Changing Lanes

Linking Bus Rapid Transit and High Occupancy Toll Networks In Northern Virginia

Breakthrough Technologies Institute

ENVIRONMENTAL DEFENSE
finding the ways that work

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Cover Photo: Bus Rapid Transit station and electronic fare collection machine in Curitiba, Brazil.

Executive Summary

State and local officials in the metropolitan Washington, DC, region face crucial choices regarding proposed High Occupancy Toll (HOT) lanes on I-395/95, the Capital Beltway, and other major highways. If constructed, these projects might build on recent successful experiences with HOT lanes in California, Texas and Minnesota, and create the longest HOT lane network in the country. Decisions in coming months could establish a precedent for how other HOT lanes are built in the Washington region and around the nation.

HOT lanes are one of many promising, innovative, market-incentive strategies that could help better manage new and existing highway capacity. HOT lanes allow motorists access to specially managed high-speed lanes in return for paying tolls, which vary based on the demand for the lanes – higher when demand is greatest, lower when there is less competition for scarce high speed road space. Buses, vanpools and other high occupancy vehicles travel free or at a discount. There appears to be significant potential for a HOT lane/public transportation network to attract new public transportation riders.

HOT lanes could be good or bad depending on implementation. If implemented well, HOT lanes and other tolling strategies could provide a means to manage congestion, expand public transportation and travel choices, and help focus development to minimize traffic growth, air pollution, fuel use, and the need for new highways. If implemented poorly, HOT lanes could exacerbate sprawl development, boost dependence on costly foreign oil, and counter progress in addressing the region's continuing serious air quality problems.

Before approving new HOT lanes, area officials and agencies must do far more to consider and address these risks and opportunities through the transportation planning and project review process. Without such efforts, HOT lanes threaten to bring more traffic to our highways and more environmental degradation to our communities.

This report, authored by the Breakthrough Technologies Institute, Environmental Defense and Smart Mobility, Inc., examines many key issues imperative to review by officials, agencies, citizens and stakeholders as these proposals are considered under Virginia's Public Private Transportation Act and various other state and federal laws. It focuses particularly on how HOT lanes might provide new opportunities to improve public transportation in underserved or unserved travel markets, particularly by creating managed rights-of-way in congested highway corridors to connect major and emerging activity centers with Bus Rapid Transit (BRT) services. It also compares key attributes of two active proposals for developing HOT lanes in the I-95/395 corridor of northern Virginia.

Value-Added: Bus Rapid Transit

A BRT system could be a critical component of any HOT lane network. BRT encompasses a spectrum of high-quality, rubber-tired transit systems that improve on traditional bus services through various combinations of congestion-free lanes, real-time passenger information systems, high efficiency fare collection and boarding systems, and special attention to integrating vehicle,

station and system design. Together these enhancements can enable BRT to deliver performance comparable to rail systems at a fraction of the cost.

This study evaluates the potential to expand transit use in HOT lane corridors by introducing BRT and express bus services on proposed HOT lanes. For example, a travel model analysis of a BRT system operating on a Northern Virginia HOT lane network, with connections to nearby activity centers, suggests such a system might attract 8,000 new transit commuters daily and 23,000 new net transit trips per day in 2010, with 80 percent of these drawn from single occupant vehicles. Many of these trips would be generated in neighborhoods along I-95 south of the Beltway – most destined to major activity centers in Arlington, Tysons Corner, and the Dulles Airport area – with significant morning travel also going east from I-95 to Arlington. There is also a substantial reverse direction commuting market in Fairfax County, where much job growth has occurred in outer parts of the county.

Keys to Success at Winning Acceptance for HOT Lane Designs

Better, Enforceable Performance Standards - State and local leaders should not approve new HOT lanes without requiring a robust public transportation element as a condition of any new HOT lane projects, along with other enforceable commitments. These commitments should ensure a portion of HOT lane toll revenues are dedicated to funding public transportation and operation of HOT lane corridors to meet performance objectives that maximize traveler choices and minimize potential harmful effects. Such performance requirements should focus especially on increasing the non-automobile driver mode share in the corridor, ensuring timely reduction of air regional and local air pollution, and managing induced land use impacts related to increased corridor capacity. Such analysis should more fully consider options for pricing and better managing existing highway space as an alternative to building expensive new tolled lanes to reduce the cost and impacts of new road capacity. Indeed, the cost of new lanes could preclude or compromise important opportunities both to accommodate improved public transportation in proposed HOT lane corridors and to generate revenue to pay for improved transit and for mitigation of adverse impacts.

Consider Alternatives - Experience in other places shows adjustable electronically-collected tolls can be very effective at protecting the capacity and high speed of the limited access highway lanes to which they apply. On SR 91 in southern California, time-of-day tolls enable HOT lanes to serve twice as many vehicles per lane in the peak hour at three to four times the speed of the parallel free congested lanes.

Given the high costs of building new lanes, officials should consider how to apply toll management to boost the efficiency of at least a portion of the existing highway rights-of-way by converting it into BRT/HOT lanes. This would create added road capacity at a much lower cost and free up more toll revenue for improving transit options. The easiest way to add BRT/HOT lane capacity at low cost would be to adopt more Rush Hour Lanes (e.g., converting shoulder lanes to BRT/HOT lanes, as I-66 shoulder lanes now allow HOVs in peak periods). Officials should also re-examine the assumption that it is only new lanes that can be tolled and that there are no viable options to better manage existing general purpose lanes.

Managing Side Effects - Although additional HOT lanes may help pay for themselves, as now proposed in Northern Virginia they are likely to create congestion on local roads. A recent study of the Capital Beltway in Northern Virginia by a Federal Highway Administration expert shows that a 10-lane alternative, with tolls on six of the lanes, could generate three times more toll revenue than the current HOT lane plan, while boosting traffic only 2 percent over the current configuration. By contrast, the current proposal to widen the Beltway to 12 lanes with 4 new HOT lanes would boost traffic by 12 percent over the current configuration, putting 36,000 more vehicle trips per day on roads connecting to the Beltway. That means more HOT lanes, if designed poorly, may mean more traffic on connecting roads.

HOT lanes offer promise but should not be blindly embraced as a cure-all for traffic and transportation financing woes in the Washington region. Proposals for private investment in creating these lanes should be further explored, but subject to much more thorough consideration of alternatives and their impacts.

CHAPTER 1

Introduction

The metropolitan Washington, DC, region faces increasing challenges in managing growth and in financing new and improved transportation infrastructure. New strategies, such as High Occupancy Toll (HOT) lanes (which are operated under special restrictions and various toll schedules to improve traffic flows), are receiving particular attention. This is especially true in Virginia, where the private sector is proposing to add HOT lanes to I-395/95 and the Capital Beltway under Virginia's Public Private Transportation Act (PPTA). If constructed, these HOT lanes would form the longest HOT lane network in the country. They also would establish a precedent for how other HOT lanes may be built elsewhere in the Washington region and around the nation.

Although HOT lanes offer great promise, they also pose substantial risks. If implemented poorly, HOT lanes could exacerbate sprawl, increase dependence on petroleum-fueled cars, and inhibit progress in air quality improvements.

The Breakthrough Technologies Institute (BTI) and Environmental Defense are exploring ways to ensure that HOT lanes maximize regional benefits while minimizing harmful impacts. With technical support from Smart Mobility, Inc., a transportation modeling and consulting firm, BTI and Environmental Defense modeled the potential for bus rapid transit (BRT) operating within the HOT lanes planned for I-95/395 and the Capital Beltway in northern Virginia. In May 2005, BTI and Environmental Defense sponsored a planning charrette with regional transportation planners and operators, presenting the initial results of the modeling[1] as a prelude to discussions with agency stakeholders.

This report is a result of that discussion and outreach. It incorporates many of the group's suggestions and comments and highlights some of the key issues that need further study. The report's findings reveal significant opportunities for new transit ridership in the corridors, with BRT a promising option for capturing that ridership. It also finds that there are many questions that need to be answered before HOT lane proposals are approved.

It is our hope that this information will inspire state and local leaders to require a robust public transportation element as a condition of any new HOT lane project. Other conditions should include enforceable commitments to ensure a portion of HOT lane toll revenues are dedicated to funding public transportation and operation of HOT lane corridors to meet performance objectives that maximize traveler choices and minimize potential harmful effects.

Although this report focuses on the potential linkage between BRT with HOT lanes, it is important to note that land use impacts and patterns, as well as alternative tolling options, also are very important and need to be fully evaluated. Moreover, HOT lane revenues could be used to fund non-BRT transit options, such as improved commuter rail or Metrorail service.

[1] Presentation by BTI, Environmental Defense and Smart Mobility, Inc. 2005. BRT, HOT Lanes, and the Washington, DC Region: Fitting it All Together. Viewable at www.gobrt.org/BRTHOTCompositeProjectBriefing10May05b.pdf

Decisions about such alternatives should be made through objective regional planning and corridor environmental alternatives analysis.

Due to limitations of time and resources, and the complexity of the region's governance, this report focuses on opportunities and risks related to BRT and HOT lane development in northern Virginia only. However, the concepts are relevant to other communities across the United States.

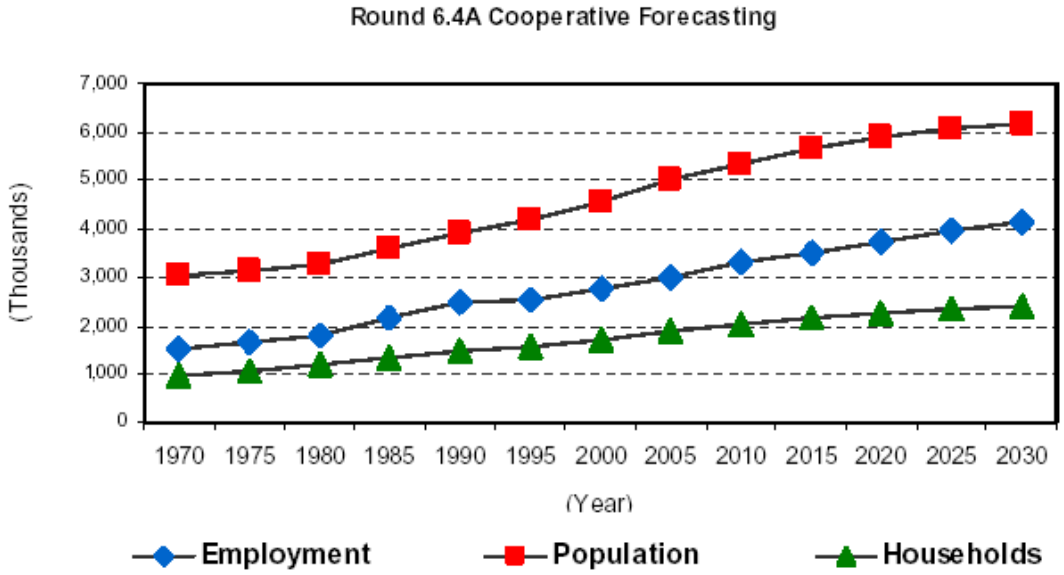
CHAPTER 2

The Need for New Transportation Alternatives

According to the Metropolitan Washington Council of Governments, the Washington region will experience "dramatic increases in employment, households, and population by 2030."[2] The number of jobs is expected to increase by 50 percent, with the largest number of new jobs expected in the inner suburbs. Population and the number of households also are expected to grow substantially, with much of the growth projected to occur in the outer suburbs.[3]

In total, the region expects to add roughly 1.6 million jobs and 2 million people by 2030. Transportation investment and system management choices made in the next decade will play a major role in shaping the pattern of this job and housing growth. To what degree will such growth spur more traffic or less? More mass transit use or less? Will there be a greater or reduced reliance on walking, biking, and telecommunicating as a substitute for driving?

