow for the incorporation of existing FTA-funded HOV facilities into HOT Networks, as defined in this report.

5. The President's FY 2004 budget proposal would expand the eligible use of Section 5309 New Starts funds to include "cost-effective, non-fixed guideway coridor solutions." This effectively would make Bus Rapid Transit systems eligible for New Starts funding. Pursuant to this increased flexibility, FTA should amend its rules to permit new "non-fixed gideway facilities" funded under Section 5309 to be designated as part of a HOT Network and to be used by single-occupant vehicles, provided that such use would not interfere with the efficient operation of Bus Rapid Transit in those facilities.

We recommend that Congress consider a "HOT Networks" initiative substantially along the lines discussed above, as an element of its 2003 reauthorization proposal.

Part 7

Potential HOT Networks Coalition

New policy ideas may look good on paper, but they can only become reality if sufficient support exists to constitute a critical mass. In this section, we look at the potential for a political coalition in favor of HOT Networks.

A. Mass Transit Supporters

The emergence of Bus Rapid Transit (BRT) as a new form of transit is one of the most important developments in decades. It represents a realization, by the FTA as well as by many transit supporters, that in many situations the creation of new rail systems (mostly light rail) is simply too costly to be feasible. We noted in Part 2 that the FTA is currently confronting a situation in which it has far more light rail New Start requests than it can possibly fund. Yet BRT offers the potential of providing service of comparable quality to light rail at a fraction of the capital cost.

In order to provide high-quality BRT service, it must operate for as much of each trip as possible either on exclusive right of way (e.g., busways on arterials) or on a freeway lane that is managed so as to remain uncongested. The latter is what HOT Networks offer to a well-planned BRT express-bus system. And HOT Networks provide the freeway portion of this uncongested guideway at modest cost to the metro transit system because drivers willing to pay market-priced tolls will cover the majority of the capital costs.

Traditional HOV lanes have always received equivocal support from some in the mass transit community. Some segments of this community recall that some of today's HOV lanes began as exclusive busways, and were only opened up to carpools due to political pressure caused by the large amount of unused capacity on these busways.[37] That was true even of America's most successful combined transit/HOV facilities, the El Monte Busway on I-10 in Los Angeles and the Shirley Busway on I-95 in Northern Virginia. In one sense, our proposal calls for a return to the earlier concept, in which the HOT Networks have as a major purpose the provision of uncongested guideways for extensive BRT service. But instead of using the remaining capacity for non-paying (carpool) vehicles, our proposal instead calls for charging all cars and light trucks that opt to use these premium lanes. That is necessary both to generate the funds needed to pay for the network and to manage traffic flow to preserve the time-saving advantage necessary for high-quality express bus service. This is a new way of thinking about transit and automobiles, but we believe the benefits are large enough that many members of the transit community will embrace it.

B. Smart Growth Advocates

Although we noted in Part 2 the opposition to HOT lanes, on smart-growth grounds, by Maryland's Gov. Parris Glendening, that one case should not be taken as a definitive verdict on HOT Networks by those concerned with transportation, land-use, growth, and social-justice issues. A countervailing example is the Bay Area Transportation and Land Use Coalition, which includes nearly 90 such organizations in the San Francisco metro area. In its major report, *World Class Transit for the Bay Area*, the Coalition endorsed a regional express bus system that relied on HOV lanes, but with the potential for tolls where it would increase efficiency on the road.[38]

Reviewing ongoing plans and proposals from the Metropolitan Planning Commission and various agencies, the authors noted the very high cost of additional heavy and light rail projects, stating that "express buses would be faster, less expensive, available sooner, and could carry many more people than new rail extensions." Such express bus service "will bypass traffic by using the Bay Area's growing High-Occupancy Vehicle (bus/carpool) lane system." Of particular significance, the authors note the importance of keeping those lanes free-flowing by limiting the number of vehicles, while conversely avoiding the waste of highway space inherent in a lot of unused capacity:

> *One way to avoid this [too much or too little traffic in these lanes] is to allow single occupancy vehicles to use the bus/carpool lanes for a fee, as has successfully been done in southern California. Tolls would rise as congestion in mixed-flow lanes increased to keep traffic flowing smoothly on the bus/carpool lane. Electronic signs would indicate the current toll, allowing solo drivers to decide if they wanted to enter the bus/carpool lane. Fares would be collected automatically and electronically so that cars would not have to stop.*[39]