FIGURE 1: ROUND 6.4A COOPERATIVE FORECASTING



[1]Based on the 1983 definition of the Washington Metropolitan Statistical Area (MSA)

Source: *Growth Trends to 2030: Cooperative Forecasting in the Washington Region*, Metropolitan Washington Council of Governments

Current growth trends portend a worsening of the region's traffic problems. For the fifth year in a row, the region has experienced the third worst traffic in the country and is quickly catching up

[2] Metropolitan Washington Council of Governments. 2003. *Growth Trends to 2030: Cooperative Forecasting in the Washington Region.* www.mwcog.org/uploads/pub-documents/B1tb20031126144141.pdf
[3] *Ibid.*

to second-place San Francisco.[4] Non-managed roads are filled almost as quickly as new lane capacity is added, and studies suggest that adding new outer beltways - even if these are toll managed facilities - may generate *more* new traffic and sprawl.[5]

Washington's Metrorail system has played an important role in helping to focus the region's tremendous growth. But financial and other constraints are causing the region's transit system operators to struggle to provide adequate, dependable service. As the Metrorail ages, it requires increasing maintenance and repairs; riders experienced 64 percent more Metrorail breakdowns today than they did in 2000.[6] And as shown below, each of the five Metrorail lines are projected to be near or at 100 percent utilization by 2010.

TABLE 1: METRORAIL VEHICLE LOADING AT MAXIMUM LOAD POINTS, 2005-2010

Line	Passenger capacity	Passenger demand	Capacity Utilization	2005	2006	2007	2008	2009	2010
Red	17,760	15,000	84%	87%	89%	91%	94%	96%	99%
Blue	6,720	5,890	88%	90%	92%	95%	98%	100%	103%
Orange	12,720	10,900	86%	88%	90%	93%	95%	98%	101%
Yellow	6,480	5,670	88%	90%	92%	95%	97%	100%	103%
Green	8,640	7,460	86%	89%	91%	94%	96%	99%	101%

Source: WMATA, Office of Business Planning and Project Development.
Note: Utilization conditions above 85% are considered to be highly congested conditions. Passengers can no longer board crowded trains above 100% utilization.

Although the challenges are well-documented, solutions remain elusive. Area governments continue to enable extensive car-dependent growth in the outer suburbs, in areas where there are few options for mobility other than driving. This increases average trip lengths, boosts traffic growth and dependence on costly imported oil, and spurs demands for more highway investment, all of which could be avoided through better land use planning and growth management. Ensuring that jobs and housing are located closer together and near existing transportation infrastructure (such as Metrorail) is vital to helping the region grow in a more sustainable manner with less traffic growth.[7]

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[4] Ginsberg, S. & Dwyer, T. May 10, 2005. Traffic Creeps Toward Nation's Worst. *The Washington Post*. p. A01. www.washingtonpost.com/wp-dyn/content/article/2005/05/09/AR2005050900408.html

[5] Replogle, Michael. April 2005. *New Toll Road vs. Toll Managed Lanes on Existing Motorways: Alternatives and Impacts in Metropolitan Washington, DC.* Presented at International Road Federation Conference. www.piarc.org/library/en/seminaires/4BBA7046g2J38jF41y18.php; and
Environmental Defense, Chesapeake Bay Foundation, Audubon Naturalist Society, Sierra Club and the Coalition for Smarter Growth. January 2005. *The Intercounty Connector: Impacts and Alternatives.* www.environmentaldefense.org/go/iccoptions

[6] Layton, L. & Becker, J. June 5, 2005. Efforts to Repair Aging System Compound Metro's Problems. *The Washington Post*. p. A01. www.washingtonpost.com/wp-dyn/content/article/2005/06/04/AR2005060400350.html

[7] For more detailed analysis of these relationships, see: Chesapeake Bay Foundation and Environmental Defense. 1996. *A Network of Livable Communities.* Washington, DC. www.environmentaldefense.org/documents/746_networkof.PDF

New funding sources also remain elusive. A Northern Virginia referendum to raise transportation funds failed due to anti-tax sentiments and concerns that the funding would exacerbate sprawl and traffic growth. New motor vehicle fuel taxes appear unlikely to win political support, particularly if gasoline prices remain high.

Solving the growing transportation crisis will require new thinking. Better land use decisions can help reduce the growth in transportation demand. Innovative pricing strategies, like HOT lanes, can help reduce the need for new roads by managing existing roads better and providing funding for public transportation alternatives.

CHAPTER 3

What Are BRT and HOT Lanes?

Bus Rapid Transit

Bus Rapid Transit (or BRT) is a high-quality, rubber-tired transit system that delivers the performance of comparable rail systems at a fraction of the cost. BRT currently operates in dozens of cities around the world.[8] Common BRT features include:

- High-capacity, comfortable, low-floor vehicles enabling level boarding through multiple doors (similar to boarding a Metro train);
- Frequent, reliable, high-speed service provided in whole or in part on dedicated bus lanes or busways;
- Rail-like stations that provide shelter from the weather, a platform on the same level as the transit vehicle, and fare payment away from the vehicle to reduce boarding delay; and
- Intelligent technology systems (ITS) that ensure efficient operations, inform passengers of vehicle arrivals, and provide transit vehicles with priority at traffic signals.

The combination of these features enables BRT to carry large numbers of people quickly and comfortably. In several cities where BRT provides all these features and runs on dedicated busways in transit-oriented development corridors, BRT services feel like riding a Metro, with peak hour capacities significantly exceeding the peak hour capacity of even the most heavily used Metrorail lines.

In other cities, express buses use some of the features of a BRT system to provide service that is similar to commuter rail; these include serving longer distance work trips, less frequent service, infrequent stop spacing, and lower hourly passenger demand and capacity.

HOT Lanes and Time-of-Day Tolls on Managed Lanes

High Occupancy Toll (HOT) lanes are a type of managed lane that allows free passage for high occupancy vehicles while charging a toll for other vehicles. During peak periods, the toll is set high enough to discourage some drivers from using the managed lane, thus keeping the traffic free-flowing for high occupancy vehicles. Successful HOT lanes in California show that peak hour toll rates of $0.40 to $0.70 per mile or more may be needed to sustain free-flow conditions, yet such rates have won strong, sustained public approval.[9]

Time-of-day tolls on managed lanes (sometimes referred to as “value pricing” or “congestion pricing”) encompass a broader array of toll traffic management options. This includes HOT lanes

[8] See www.gobrt.org for a detailed description of BRT systems around the world.

[9] Currently there are four successful HOT lane systems in the United States, located in California and Texas. Drivers using San Diego’s I-15 indicate a 91 percent level of support for the HOT lane system. Some 73 percent of non-I-15 motorists agreed that traffic on other corridor roads was reduced following HOT lane implementation, and a majority of corridor drivers supported extension of the I-15 HOT lanes. www.itsdocs.fhwa.dot.gov/JPODOCS/REPTS_TE/hot/chapter_4.htm

as well as full facility pricing, where all vehicles regardless of occupancy are charged a toll. Such a system is found on the Electronic Toll Road (ETR) 407 around Toronto, Ontario and on the bridges and tunnels crossing the Hudson River from New Jersey into Manhattan.

Improvements in technology and a chronic shortage of transportation funding are making HOT lanes and other managed lanes increasingly viable. Transponders and cameras substitute for toll booths on several major highways, making toll collection and enforcement much more efficient.

For example, in March 2001 the Port Authority of New York-New Jersey introduced time-of-day tolls on Hudson River bridges and tunnels and Staten Island bridges. People who avoid rush hours are given a discount, similar to movie theaters and other businesses and services offering discounts during off-peak hours. Regional officials estimate that the tolls have cut traffic in the peak hours by 7 percent. Moreover, toll revenues support better rail transit and regional transportation infrastructure and services.

Similarly, on I-15 in San Diego, 10 miles of underused HOV lanes were opened in the late 1990s to solo drivers willing to pay a toll that is set higher during rush hours and lower during off-peak periods. Tolls are adjusted as frequently as every 6 minutes based on anticipated traffic demands so the toll-managed lanes generally remain free-flowing at all hours. A portion of toll revenues is dedicated to supporting expanded express bus service in the I-15 corridor.

San Diego HOT lane varies the toll through the day and night to ensure free-flow travel at all hours.

Combining BRT and HOT lanes or time-of-day priced lanes

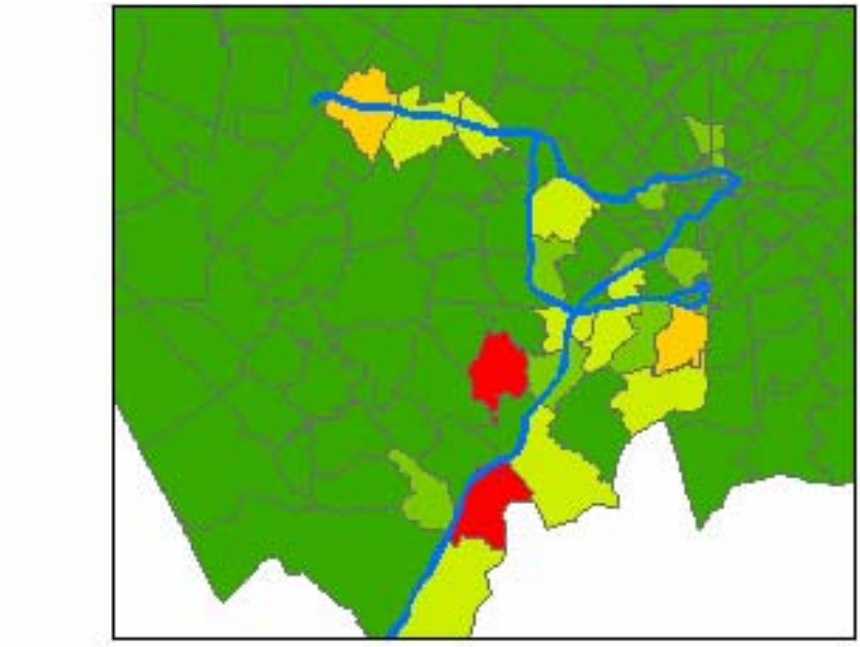
When done right, combining HOT lanes or toll managed lanes with BRT may be one of the best solutions available to address transportation capacity issues while minimizing the harmful impacts of new highway construction. For example:

- Toll rates can be adjusted to manage traffic and ensure uncongested roadway capacity is available for BRT vehicles;
- Sufficient toll revenues may be generated to pay for the operations and maintenance of the road *and* to support the operations and maintenance of the BRT system (as is the case in San Diego); and
- As shown in Virginia, the private sector may be willing to pay much of the costs for the new infrastructure, thus avoiding the high infrastructure costs of other transit modes, such as rail.

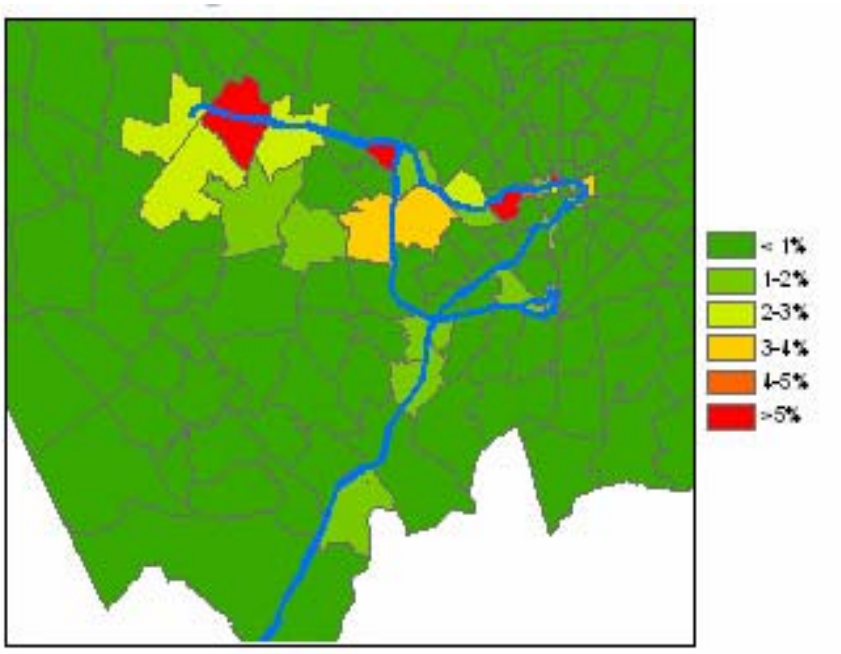
There are other benefits as well. BTI and Environmental Defense commissioned Smart Mobility, Inc., a respected transportation modeling and consulting firm, to develop a computer simulation of a potential BRT-HOT network concept. This was evaluated using a new sketch-planning model (see Appendix A) that was based upon Census travel data and elements of the Transportation Planning Board's (TPB) regional travel model.

As shown in the figure below, the model evaluated BRT operating on I-95/395, the Capital Beltway, I-66, and the Dulles Toll Road. Our initial results suggest that a BRT system operating on these routes could attract 8,000 new transit commuters daily. Many of these trips would be generated in neighborhoods along I-95 south of the Beltway and most would be destined to major activity centers in Arlington, Tysons Corner, and the Dulles Airport area. The modeling also shows strong directional demand on the Beltway: north in the morning from I-95 to Tysons Corner as well as east in the morning from I-95 to Alexandria. There is a significant reverse direction commuting market in Fairfax County, where much job growth has occurred in outer parts of the county.

FIGURES 2-3: PROPOSED BRT-HOT LANE NETWORK



Work Trip Net New Origins Due to BRT



Work Trip Net New Destinations Due to BRT

BRT can attract car-owners to transit. Our modeling showed that up to 80 percent of new transit trips along the HOT lanes could be generated from car drivers. In Brisbane, Australia, transportation officials estimate that a single high-level BRT corridor, the Southeast Busway,

resulted in 375,000 fewer car trips in 2002.[10] In Los Angeles, implementation of a rapid bus system resulted in a 42 percent ridership increase, one third of which were new riders.[11] Similarly, Las Vegas recently opened a BRT route, the Metropolitan Area Express, and 10 percent of passengers state that they gave up driving to take MAX.[12]

BRT Station, Brisbane, Australia

[10] TCRP Report 90: *Bus Rapid Transit, Volume 1: Case studies in Bus Rapid Transit*, Brisbane, Australia Brief: South East Busway. http://gulliver.trb.org/publications/tcrp/tcrp90v1_cs/Brisbane.pdf

[11] Los Angeles County Metropolitan Transportation Authority, *Final Report, Los Angeles Metro Rapid Demonstration Program* (2002)

[12] Sofradzija, Omar, Rapid Transit: Sahara-downtown route in works. *Las Vegas Review Journal* (May 20, 2005). www.reviewjournal.com/lvrj_home/2005/May-20-Fri-2005/news/26558104.html

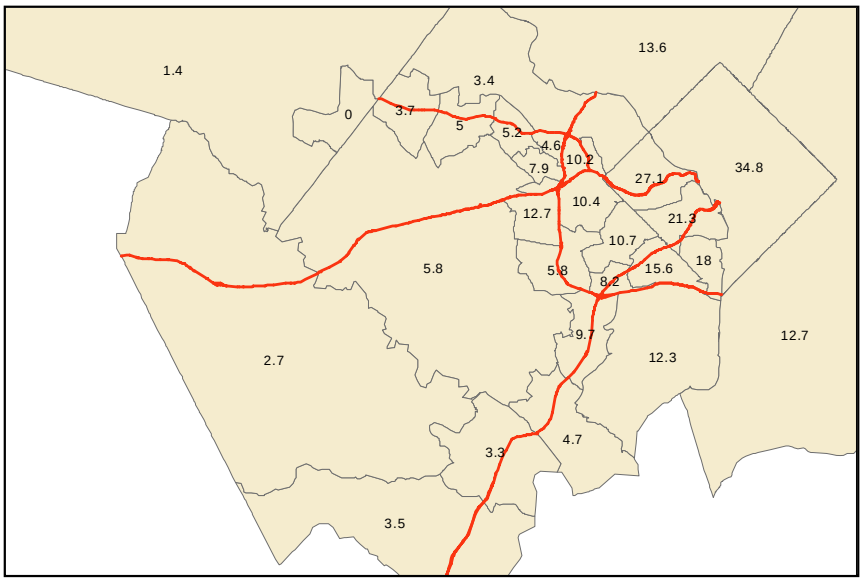
CHAPTER 4

Transit Service Opportunities in the Northern Virginia Portion of the Metropolitan Washington Region

In a recent *Washington Post* poll, 63 percent of respondents said it was *not* possible to get from their home to work via public transportation.[13] In the same survey, nearly 50 percent of the respondents who already take the Metro to work rated Metro's convenience to their workplace as *not so good* or *poor*.[14]

As shown by the two maps below, transit ridership outside of the Beltway is typically quite low. Because many local governments failed to plan land use and transit together, many of these communities are not served by robust public transportation systems and might be served by a new BRT express bus system that takes advantage of the proposed HOT lane network.[15] This suggests an opportunity to attract new mass transit riders by way of a HOT lane/public transportation network.

FIGURE 6: 2000 CENSUS TRANSIT WORK TRIP SHARE BY PLACE OF RESIDENCE

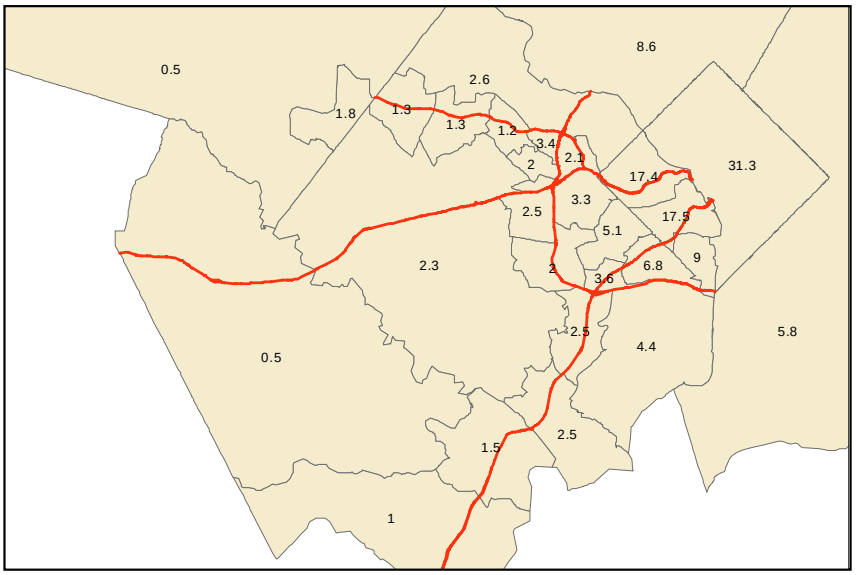


[13] *The Washington Post* poll, conducted by telephone January 27-31, 2005. www.washingtonpost.com/wp-srv/polls/2005027/q6/index.html

[14] *The Washington Post* poll, conducted by telephone January 27-31, 2005. www.washingtonpost.com/wp-srv/polls/2005027/q19_6/party/index.html

[15] Note that due to time and resource limitations, it is beyond the scope of this report to consider or discuss the many transit service needs, opportunities and gaps in Maryland and the District of Columbia, except as the northern Virginia corridors under examination relate to the other parts of the metropolitan area.

FIGURE 7: 2000 CENSUS TRANSIT WORK TRIP SHARE BY PLACE OF EMPLOYMENT



Opportunities to use BRT/HOT lanes generally can be divided into three categories:

1) Areas where transit currently does not exist;
2) Areas currently served by transit but in need of enhanced service to meet current and future demand; and
3) Growing activity centers where transit service may be needed in the future.

Gaps In Existing Service

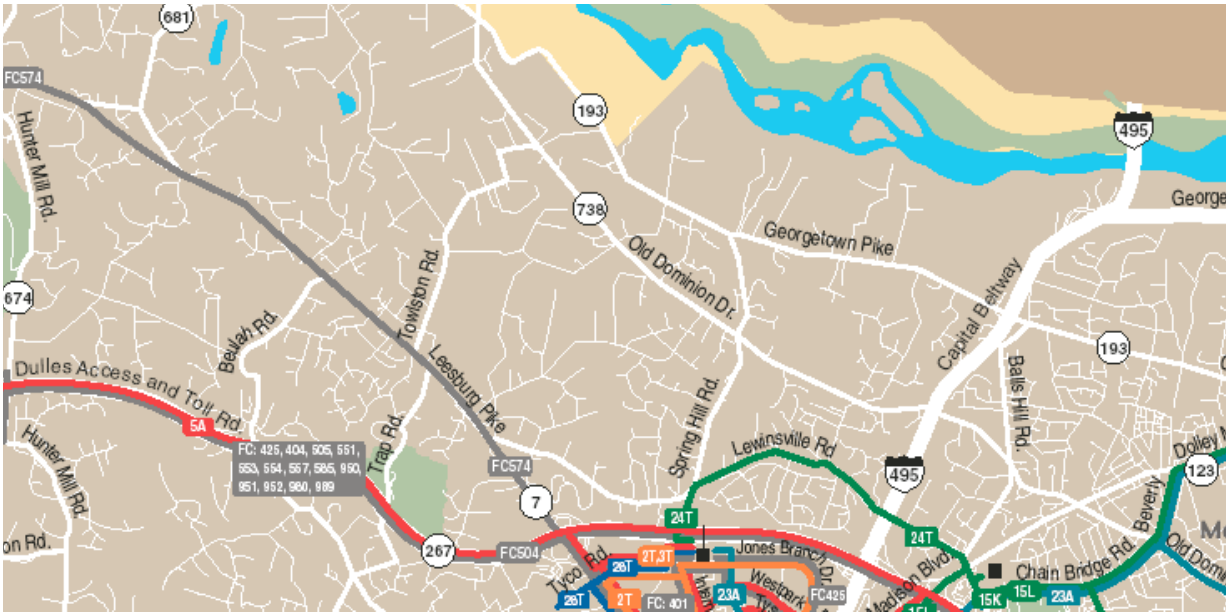
The Metrorail system originally was built as a hub-and-spoke system based upon the premise that most commuters would travel into the District of Columbia from the near-in suburbs. Over the years, the region's economic geography has shifted, with new activity centers sprouting up outside of the District. Although rising energy prices and other concerns might prompt future changes in growth forecasts, current forecasts show that an increasing share of job and housing growth will occur in the middle and outer suburbs.[16] This trend has prompted an increasing share of residents to commute between areas that Metro was never intended to serve, including long-distance, radial commutes from southern Prince William County to Montgomery County; West Virginia and Pennsylvania to Fairfax County; and reverse commutes from Arlington to Fairfax and Reston.

[16] Metropolitan Washington Council of Governments, *Growth Trends to 2030: Cooperative Forecasting in the Washington Region* (2003) www.mwcog.org/uploads/pub-documents/B1tb20031126144141.pdf

Transit from Virginia's Dulles Toll Road Across the American Legion Bridge in Maryland (Virginia/Maryland)

As shown in the map below, there is no transit service from areas along the Dulles Toll Road and Dulles Airport Access Road (collectively referred to as the Dulles Toll Road) to Maryland and vice versa. Yet there are a significant number of drivers who make this trip, mostly traveling between inner suburban locations north of the Potomac River and areas such as Tysons Corner, Dulles Airport, or other locations along the Dulles Toll Road and I-66 corridors. A 2004 VDOT study showed that Maryland-registered vehicles made up approximately 30 percent of the vehicles traveling west on the Dulles Toll Road and Dulles Airport Access Road (though VDOT's analysis neglected to highlight that a large share of these Maryland trips originated from locations inside the Capital Beltway).[17] Bus rapid transit services on Capital Beltway toll managed lanes and key radial routes in Virginia could provide these commuters with a better option than sitting in traffic, and help reduce pressure to expand existing highways or build new sprawl-inducing outer beltways.

FIGURE 8: DULLES TOLL ROAD



Source: Washington Area Metropolitan Transportation Authority

Transit Across the Wilson Bridge (Virginia/Maryland)

The most expensive transportation project in the region now under construction is the $2.43 billion, 12-lane replacement for the existing 6-lane Wilson Bridge, which carries the Capital

[17] Virginia Department of Transportation. May 10, 2004. VDOT Releases American Legion Bridge Commuting Patterns. www.virginiadot.org/infoservice/news/newsrelease.asp?ID=NOVA-NV04-17

Beltway across the Potomac River south of Washington, DC. Scheduled to open in 2008, the project aims to reduce congestion on and around the bridge, which currently carries more than three times the traffic it was designed to handle.[18]

Despite long-standing congestion problems, the existing bridge currently has only limited bus service running across it. Two of the 12 lanes now under construction must be used for future rail or bus transit or HOVs to satisfy the project's legally binding environmental and planning agreements. (The bridge structure is designed to accommodate heavy rail options.)