To be sure, this is just one report of one organization. Its proposal would still permit carpools to use the lanes at no charge, as in traditional HOV lanes. And where there are already four lanes in each direction on a freeway, the Coalition called for conversion of a general-purpose lane to HOV or HOT, rather than construction of a new lane. Yet the trade-off here is straightforward. The enormous cost of adding missing links to the existing HOV system, especially the freeway-to-freeway connectors needed for seamless express bus service, is so large that development of such a network via traditional means would take two to three more decades (as indicated in the regional transportation plans we reviewed in Part 4). But with the peak-period toll revenues available by charging all but super-HOVs to use the lanes, enough capital could be raised to complete the network within a decade.

C. Environmental Groups

Creating a HOT Network inherently involves adding lane-miles and interchange connectors to a metro area's freeway system. For that reason, despite its benefits for transit and mobility, some environmental groups will be unable to support the idea. But that is not the end of the story.

Several environmental groups have actively supported HOT lanes, even where implementation involved the addition of highway capacity. One case in point is Environmental Defense. That organization supported the development of the 91 Express Lanes, which involved the addition of over 40 lane-miles of new capacity in the congested SR 91 corridor in Orange County, as well as the introduction of HOT lanes on US 50 in Maryland. The organization's support stemmed from its underlying goal of moving toward a system in which drivers pay directly for road use by means of pricing that reflects the cost of providing peak-period capacity. ED has also supported the I-15 HOT lanes project in San Diego, and it has proposed several HOT lanes projects in the San Francisco Bay Area. In the Washington, D.C. metro area, ED has consistently supported HOT lane proposals made by citizen groups and various advisory committees, and it has testified in their favor on Capitol Hill. ED has also stressed the importance of having adequate transit service in place where such pricing is used.

Several other environmental groups have endorsed "congestion pricing" in general, for similar reasons. Their support should not be ruled out for HOT Networks, given the concept's large benefits for transit and potentially positive impact on emissions.

The emissions question was studied by UCLA transportation researcher Eugene Kim. In his Ph.D. dissertation on HOT lanes, Kim modeled the potential conversion of an HOV lane on a congested freeway to either a general purpose lane, a HOT lane, or a tolled express lane, using a deterministic travel-demand model to estimate comparative travel times.[40] For his emissions analysis, he then used a model widely employed in California[41] to compare emissions of ROG, NOx and CO for each case. Kim's conclusion was that the tolled express lane (which is what our HOT Network proposal involves) would produce greater environmental benefits than continuing the lane as HOV:

> *In terms of emissions, the baseline 'no action' HOVL case produces a greater output of ROG, NOx, and CO than converting to either GPL [general purpose lane]or toll lane. Of the two competing investment alternatives, converting to toll lane will provide greater reduction [in emissions] than converting to general purpose use. (p. 245)*
>
> *A toll lane provides the largest emission reductions because it eliminates some vehicle trips (like an HOVL) while reducing congested conditions more effectively than a GPL, and partially addresses the effects of latent demand. (p. 249)*

D. Business Leadership

Traffic congestion of the magnitude encountered in America's large metro areas puts those areas at a competitive disadvantage. In such locations, employers often must offer higher compensation to offset the poor quality of the commuting experience (and the transportation system, more generally). TTI estimates the annual cost of congestion—just in wasted fuel and people's time—at from $1.3 billion in Miami to $14.6 billion in greater Los Angeles. Projections of future congestion in these regions suggest that lost time may increase at a greater rate than personal income over the next several decades. Such considerations may well lead the business community to support the kind of large-scale efforts to improve metro-area transportation that HOT Networks represent. Previous major transportation investments—urban freeways in the 1960s and urban rail transit in the 1980s and 1990s—depended critically on support from business leadership in the metro areas in question. Business leaders may come to see HOT Networks as the next logical step in improving their region's competitiveness.