However, Maryland and Virginia officials have not even discussed, let alone begun, planning for improved transit options in this corridor. According to *The Washington Post*, "Maryland leaders say they're not considering rail because Virginia opposes it, while Virginia's transportation secretary said the state is open to rail and other possibilities."[19] Without improvements to transit options and services, the ability of the new bridge to mitigate traffic congestion will be seriously hindered. BRT may be the most promising option to expand travel choices across the bridge in the near term, as it could likely be implemented much more quickly and at less cost than a rail option.

It is worth noting that groups advocating rail across the Wilson Bridge, including the Sierra Club, Coalition for Smarter Growth, and 1000 Friends of Maryland, recently convinced the developer of National Harbor, a large mixed-use center immediately south of the Wilson Bridge in Maryland, to add housing to this center, with more emphasis on walkability and a sense of place. These promise to boost the viability of transit investment and transit-focused development in the corridor.

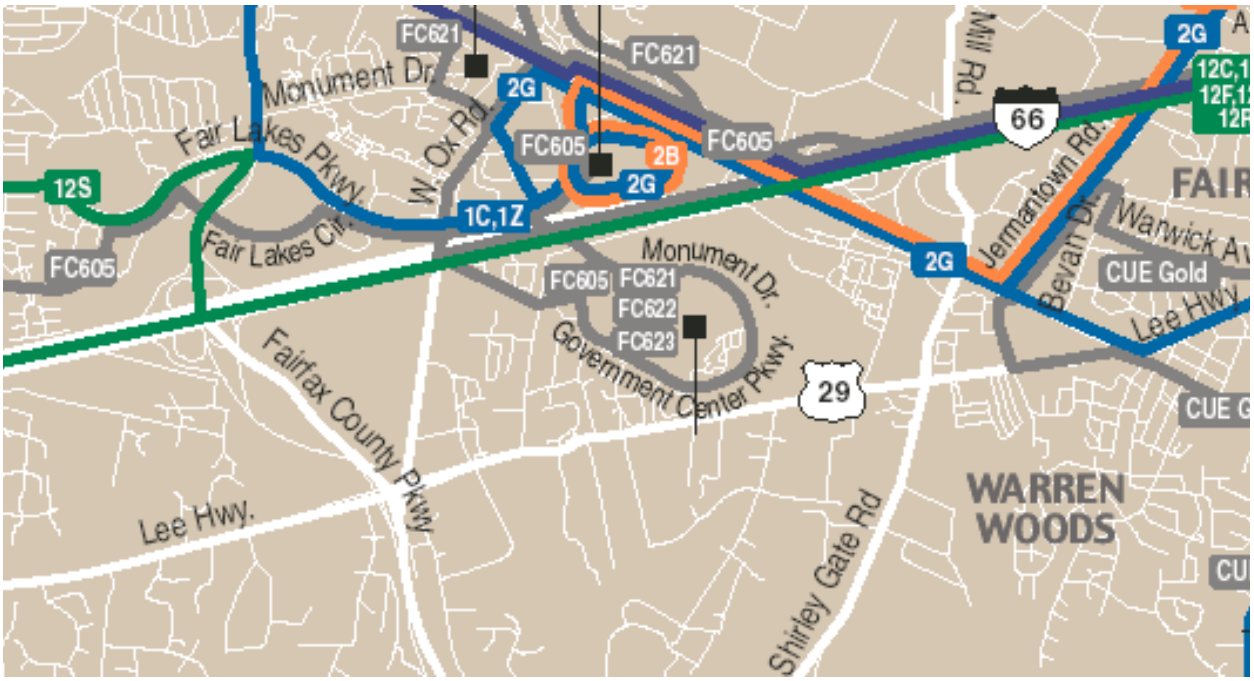
Transit From I-66 to I-95 (Virginia)

Commuters traveling from areas along I-95 south of Washington, DC, to points along I-66 currently have little or no convenient transit options, especially those traveling along the Fairfax County Parkway, as shown in the map below.

[18] Woodrow Wilson Bridge Project: *Project Overview 2004-2005*. www.wilsonbridge.com/pdfs/2004_overviewBrochure_Final.pdf

[19] Ginsberg, Stephen. June 29, 2005. Transit Plan for New Bridge Stuck in Official Gridlock. *The Washington Post*.

FIGURE 9: TRANSIT FROM I-66 TO I-95



Source: Washington Area Metropolitan Transportation Authority

This service gap could provide an opportunity to provide BRT or other bus service, giving drivers an incentive to use alternative forms of transportation, rather than driving alone along the parkway.

Transit on I-66 From Haymarket (Virginia)

While there are several efforts underway to limit growth in Haymarket, VA, and other western suburbs, some large-scale growth is likely to occur over the next several years. Transit service likely will be needed to enable people to travel from points west into Washington, DC, Arlington and Fairfax.

Although commuters may pass existing transit options along I-66, particularly the Orange line at the Vienna Fairfax Metro station, the park-and-ride lots are filled and trains are often overcrowded. Moreover, these trains must stop at eight intermediate stops before reaching the Potomac River.

BRT along I-66 could provide another option with new express services. This could help overcrowding on Metro's Orange line and could provide a viable alternative to widening I-66 inside the Beltway, as some have recently proposed to the dismay of Arlington County residents and officials and others.

Poorly Served Areas/Areas Needing Enhanced Service

Many areas are currently served by several transit options, including Metrorail, Metrobus, Virginia Railway Express, local transit services like OmniRide, and private express bus services. In some places, however, transit service is not meeting demands. The following locations are served by transit but were identified by charrette participants as potentially needing additional service.

Georgetown/K Street (Washington, DC)

Georgetown and the K Street corridor are served by the Georgetown Metro Connection, ten Metrobus routes, and ten shuttle bus routes.[20] However, a June 2004 study by the DC Department of Transportation and Washington Metropolitan Area Transit Authority showed that only 12 percent of DC residents can reach Georgetown in less than one hour by transit.[21] In addition, the road infrastructure along K Street leading into Georgetown is deteriorating, bus service along this route is slow and unreliable, and the service lanes are not used efficiently.

Charrette participants identified the Georgetown/K Street area as a potential service opportunity for transit. Indeed, District officials have proposed the construction of a K Street busway, which would be an urban arterial type of BRT likely enjoying much closer stop spacing and higher frequency services than the more commuter-rail-like BRT services that might operate in HOT lane corridors. According to WMATA, a busway in this corridor would significantly reduce bus travel time and save $1.9 million per year in bus subsidies and $5.5 million per year in capital costs from reduced fleet requirements.[22]

The K Street busway could be linked to express bus or BRT service through I-66. This could be particularly effective if I-66 is converted into a HOT lane facility in lieu of widening.

Southeast Washington, DC/Site of New Baseball Stadium (Washington, DC)

With the relocation of the Montreal Expos baseball team to Southeast Washington (where a new 41,000-seat stadium is being developed), there are ambitious plans to rebuild this section of the District.[23] Additional transit options will be needed to accommodate new residents, businesses, and visitors associated with this redevelopment, especially as the Orange line reaches its maximum capacity in downtown Washington.

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[20] The Georgetown Project web site (2005)
www.thegeorgetownproject.org/displaycontent.asp?keyword=transportation

[21] District of Columbia Department of Transportation, Metropolitan Washington Transportation Authority, *District of Columbia Transit Improvements Alternatives Analysis: Need Assessment* (2004)
www.dctransitfuture.com/pubs/p1.pdf

[22] District of Columbia Department of Transportation, Metropolitan Washington Transportation Authority. *K Street Busway Project.* www.wmata.com/about/expansion/kst_busway.pdf

[23] Government of the District of Columbia Office of the Chief Financial Officer, *Phase I Environmental Site Assessment: The New District of Columbia Baseball Stadium* (2005)
cfo.dc.gov/cfo/frames.asp?doc=/cfo/lib/cfo/services/Appendix_C_Phase_I.pdf

Columbia Pike (Arlington, VA)

In September 2003, Metro and Arlington Transit added new bus service along Columbia Pike in Arlington. This included direct Metro and Arlington Transit bus routes to the Pentagon and additional service in the residential neighborhoods near Columbia Pike. [24] According to WMATA, these modest improvements enabled buses to provide service equivalent to Metrorail's Blue line, but at a small fraction of the cost.[25]

Arlington County also is seeking to revitalize Columbia Pike by bringing more mixed-use development to the corridor. When this new development is complete, enhanced transit services likely will be necessary.

Recognizing this, local officials currently are participating in the Pike Transit Initiative – a year-long study of potential high capacity, environmentally friendly transit options for Columbia Pike. Transit alternatives under consideration include BRT and streetcars.[26]

Streetcars can be of value as short-distance, low-speed neighborhood circulators that bring a strong identity to the transit service and the area it serves, like the Portland Streetcar in Oregon. However, they are less effective at serving regional travel and typically come at a higher cost. Streetcars would be unable to connect directly to a regional HOT lane network and would likely necessitate more forced passenger transfers, which add delays to transit trips. Streetcars are limited to the location of their tracks and these tracks can create problems for other modes in the street, such as bicycles. BRT can also be designed, like streetcars, to yield a strong positive identity for corridor transit service and the area it serves, particularly if attention is given to station and vehicle design and system marketing.

Annandale/Little River Turnpike (Virginia)

Only a few bus routes currently serve Annandale, most only serving the Pentagon or the King Street Metro station. Very few routes connect Annandale with Tysons Corner, Arlington, Springfield or other job centers. In addition, the closest Metro station is Dunn Loring-Merrifield, which is too far to make Metro convenient for most commuters.

Thus, Annandale may be significantly underserved by transit. This lack of service forces many people into cars, leading to congestion along the Beltway between Little River Turnpike and I-66, as well as to spillover congestion on local roads.

Moreover, a new 200,000-square-foot office building is under construction on Little River Turnpike within yards of the Beltway. Advertisements claim the building will be commuter friendly, with landscaped pedestrian walkways.[27] However, it appears these walkways will lead

[24] Arlington County Commuter Services, *What is Pike Ride?* http://www.commuterpage.com/PikeRide/
[25] Layton, L., Columbia Pike Gets Bus Equivalent of Subway Service. *The Washington Post.* p. B01 (September 11, 2003) www.washingtonpost.com/ac2/wp-dyn?pagename=article&contentId=A57487-2003Sep10&notFound=true
[26] Pike Transit Initiative, slides from public "open house" presentation. http://www.piketransit.com/downloads/04-2005-Public-Open-Presentation.pdf
[27] Heritage Center Annandale web site. www.heritagecenterannandale.com/officebuilding.html

only to the garage and parking area, rather than to any form of transit. New express bus service could expand travel options in this area; investment in BRT service and stations could help make the area more transit-oriented.

Tysons Corner

Tysons Corner, a sprawling, automobile-dominated major activity center with more jobs than downtown Baltimore, Maryland, is served by some transit, but these services carry only about one in 20 work trips destined for the area. At least six Fairfax County Connector bus lines and 12 Metrobus lines serve the Tysons Corner area and run on or near the Beltway during peak periods. Most of the Fairfax Connector buses are local connectors that travel around the Tysons Corner area as circulators or make stops in nearby residential areas. The Metrobuses travel to surrounding job centers in Arlington and to the Dunn Loring-Merrifield, East Falls Church, and West Falls Church Metro stations. Tysons Corner's pedestrian-hostile urban design, including its notorious lack of sidewalks and other pedestrian amenities, and extensive free or low-cost automobile parking, pose a major barrier to reducing car-dependence and increasing bus or rail transit use in this center.

A Metro extension is planned for Tysons Corner at a projected cost of over $200 million per mile. Even with this extension, much of Tysons Corner will remain beyond easy walking distance of a Metro station. Official studies suggest the multi-billion dollar Metro extension will capture only 15,000 new transit riders, most of whom are bound for DC from the proposed Wiehle Avenue station parking garage, at a cost of $95,000 per new daily rider during the opening year.[28]

Over the next several years, Tysons Corner will be transformed by a series of new developments, substantially increasing the density of the area yet at the same time offering opportunities to make the area more transit friendly and walkable. For example, a recent *Washington Post* article noted that "the owners of Tysons Corner Center, already the region's largest mall, are developing a plan that would double its size and move toward transforming the iconic suburban shopping destination into something like a small city."[29]

Currently, very few of the Metrobuses that serve Tysons Corner travel into Washington, DC, thereby limiting travel into the city and requiring a transfer to the crowded Orange Metro line. There also are very few transit routes that use the Beltway to connect Tysons Corner to places such as Bethesda or Springfield. Express buses on the Beltway and I-66 could have great value in enhancing Tysons Corner's transportation options, with or without the expensive planned Metro extension. Development of BRT stations as part of an integrated BRT-HOT lane system that also extends to connecting arterial streets in the area could be helpful in accelerating the transition of Tysons Corner into a more pedestrian-, bicycle-, and transit-oriented center.

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[28] Whorisky, P., Price Soars For Extension Of Metrorail. *The Washington Post.* p. A01 (June 25, 2005) www.washingtonpost.com/wp-dyn/content/article/2005/06/24/AR2005062401636.html?nav=rss_metro; and www.dullescorridorrail.com/update.htm.

[29] Whorisky, P., Rebirth at Tysons Corner. *The Washington Post.* p. B01(February 4, 2005). www.washingtonpost.com/wp-dyn/articles/A61819-2005Feb3.html

Dulles Toll Road (Virginia)

Transit on the Dulles Toll Road is limited to just one Metrobus route and some Fairfax Connector Service. There is no transit service that provides a *direct* connection between western Fairfax County and important parts of the region, such as Bethesda or Springfield. A trip today from Dulles Airport to Bethesda, for example, requires use of a premium express bus connecting the airport to West Falls Church Metro, followed by a long and circuitous Metro journey, transferring between two lines, typically requiring over 90 minutes of travel time – nearly three times longer than by private car. An expensive proposed Metro extension to Dulles Airport, which faces even more considerable financing problems than the Metro extension from West Falls Church to Wiehle Avenue, would not remedy this problem. Express bus or BRT service could run along the Dulles Toll Road and then onto the Beltway, addressing these unserved transit markets. BRT services could extend on key arterials into Reston town center and employment centers in the Herndon area.

Seminary Road (Alexandria, VA)

Charrette participants identified the area near I-395 and Seminary Road, known as Mark Center, as both an area where enhanced transit service is needed and an emerging activity center. While already served by numerous bus lines and nearby Metrorail, the city of Alexandria has approved plans for a project that would bring 1.3 million square feet of additional office space at this location.[30] With this growth, the existing transit options may not be sufficient to meet demand, and opportunities for other transit options (such as BRT service along I-395) may be necessary.

Emerging Activity Centers

Potomac Yards (Alexandria, VA)

Potomac Yards in Virginia currently has very little transit service. Expected development will bring several thousand new jobs and residents to the corridor, all of whom will require transportation services.

There are plans to increase bus service in the corridor. This is not a long-term solution and a more permanent solution with greater capacity will be necessary. One option is BRT or a new Metrorail station. Given the cost of adding Metro and current funding constraints, BRT on Route 1 through Crystal City and Potomac Yards is a more attractive option.[31] This service could link with the Crystal City Metro station. In 2002, Virginia's Department of Rail and Public Transportation studied the impact of adding transit (bus or rail) from the Pentagon Metro station down Route 1 and the Jefferson Davis Highway to the Braddock Road Metro station.

[30] City of Alexandria, Virginia, *Annual Report 2003.* ci.alexandria.va.us/city/annual_reports/report2003/ar2003.pdf
[31] Arlington County Commuter Services, Upcoming Events: Crystal City/Potomac Yard Transit Improvements. www.commuterpage.com/eventdetail.cfm?eventID=331

I-495/I-95 Interchange (Springfield, VA)

Two locations in Springfield near the I-495 (Capital Beltway)/I-95 interchange were identified by the Council of Governments in 2002 as emerging activity centers. These areas had the greatest number of jobs per acre of any of the 20 suburban employment centers identified in the report.

By 2025, both areas will still lead the suburban employment centers in job density and will experience significant job growth. The current level of job density and the predicted growth indicates that more transit will be necessary in the Springfield area to accommodate transport demand to the area. A transfer center between BRT services on I-95/I-395 and I-495 might also provide transfer access to local circulator transit services in what is currently an automobile-oriented neighborhood.

Metro West (Fairfax, VA)

Fairfax County is planning a mixed-use, transit-oriented, pedestrian-friendly community just south of the Vienna-Fairfax-George Mason University Metro station. The plans call for more than 2,200 new townhouses, condominiums, stores and offices, making the area an emerging activity center.[32] Transit improvements in this area, including possible BRT services, could help ensure the success of this development plan.

Fort Belvoir (Virginia)

The Department of Defense recently announced plans to move more than 18,000 jobs from the Pentagon to Fort Belvoir, a military installation located in Fairfax County. Fort Belvoir currently is not served by Metro. Therefore, moving jobs to this location without an increase in transit service will likely exacerbate congestion throughout the area. Anticipating these challenges, regional officials already are studying the potential for extending light rail to Ft. Belvoir.[33] As mentioned above, however, the prospects for major new rail investments are not promising, given the lack of available funding and the amount of resources devoted to rail in the Dulles Corridor. New express bus and BRT services might be far more practical, timely and cost-effective for those working at Ft. Belvoir. Even bus-based transit services, however, will be challenged to provide convenient, attractive, economically viable alternatives to driving within this dispersed, congested, largely automobile-oriented employment area.

Fredericksburg/Stafford County/Spotsylvania County

Several factors have made the Fredericksburg area, along with surrounding Stafford and Spotsylvania Counties, an emerging activity center. Soaring real estate prices in the close-in

[32] Rein, L., Mini-City Plan Discourages Use of Cars. *The Washington Post.* p. B01 (June 22, 2005) www.washingtonpost.com/wp-dyn/content/article/2005/06/21/AR2005062101564.html

[33] Smith, L., Metro Studies Ft. Belvoir Extension. *The Washington Post.* p. B01 (May 20, 2005) www.washingtonpost.com/wp-dyn/content/article/2005/05/19/AR2005051901618.html; and Spencer, S. & Cohn, D., Pentagon Plans to Close 180 Sites, Shift Area Jobs to Outer Suburbs. *The Washington Post.* p. A01 (May 14, 2005) www.washingtonpost.com/wp-dyn/content/article/2005/05/13/AR2005051301816.html

suburbs around Washington, DC, for example, have led many people to purchase homes in far outlying areas, such as Fredericksburg. In addition, Fredericksburg is located in close proximity to several military installations, including Fort Belvoir and Quantico Marine Corps Base. Finally, several major companies, including Capital One Financial Services and Dominion Power, have located their headquarters or large offices in the Fredericksburg area.[34] These factors are combining to make the area a booming activity center, which only stands to increase its growth rates if the Department of Defense transfers thousands of jobs from the Pentagon to Fort Belvoir and other military bases. With all this growth, Fredericksburg will need better transit connections with other areas in the region, including Washington, DC.

The Virginia Railway Express (VRE) commuter rail provides important service to the Fredericksburg-Pentagon-Washington, DC corridor, but mostly provides morning in-bound and evening out-bound service for commuters in this market. While this provides a valuable option for many commuters, VRE shares its track with freight railroads, limiting VRE's capacity and service reliability, and at times seriously compromising schedule adherence. Proposals have recently been advanced for development of a third track to boost rail passenger and freight capacity and reliability in this corridor, which could cost roughly $300 million; however, financing remains uncertain. There also are proposals for transit-oriented development at some VRE stations in the corridor. BRT service on I-95 HOT lanes might complement existing or improved VRE services, while potentially providing a one-seat ride to more destinations and serving some reverse commuters.

It should be noted that major investments that significantly expand transportation capacity to areas at the outer edge of Washington DC's commuter shed - such as new commuter rail, HOT lane, and BRT services extending to Fredericksburg - pose a high risk of further exacerbating sprawl development. It is important that such proposals be advanced together with initiatives to evaluate and mitigate related induced land use and traffic impacts.

[34] Simply Fredericksburg web site. www.simplyfredericksburg.com/fredericksburg/fredericksburg.shtml

CHAPTER 5

HOT Lanes and Transit in Current I-95/395 Proposals

To understand how a HOT lane/BRT system might serve these markets, it is first important to understand what is being proposed. For purposes of this paper, we are focusing on two competing proposals to build HOT lanes on I-395/95, which are the subject of an ongoing review by Virginia and regional officials. The first proposal was submitted by a consortium led by Fluor Daniel. The second proposal was submitted by a consortium led by Clark Construction. The following is a summary of the major provisions of the Fluor and Clark proposals.

TABLE 2: HOT LANE PROPOSALS FOR I-395/95

Segment or Attribute	Length	Fluor	Clark
14th Street bridge to I-495	10 miles	Re-stripe to create 3 lanes: • NB exit at Edsall Road • SB entry at Route 110 • Southbound (SB) entry and NB exit at Eads Street • SB entry and NB exit at Seminary Road	Re-stripe to create 3 lanes: • Northbound (NB) exit at Edsall Rd
I-495 to Route 234	18 miles	Re-stripe to create 3 lanes: • NB and SB entries and exits at Lorton Road • SB entry at Prince William Parkway • NB and SB entries and exits at Route 234	Re-stripe to create 3 lanes: • SB and NB exit at Dale Boulevard • SB exit at Route 234
Route 234 to Route 610	9 miles	2 new HOT lanes: • SB entry and NB exit at Route 619 • NB and SB entries and exits at Garrisonville Road	3 new HOT lanes: • SB exit and NB entry at Russel Road • SB exit and NB entry at Garrisonville Road
Route 610 to Route 17	11 miles	2 new HOT lanes: • SB entry and exit and NB entry at Courthouse Rd • NB entry and exit and SB exit at Route 627 • SB exit and NB entry at Route 17	2 new HOT lanes: • SB exit and NB entry at Courthouse Rd • SB exit and NB entry at Route 627 • SB exit and NB entry at Route 17
Route 17 to Route 1	7 miles	2 new HOT lanes: • SB entry and exit and NB entry at Route 3 • SB exit and NB entry at Route 1 • SB exit and NB entry at Route 17 bypass • SB exit and NB entry at Massaponax terminus	New general purpose (GP) lane northbound and new, 2 mile collector/distributor road between Route 17 and Route 3.
Bus Transit	N/A	• $65 million for bus stations, stops, and park-and-ride lots	$30 million for new park-and-ride lots.

		• Control center to be co-located with I-495 control center	
Rail Transit	N/A	N/A	$30 million for new VRE rail cars
Transit operating costs	N/A	• Under tax exempt option, $510 million (nominal) estimated to be available for transit over agreement life (senior to subordinate debt) • Under concession plan, $1 billion (nominal) available for transit in annual installments over 60 years, or $250 million lump sum up front, all of which is guaranteed.	Estimated $450 million available for transit over life of agreement (subordinate to debt service)
Total Proposed Cost	n/a	$913,500,000	$815,975,000

Although both proposals hold the potential for creating new transit opportunities, they raise significant questions that need to be resolved as part of the project approval and environmental review processes.

Tolling Existing Capacity

Both proposals would convert existing HOV lanes to HOT operation and add an additional HOT lane. They also would leave existing general purpose lanes unmanaged and, in the case of the Clark proposal, add new general purpose lanes. It is important to consider options where existing lanes are converted to managed operations, and these options should be considered before new HOT lane projects are approved.

Converting existing lanes to managed operations can yield substantially more peak period capacity by addressing what traffic engineers have termed "the freeway congestion paradox."[35] Maximum traffic volumes are achieved when vehicles travel at 55 to 65 mph. At a threshold of about 2,000 vehicles per lane per hour, traffic flow breaks down, causing speed and vehicle throughput to fall precipitously. Though demand may decrease after the peak period, the highway's throughput capacity does not recover fully until queued vehicles have had time to clear. By using price to regulate the number of vehicles using the road, tolling can ensure that traffic flow does not break down in the first place. This *increases* highway vehicle throughput in peak periods, without the need for new lanes.