E. Auto Clubs

The record of automobile clubs on HOT lanes is mixed. Traditionally, auto clubs have been opposed to greater use of tolls on grounds of double taxation (i.e., paying both a toll and a fuel tax to use the same stretch of highway). And when HOT lanes were being debated in Maryland in 2001, one of the most outspoken opponents was the American Automobile Association's Mid-Atlantic region. However, in 2002 when HOT lanes were proposed for a section of the Washington Beltway in Virginia, that same spokesperson had a far more moderate reaction, telling the *Washington Post* that "[T]he book is still open as to whether pricing these things really works."And he added that Triple A realizes the need for improved roads and new ways of paying for them, acknowledging that, "The time is probably here when the piper has to be paid."[42]

In Los Angeles, the Auto Club of Southern California has been guardedly supportive of HOT lanes. That organization was one of over 60 participants in a task force, funded by the Federal Highway Administration, to explore the possibilities for using pricing mechanisms to deal with congestion and emissions on the Los Angeles freeway system. That task force's main recommendation was that congestion pricing should be introduced via HOT lanes on the most congested freeways. The Auto Club supported that recommendation, clarifying its understanding that existing general-purpose lanes would not be converted to HOT lanes; rather, the HOT lanes would be developed via some combination of converting existing HOV lanes and adding new purpose-built HOT lanes.[43] More recently, this group has supported "further research and demonstration projects of direct road-use pricing."[44]

A more broadly based coalition of highway users, the American Highway Users Alliance, though it has not taken a formal position on HOT lanes, has indicated support for the concept of HOT Networks.[45]

F. Transportation Builders

An obvious member of a pro-HOT Networks coalition would be organizations representing public works construction firms, such as the American Road & Transportation Builders Association. While such groups already support more investment in highway and transit projects, a program of completing HOT Networks in major metro areas would mean that significantly more projects would be available for their members to build over the next decade, thanks to the availability of a new funding source, the toll revenues.

G. Pricing Advocates

There is a small but well-connected network of transportation planners and researchers who believe that direct pricing of road use at the time and place of use is a better long-term approach than continued reliance on fuel taxes. Their numbers include consultants at engineering and research firms, academic transportation economists, researchers at the Transportation Research Board and various think tanks, and transportation planners at MPOs, state DOTs, and the Federal Highway Administration and Federal Transit Administration. While not possessing much lobbying clout, this informal network of pricing supporters seems likely to respond favorably to the HOT Networks concept as a politically feasible way forward for urban road pricing. Their support could be very helpful in gaining respectability for the idea among opinion leaders.

Part 8

Conclusions and Recommendations

Today's HOV lanes represent a valiant but thus-far unsuccessful effort to address traffic congestion in America's large metro areas. Despite many billions worth of capital investment, HOV lanes have failed to increase the fraction of commute trips made by carpool, even in places like Los Angeles where many HOV lanes are well-utilized. Nor has their potential been used to provide extensive express bus service (with a few notable exceptions). And transit's commuter mode share has also continued to decline in most metro areas (again, with some notable exceptions).

This report suggests a new approach. The two California HOT lane projects have demonstrated the power of variable pricing to manage traffic flow under peak-demand conditions. They have also demonstrated that significant monetary demand exists for faster rush-hour trips, with the potential to produce large annual revenue streams. Those revenue streams could be the basis for issuing toll revenue bonds to finance the build-out of today's fragmented HOV facilities into seamless networks of premium lanes. Managing those lanes via market pricing would ensure that they operate uncongested, at high throughput, over the long-term. The resulting network would provide a high-speed guideway for extensive express Bus Rapid Transit (BRT) service.

Our quantitative analysis suggests that a HOT Network approach along these lines could produce the extensive, seamless network of limited-access lanes only dreamed of in the "unconstrained" 30-year plans of MPOs. These hugely beneficial networks could be in place in 10 years, rather than 30 or more. And they could be largely paid for not with scarce federal, state, and local transportation funds but with monies willingly provided by those whose time makes it worth their while to pay for premium service during rush hours. Greatly benefiting from their largesse would be millions of transit riders, who would gain an extensive new BRT service spanning the whole metro area.

The trade-off for achieving these good things is to change the operating concept of these systems of limited-access lanes. Carpools (which, in fact, are mostly "fam-pools") can no longer be allowed to use this premium capacity without paying for it. Only super-high-occupancy vehicles will get a free ride on the HOT Network. That will ensure enough saleable capacity to produce the needed toll revenue streams to cover the lion's share of the system's cost. In other words, this means adopting the business model of the 91 Express Lanes rather than that of the I-15 Express Lanes. The former is a set of toll lanes on which certain HOV users can drive for free; the latter is an HOV facility on which certain paying customers can drive for a fee.