For example, the managed lanes in the median of SR-91 in Orange County, California almost always operate at speeds of 60 to 65 mph. In the peak hour, they carry almost as many vehicles as are moved in the parallel unmanaged lanes, even though there are double the number of these lanes. [36] As Patrick DeCorla-Souza of the Federal Highway Administration notes, "Almost half

[35] Chen, Chao and Varaiya, Pravin, The Freeway-Congestion Paradox. *Access*. Number 20, Spring 2002.
[36] U.S. Department of Transportation. *Report on the Value Pricing Pilot Program through March 2004.* See: knowledge.fhwa.dot.gov/cops/hcx.nsf/All+Documents/AD276ECC2E3A077885257005006B5614/$FILE/March%202004%20Report%20of%20Congress.pdf

the public investment in SR-91's free lanes is simply wasted in peak hours." By pricing and managing existing lanes on limited access highways, we could "restore to full use the public investment that is being wasted every day in major metropolitan areas on congested highways, during critical times of the day when the investment is most needed." [37]

Tolling existing lanes could raise more revenue that could be used to support transportation alternatives in the corridor. In general, the more existing lanes are tolled, the higher the toll revenues and the lower the capital costs.[38] A study of a potential network of HOT lanes in the Minneapolis-St. Paul region suggests tolls could cover only 15 to 55 percent of the cost of building new toll lanes, indicating that tolling existing lanes can be more economically viable.[39]

Existing lanes and/or right-of-way also could be used to create a combination HOT/BRT lane. One solution would be to establish extra "Rush Hour Lanes" by re-striping the highway to allow shoulder use during rush hours. This strategy has been implemented on I-66 outside Washington, DC's Beltway, and is more extensively used in the Netherlands. By creating an extra rush hour lane in each direction, it would be possible to take away the extreme left lane from general-purpose use and restrict it to buses and HOVs or toll-paying vehicles. To ensure safety, overhead signs would be employed above each lane to indicate when a particular lane may be closed due to a vehicle breakdown ahead. The signs would also display the lower speed limits that would apply to all lanes during rush hours. This would ensure that safety will not be compromised by use of the shoulder lane. Also, lower speed limits may reduce the type of crashes that sometimes result from speed differentials between the Bus/HOT lane and the general-purpose lanes.

Creating rush hour lanes on the entire highway, as proposed by Patrick DeCorla-Souza of the Federal Highway Administration, might offer even greater congestion relief.[40] Under this system, shoulder lanes would be used only if incidents or accidents cause lane closures. Rush hour speeds up to 60 to 65 mph would be possible under normal conditions, and recurring congestion would be eliminated by managing demand with electronically charged variable tolls. Credits can be offered to regular customers, and these credits could be used to pay for commuter carpool parking, transit fares, or for peak period tolls. Credits could even be supplied by employers (similar to Washington, DC's transit Metrocheck program).

ETR-407 in Canada shows that it is possible to toll all lanes in a way that is convenient to highway users.[41] Opened in 1997, ETR-407 is the world's first open-access toll highway. All lanes are tolled, but there are no toll booths. Automated toll collection is installed at all entry and exit points, automatically billing customers as they drive by. Regular users have transponders that debit an account. Infrequent users are billed by mail with a $1 surcharge. A

[37] DeCorla-Souza, Patrick. 2005 (forthcoming). Improving Metropolitan Transportation Efficiency With FAST Miles. *Journal of Public Transportation.*

[38] DeCorla-Souza, Patrick, Evaluation of Toll Options Using Quick-Response Analysis Tools: A Case Study of the Capital Beltway. *Transportation Research Record 1839*. Paper No.03-2946 (2003), Transportation Research Board, Washington, DC.

[39] Cambridge Systematics, Inc. and URS Corporation, *MnPass System Study*. Final Report. Prepared for the Minnesota Department of Transportation.

[40] DeCorla-Souza, op.cit.

[41] See www.407etr.com.

similar system could be used to better manage traffic on Washington-region highways; special provisions could be made for low- and moderate-income travelers in the corridor.

Air Quality

The air quality ramifications of both proposals need to be better understood, given their impacts on public health. Mobile sources account for 70-90% of the cancer risk from air pollution in U.S. metropolitan areas and one-third to one-half of the precursors of ozone pollution. Health risks are even greater in areas adjacent to freeways, and these impacts are particularly noted on children.[42] The addition of new HOT lanes without managing existing lanes will in many cases tend to increase long-term air pollution by inducing new traffic growth and sprawl when compared to no added road capacity.[43] Adding low emission BRT vehicles to HOT lanes can help improve air quality and boost efficiency in the use of scarce roadway capacity.[44]

Tolling existing lanes in the I-95/395 corridor could help increase throughput while helping to avoid adverse impacts on sprawl development, traffic growth, air and water pollution, and greenhouse gas emissions. Thus far, the Virginia and Maryland Departments of Transportation and the regional Transportation Planning Board have shown little regard for substantial public demands for such a broader examination of managed toll lane options and impacts. [45]

Length of HOT Lanes

The Fluor proposal extends HOT lanes to Route 1 south of Fredericksburg, whereas the Clark proposal terminates the HOT lanes seven miles closer to Washington and substitutes new general purpose lanes as well as a collector-distributor road. These general purpose lanes and the C-D road are likely to have a greater induced traffic impact than the longer HOT lane system, and provide for less effective long-term traffic management. The Clark proposal effectively shortens the available right-of-way for a congestion-free transit facility, making it less attractive for BRT in that area.

Number of Entry/Exit Points

To effectively serve markets with transit, the HOT lanes will need entry and exit points that enable the BRT vehicles to serve neighborhoods in the corridor. The Fluor proposal includes many more entry and exit points than the Clark proposal. Particularly notable is the fact that the

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[42] Michael Replogle and John Balbus, M.D., M.P.H, Considering Cancer Risk in Transportation Decision-Making. *Environmental Manager*. p. 14-17 (June 2005)

[43] Sullivan, E., Evaluating the Impacts of the SR 91 Variable-Toll Express Lane Facility Final Report (1998); and Leman, C., Schiller, P., & Pauly, K., Re-Thinking HOV-High Occupancy Vehicle Facilities and the Public Interest, Chesapeake Bay Foundation (1994)

[44] Bogotá, Columbia's Transmilenio BRT resulted in a 40% drop in overall air pollutants (gulliver.trb.org/publications/tcrp/tcrp_rpt_90v1.pdf) – overall sulfur dioxide dropped 43%, nitrogen dioxide 18%, and particulate matter 18% (www.itdp.org/PR/CapeTown_51303.html). The reduction in vehicle traffic following BRT implementation in Curitiba, Brazil, has also led to one of the lowest rates of ambient air pollution in the country and 30% less fuel consumption per capita. www.fta.dot.gov/7694_7697_ENG_HTML.htm

[45] Replogle, Michael, Letter to Chris Zimmerman, Chairman, Metropolitan Washington Transportation Planning Board (April 6, 2005), *Proposed 2005 CLRP – Region Must Consider Value Pricing and Transit Alternatives to Mitigate Adverse Health Impacts of Proposed Highway Expansions*.

Fluor proposal includes entry and exit points inside the Beltway at Seminary Road, Eads Street, and Route 110, whereas the Clark proposal does not. Between the Beltway and Route 234, the proposals are more similar. For example, Fluor has an entry/exit point at Lorton Road whereas Clark includes an entry/exit point at Dale Boulevard. Further study is needed to determine whether one is preferable to the other, or whether entry/exit points are needed at both locations.

Transit Capital Financing

Perhaps the most significant difference between the proposals is the suggested financing levels for transit. Clark proposes to provide $30 million for Virginia Railway Express, which it claims is sufficient to purchase 15 rail cars and add roughly 4,500 new daily trips. Clark also proposes to provide $30 million toward new park-and-ride lots, which it estimates will add roughly 2,000-3,000 new parking spaces.

By contrast, Fluor proposes to provide $65 million toward the construction of five new park-and-ride lots with bus stations, as well as 11 additional bus stations or stops along the route. Not included in this amount is the cost of the additional entry/exit points, a portion of which could be considered supportive of transit.

It is not clear that the Clark proposal to purchase new VRE rail cars will be sufficient to ensure effective new transit capacity. To effectively use these new railcars, VRE will need additional locomotives, parking and other infrastructure. VRE's capacity remains limited by the track available to it, which must be shared with freight traffic, which is likely to continue to seriously compromise both train scheduling and service reliability unless $300 million is secured for a third track.

By including funding for stations and park-and-ride lots, the Fluor proposal appears to offer something closer to a complete system. However, many questions remain, such as the design and siting of the stations, the provision of vehicles, fare collection, maintenance, transit access design aimed at ensuring pedestrian and bike access as well as park-and-ride, and passenger information systems. These issues should be addressed before the project is approved.

Transit Operations and Maintenance Financing

Both the Fluor and the Clark proposals promise funding for transit operations and maintenance.

- Under the Fluor tax exempt plan, roughly $510 million in excess revenues is projected to be available over the financing period. Some or all of this money could be used to support transit.
- Under the Fluor concession plan, VDOT could take a lump sum payment of $250 million or annual installments that would equal roughly $1 billion over the 60-year life of the concession agreement. Some or all of this money could be used to support transit.
- Under the Clark plan, roughly $450 million in excess toll revenues is projected to be available. Some or all of this money could be used to support transit.

There are many unanswered questions regarding these proposals. First, neither proposal includes any estimate of the potential transit operations and maintenance expenses associated with the facilities. Although such expenses can best be estimated by potential transit operators, they nevertheless should be understood before any financing agreement is determined. Both proposals would be stronger if they included resources that could be used to design and model transit operations so that an estimate of operations and maintenance costs can be developed.

Second, there is no guarantee that any of these funds would be available for transit. As currently structured, excess toll revenues or the lump sum payment would accrue to the Commonwealth, which could elect not to use any of the funding for transit. Before either proposal goes forward, there should be a commitment to use a significant portion of toll revenues to support new transit service and to satisfy appropriate quantifiable service and performance standards.

Third, it appears that any excess toll revenues would be subordinate to senior toll revenue bonds and perhaps to other financing sources as well. A significant investment in transit infrastructure would not be useful if it did not include guaranteed financing for operations and maintenance. A portion of toll revenues should be set aside specifically to support transit operations and maintenance, and these revenues should be available upon opening of the facility. Alternatively, if the lump sum option is selected, the Commonwealth should set aside a portion of the lump sum to support transit.

Performance Standards

Although the proposals include some standards for traffic speed and other issues relevant to car use, they lack standards to gauge their effectiveness as multimodal facilities. They also lack standards to assess their environmental impact.

For example, to effectively serve as infrastructure for BRT and high occupancy vehicles, the managed lanes must be operated in a manner that makes BRT and HOV use attractive. This means that the toll rates must be set at a level that provides an economic incentive to use public transportation and shared ride vehicles, especially during peak periods.

Before the project is approved, there needs to be a better understanding of the relationship between toll rates and transit fares, and a commitment to adjust toll rates to provide a guaranteed mode-split or vehicle occupancy rate in the corridor. There is a precedent for such commitments elsewhere. For example, the privately developed HOT lanes in the median of SR-91 were approved subject to the requirement that the toll facility operator increase and sustain high average automobile occupancy levels in the corridor.