To some this may seem to be a difficult trade-off, but our assessment is that the gains far outweigh the losses. Those gains include major investment in much-needed urban transportation infrastructure without drawing heavily on existing public-sector funding sources, a major expansion of high-quality transit service, and the availability of real congestion relief, when it really matters, to every driver in the metro area in question.

In the 2003 surface transportation reauthorization, the Federal Highway and Transit Administrations and the Congress have an opportunity to make this vision of HOT Networks a reality. We recommend that they seize this opportunity.

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Appendix A

Bus Rapid Transit Overseas

A. Curitiba, Brazil

The concept of Bus Rapid Transit has found its truest expression abroad. Probably the most celebrated example is Curitiba, in southeastern Brazil. Curitiba authorities have used land-use legislation to encourage high density residential and commercial development along radial corridors. Each of the five main corridors consists of three parallel roadways. The central road contains two express bus lanes, flanked by frontage roads carrying local auto and truck traffic. One block away to either side run high-capacity one-way arterial streets heading into and out of the central city. Express buses—some of them double- and triple-length articulated buses that can carry up to 270 passengers—operate at high frequency in the center lanes, which are reserved exclusively for buses. Traffic signal preemption at intersections allows the buses to travel at an average speed of 18 miles an hour, twice the average speed of auto traffic. Large bus terminals at the far ends of the five express busways and smaller terminals located approximately every two kilometers along the express routes permit transfers from express to local buses. Most urban bus systems require passengers to pay the fare on the bus, during the boarding process; this takes considerable time. Curitiba's distinctive plexiglass-clad tubular bus platforms eliminate this step: passengers pay as they enter the tube and board the buses, without a queue, through extra-wide doors. The busiest busway corridor carries 27,000 riders in the peak hour. Although the city has more than half a million private cars (more cars per capita than any other Brazilian city) three quarters of all commuters—more than 1.3 million passengers a day—take the bus.

B. Ottawa, Canada

Ottawa's Transitway, built in stages between 1978 and 1996, is a 15.5-mile exclusive-use busway leading from the suburbs to the central business district where it connects to a network of exclusive bus lanes on city streets. Approximately 190 buses operate in the peak hour in each direction carrying more than 200,000 daily passengers. Buses run every 3 minutes during peak hours, every 5 minutes during the day, and every 10-15 minutes in the evenings. Fifty express routes provide peak period service between the suburbs and the central business district. Forty local routes provide timed transfers at 18 Transitway stations. Service on the busway is provided with articulated buses, with proof-of-payment fare collection to speed boarding.

Ottawa is making the Transitway a focus of future development in the region. Already, 34 percent of the region's employment is within walking distance of the Transitway. By the year 2000, nearly 40 percent of the region's employment was located within walking distance of the Transitway. Close to $1 billion of development has occurred or is committed close to the Transitway. In the future, all primary employment centers (downtown and suburban) employing more than 5,000 persons will be located at existing or future Transitway stations. Smaller employment centers will be allowed off the transitway but must have access to frequent all-day feeder service to the Transitway.

C. Paris, France

In the Paris region, RATP, the metropolitan transportation authority, has embarked on the construction of a 106-mile network of exclusive busways and bus lanes, covering one-third of the radial and two-thirds of the circumferential bus routes in the suburbs. The first such busway, known as Trans-Val-de-Marne (TVM) opened in 1993 in the southern portion of the Paris region. The new bus network will supplement the already extensive, 186-mile network of exclusive bus lanes on city streets in central Paris.

D. TransMilenio, Bogota, Colombia

Inspired by Curitiba, Bogota, Colombia has implemented a bus-based rapid transit system in just three years. Today, the system carries 670,000 daily trips, and its main line carries more than 40,000 passengers per hour.

TransMilenio operates like a rail system. High capacity 165-passenger articulated buses run on exclusive busways in the center of avenues heading to and from downtown. Passengers board buses at enclosed stations, buying tickets when they enter the station. When a bus arrives and opens its doors simultaneously with the station doors, one hundred passengers can disembark while another one hundred passengers can board in less than 30 seconds. The bus floor is level with the station floor, making boarding and disembarking safe for handicapped persons. While some buses stop at all stations, others operate as express buses stopping only at a few stations. Passengers can change from an express bus to a local and vice versa with a single ticket. Feeder buses circulating through residential neighborhoods connect with the BRT system. The main advantage of TransMilenio over rail systems is its low cost. The system was implemented at a cost of $5 million/km ($8 million/mile). The system covers its operating cost and makes a small profit.

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