A performance standard could require operation of metro Washington area toll lanes in a manner that boosts and sustains a significant increase in non-automobile driver mode share for all tolled corridors. This standard could be met by:

- Adjusting tolls by vehicle type, auto occupancy class and time-of-day to shape the travel choice decisions of both motorists and commercial traffic in the corridor;

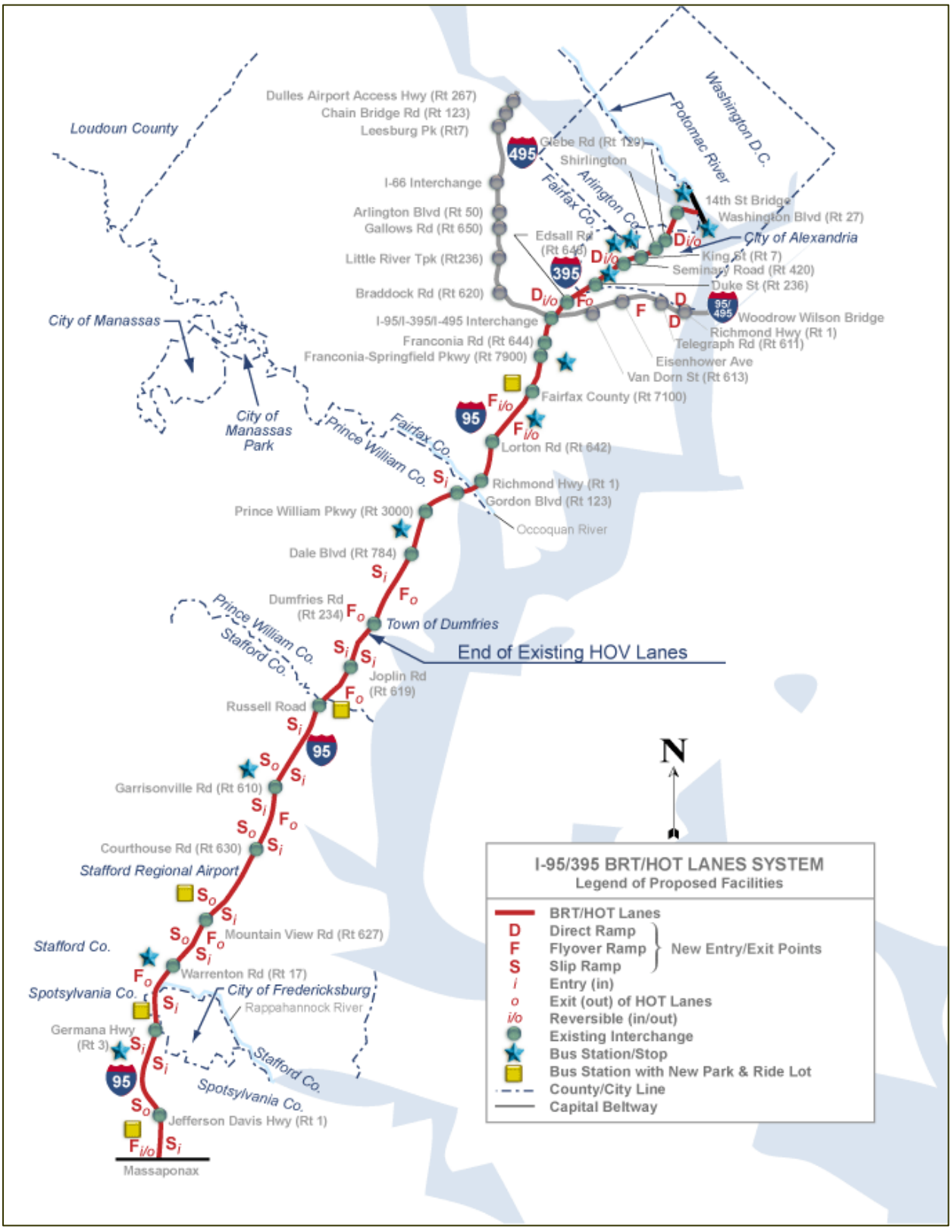
- Tendering and periodically adjusting the terms of transit and para-transit service contracts that might be offered to public or private providers in the managed corridor, with competition for the operating subsidies available from dedicated toll revenues;
- Working with employers, property managers, and transportation management organizations in the corridor to influence the terms of commuter benefits such as transit passes, parking costs and subsidies, guaranteed ride home programs, telework incentives, and travel marketing programs; and,
- Providing grants and incentives for local governments in the corridor to improve their institutional capacity and actions to support more effective growth management, to mitigate induced development impacts of expanded transportation capacity.

There also needs to be performance standards related to air quality. If it appears that a proposed HOT lane project may contribute to violations of ozone or fine particulate standards, the project should identify emission offset strategies that ensure timely attainment of the health standards, both regionally and at potential pollution hot spots along the toll lane corridors. This might include:

- Funding for additional transit operations and toll levels appropriate to provide incentives to use more transit;
- Cleaning up diesel construction and maintenance equipment used in the corridor and investing in accelerated retrofit of diesel transportation equipment frequently operated in the corridor;
- Other operational adjustments, such as increasing toll rates or reducing transit fares automatically on days when it is anticipated that there may be a violation of federal air quality standards.

Finally, there need to be some standards for managing land use impacts associated with the facility. If local jurisdiction land use decisions encourage low density sprawl rather than more clustered, mixed-use, transit-oriented development, this would degrade the performance of the corridor transportation system. Before a project is approved, a land use study should be conducted to better understand the relationship between the proposed network and current land use plans. There also should be commitments by local jurisdictions to make the land use decisions necessary to ensure long-term system effectiveness.

FIGURE 9: HOT LANE NETWORK PROPOSED BY FLUOR CORPORATION TO VIRGINIA DOT



CHAPTER 6

System Design and Operational Concepts

Assuming that the issues identified above can be addressed, there are a number of options available for BRT operations. The system could be designed to mimic a rail system by restricting specialized transit vehicles to the HOT lanes and relying upon feeder services and park-and-ride lots to get passengers into the system. Alternatively, the HOT lanes could be open to any transit vehicle, allowing vehicles to enter and leave the system as needed.

Charrette participants agreed that an open, more flexible transit service approach would be a better orientation in a HOT network environment. Among the generally desired features:

- vehicles would follow local routes and enter the HOT lanes for a congestion-free drive toward their destination;
- passengers could enter the system along these local routes or at intermediate park-and-ride lots, which should also be designed to encourage and facilitate local pedestrian and bicycle access, providing safe walking and cycling routes near stops and secure bicycle parking facilities;
- vehicles would leave the HOT lanes and interface with passengers at a series of off-line stations;
- in a few places, on-line stations might be desirable, such as at a transfer station that enables passengers to transfer from one BRT vehicle to another; and
- the system should connect to other transit facilities, such as rail stations.

The system would provide frequent, all-day bi-directional service. It also would offer a combination of express and local services, enabling passengers to choose the service that best meets their needs.

Potential HOT Lane Vehicle

While operating off the HOT lane network, there are a couple of options. Under the first option, vehicles would operate much like local buses, servicing passengers at local stops and at park-and-ride facilities. Once on the HOT lanes, they would serve as express buses, carrying passengers at highway speeds.

Under the second option, the system would operate more like a light rail transit system. Instead of small bus stops, there might be rail-like stations located at key activity centers, with real-time passenger information systems and level platform, no-step-up boarding. The stations might include fare payment in the station (like Metrorail) to ensure the most rapid boarding through multiple doors. The current plan to equip most regional buses with on-board Smartrip electronic card fare payment collection systems may be an alternative means to speed fare collection, if such contact-less payment cards become routinely used by most riders. The buses would have rights-of-way or technologies that enable them to avoid getting stuck in traffic like ordinary buses. The options include:

- dedicated bus lanes, preferably in the median;
- signal priority or preemption, which forces traffic lights to become or remain green for buses; and/or
- special lanes at intersections that allow vehicles to bypass traffic.

Similar systems are currently in use in a number of cities around the world. They offer the speed, comfort and reliability of rail transit but at a fraction of the cost. Below are some concepts, with additional information available at www.gobrt.org.

Both of these options need to be evaluated before the project is approved. The second option of operating the system like light rail, however, has a number of advantages.

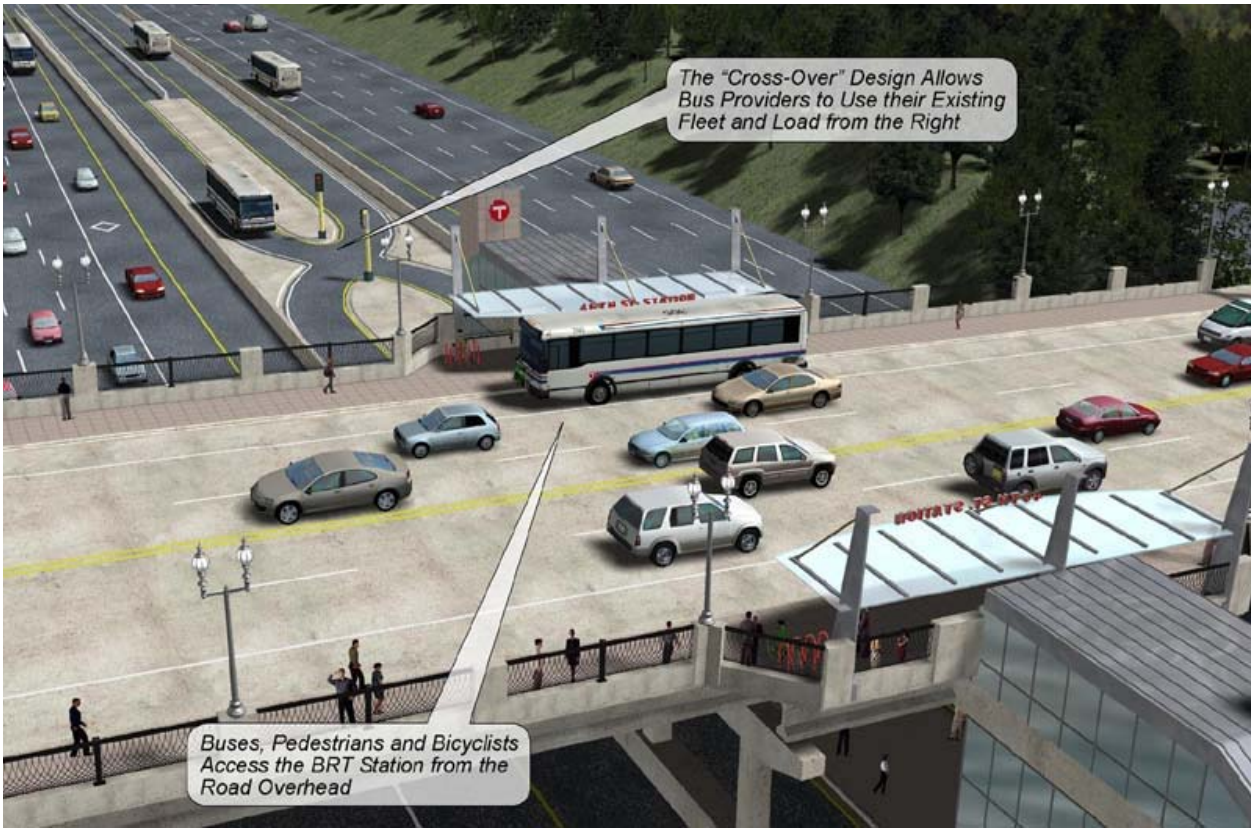
- It is more attractive and comfortable for passengers;
- The rail-like stations can serve as focal points for transit-oriented development, thus helping local jurisdictions make land use decisions that would support the system.
- A dedicated right-of-way enables vehicles to stay out of traffic, taking away one of the major disadvantages of buses.
- It would offer more passengers a single-seat ride, avoiding transfers at park-and-ride lots and/or from feeder systems.

Neighborhood station with wheelchair lift

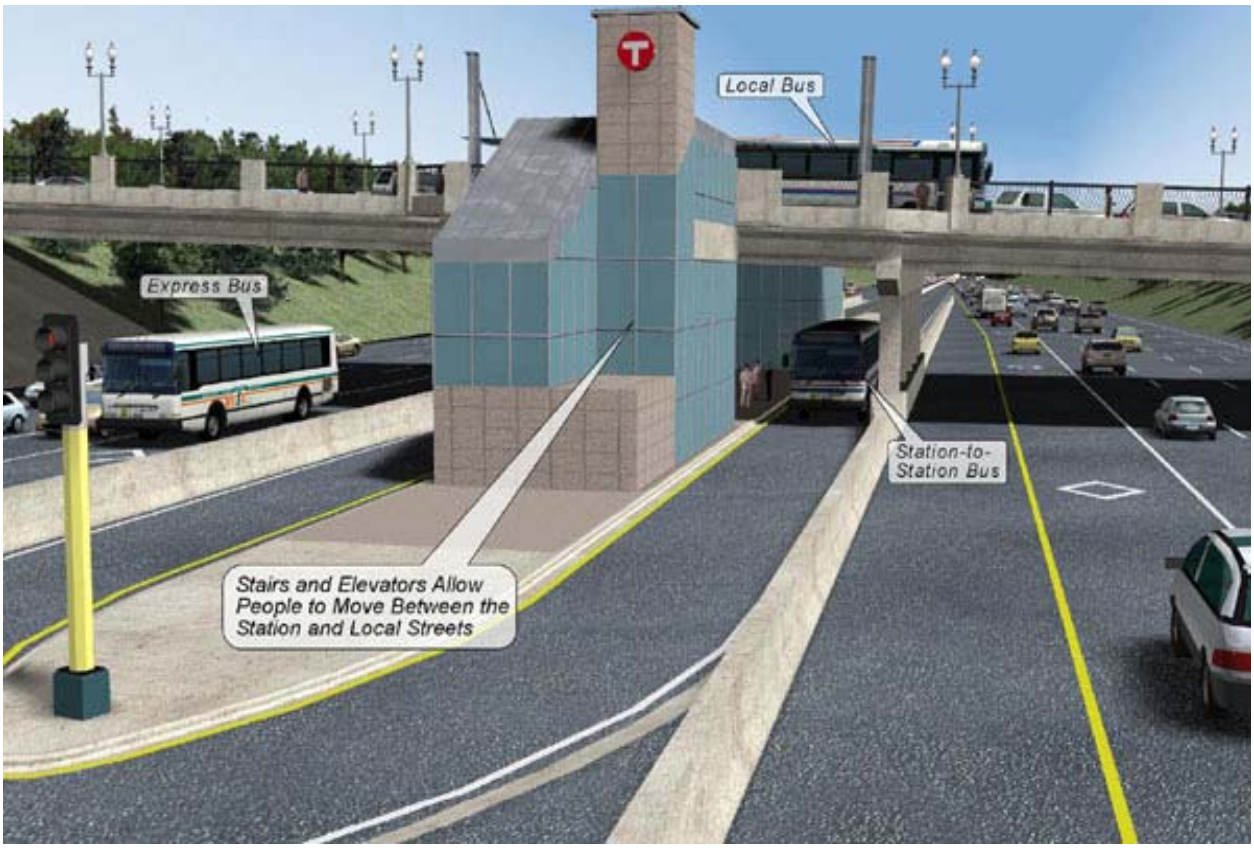
Smart card access integrated with Metrorail

Vehicles would dock with multiple doors, like Metro

Transfer Concept: I-95 vehicles transferring passengers to I-495 vehicles destined for Tysons Corner



Possible concept for an in-line toll managed lane Bus Rapid Transit station to permit transfer to bus or rail service that crosses over HOT lanes. (Courtesy of Minnesota Department of Transportation, I-35W Project, 2004)



Possible concept for an in-line toll managed lane Bus Rapid Transit station (Courtesy of Minnesota Department of Transportation, I-35W Project, 2004)

CHAPTER 7

Challenges and Risks

This section identifies some of the challenges and risks that need to be considered during the planning of the HOT network concept.

One of the greatest challenges faced by toll managed lanes is determining whether the traffic forecasts are accurate and who bears the risk of loss if they are not accurate. This is especially critical on the I-95/395 project, because toll revenues are being promised to help support transit operations. If the government makes a significant investment in transportation infrastructure, and the toll revenues are not available to support operations and maintenance, taxpayers could be asked to make up a significant shortfall.

The risk associated with inaccurate traffic forecasts on toll roads has been recognized by transportation agencies and bond rating firms, such as Fitch Ratings.[46] Transportation agencies are working to improve the accuracy of their traffic models to help avoid this risk in the future. In the DC region, the metropolitan Washington Transportation Planning Board is working to improve the sensitivity and confidence level for its traffic models, thanks in part to critiques by Environmental Defense and the Transportation Research Board, which was commissioned to independently peer review TPB's travel models.[47] Work is ongoing to enhance the regional travel models, especially to improve their capability to evaluate road pricing and time-of-day of travel impacts, two areas where the current models have been weak.

A second challenge is ensuring that tolls are set at the appropriate level. If the price is too high, too few drivers will use the lanes, potentially leading to insufficient toll revenues. If the price is too low, too many cars will use the lanes, leading to congestion. This challenge is compounded by where a transit system is located on the facility, because transit fares will influence HOT-lane and transit use, and sufficient revenues should be available to support both road and transit operations and maintenance.

Forecasting and economic modeling enable a range of strategies to address these issues. Moreover, new toll collection technology enables experimentation and dynamic pricing so that facility managers can optimize toll rates to meet the goals and needs of the facility as conditions change.

A third challenge is determining how scarce right-of-way in tolled corridors will be used. For example, there is a tradeoff between using right-of-way for new lanes and using right-of-way for other facilities, such as in-line transit stations and connector ramps. There are similar tradeoffs

[46] Fitch Ratings, *The Continuing Search for Bliss: Flexible Toll Road Structures* (2004). www.fitchratings.com

[47] *A Citizen Guide to Critiques of the Metropolitan Washington Area Travel Model: What Does it All Mean?*, Smart Mobility, Inc. June 2004. Letter from D. Forkenbrock, Chair, Transportation Research Board, to Peter Shapiro, Chairman, National Capital Region Transportation Planning Board, September 8, 2003; Letter from D. Forkenbrock, Chair, Transportation Research Board, to Christopher Zimmerman, Chairman, National Capital Region Transportation Planning Board, May 10, 2004.

that must be considered outside of the right-of-way, so that provision is made for bus stations, pedestrian-friendly walkways, bike-and-ride and park–and-ride facilities, landscaped surroundings, and other features that will increase the accessibility, efficiency, and attractiveness of the system.

Currently, plans are proceeding to build HOT lanes without including these considerations. Virginia should insist on an analysis of potential station and ramp locations to ensure that the HOT lane design does not preclude necessary transit facilities. This issue is particularly critical along the Beltway, where the current 12-lane alternative will absorb all of the available right of way, leaving little if any space for transit stations, ramps, and other necessary infrastructure. According to a 2003 Transportation Research Board paper by FHWA's Patrick DeCorla-Souza, a 10-lane alternative (with tolls on 6 of the lanes) would generate three times more toll revenue than the 12-lane tolled proposal and would preserve space for transit.[48]

A fourth challenge that has yet to be addressed is managing traffic that will use arterial roads leading to and from new HOT lanes. Will these roads become more congested? Will they be widened? Will new transit services and improvements to walking, bicycling, and travel demand management be used to offset this increased traffic? DeCorla-Souza's 2003 TRB paper indicates that adding two new HOT lanes in each direction to the Capital Beltway in northern Virginia is likely to increase traffic on that road by 12% (36,000 vehicles per day) compared to only a 2% increase if only one new lane is added in each direction, while tolling two existing lanes in each direction. Each of those vehicle trips will start and end on the local and arterial road network. Will toll revenues be available to help mitigate these impacts? Will cars and buses speeded by HOT lanes get stuck on local roads that feed into the HOT lanes?

In the end, public support for toll managed lanes is likely to depend on whether citizens believe they are getting something of value from them at a reasonable cost. If the public believes it gets more travel choices, opportunities to save time and money, and a more reliable transportation system, and believes that their tolls are being used to advance those goals, they are likely to support these new approaches to transportation policy and facility management. If they think the tolls are just another money grab by politicians or corporate interests and feel they are just getting stuck more in traffic on congested roads leading to the new HOT lanes, without getting new ways out of congestion, they will likely get more fed up, creating a backlash against this new approach.

Thus, a balance must be struck. Dedicating a portion of HOT lane revenues to improved transit, including BRT, and ensuring that HOT lanes are designed for efficient BRT system development and use could play a big role in ensuring citizen acceptance of escalating future peak hour tolls and expanded use of market incentives to manage traffic on the Washington metro area's highways. A key part of this balancing act is likely to be the use of strategies to create more managed lanes out of existing capacity, while adding fewer new toll lanes than tolled lanes. The easiest way to do this is probably to adopt more Rush Hour Lanes - converting shoulder lanes to BRT/HOT lanes, just as I-66 shoulder lanes allow HOVs in the peak period. This will also take

[48] DeCorla-Souza, Patrick, Evaluation of Toll Options Using Quick-Response Analysis Tools: A Case Study of the Capital Beltway. *Transportation Research Record 1839*. Paper No.03-2946, Transportation Research Board: Washington, DC.

some re-examination of the widespread assumption that it is only new lanes can be tolled and that there are no viable options to better manage existing general purpose lanes. A growing number of studies suggest new unexplored pathways that deserve a closer look because of substantial potential benefits in congestion relief, cost-savings, and avoided adverse impacts.

This study suggests there are multiple under-served potential transit markets that might benefit from linking BRT development with HOT or toll managed lanes in Virginia, and no doubt there are others in Maryland and the District of Columbia as well.

CHAPTER 8

Conclusion

HOT lanes and other forms of toll-managed lanes appear to have an important role to play in enhancing mobility for future generations of Washingtonians. The decisions we make now will strongly influence how future projects are designed and built. Crucial choices must be made on environmental, financial, land use and other questions that will shape the growth of our region. Before approving any HOT lane projects, local officials should carefully consider these issues and find ways to improve mobility while minimizing the potential harmful effects of new highway capacity. This should be done in an open and inclusive process that considers all viable options.

Appendix A

Sketch Model

Why a Sketch Model?

Good transit planning requires a regional model to estimate ridership. Regional transportation models estimate future trips based on future land use, roadway networks, and transit service.

The model most commonly used for estimating transit ridership in the Washington D.C. region is the model maintained by the Metropolitan Washington Council of Governments Transportation Planning Board (MWCOG TPB). However, there are four significant drawbacks in using the MWCOG TPB model in this project:

1) The model is estimated from 1993 travel survey information and so is out-of-date.
2) The model greatly overestimates existing transit ridership in suburban northern Virginia (demonstrated in graphics below).
3) A major reason for the overestimation is the failure to adequately incorporate local land use characteristics into the estimation process.
4) Running the MWCOG TPB model is time consuming, both in setting up files and in computer time.

Data for Sketch Model

The model works with the same Transportation Analysis Zones (TAZs) used in the MWCOG TPB model. Given that the focus is on transit, the far outlying areas with little transit ridership were eliminated from the model. The model includes the District of Columbia, Montgomery and Prince George's Counties in Maryland, and Arlington, Fairfax, Loudoun and Prince William Counties in Virginia, as well as the Cities of Alexandria, Fairfax, Manassas and Manassas Park.

Transit ridership data is from the 2000 Census long form. These data include the origin and destination TAZ for work trips for about 1/6 of the region's population. In addition to being much more current than the MWCOG TPB household travel survey, the survey size also is much larger. The Census 2000 trip tables were expanded to represent 2010 based on MWCOG 2010 forecasts for population and employment.

The sketch model is programmed in TransCAD software. The MWCOG TPB model roadway and transit networks were imported from TP+ to TransCAD. These networks are "skimmed" to estimate morning peak period congested travel times for single-occupancy vehicle (SOV), high-occupancy vehicle (HOV) and transit.

Model Estimation

Four binomial logit statistical models were estimated:

1) Auto vs. transit where transit walk access is available.
2) Auto SOV vs. auto HOV where transit walk access is available.
3) Auto vs. transit where transit walk access is unavailable.
4) Auto SOV vs. auto HOV where transit walk access is unavailable.

The following variables were statistically significant – primarily at very high confidence levels:

- In-vehicle transit travel time (IVT)
- Transit wait time (WAIT)
- Transit walk time (WALK)
- Transit drive access time (DRIVE)
- Auto (SOV) travel time (SOVTIME)
- Auto (SOV) travel distance (SOVDIST)
- Housing density at the home end (SQRHSM)
- Intersection density at the home end (HI)
- Employment density at the work end (SQRESM)
- Intersection density at the work end (EI)
- Proportion of home TAZ area within ½ mile of Metro station (HMETRO)
- Proportion of work TAZ area within ½ mile of Metro station (EMETRO)
- Fraction of households with under $40,000 household income (INC1)

The intersection density variables are proxies for walkability and are positively related to transit usage.

The estimated coefficients and t statistics for each model are given in the tables below.

Walk Access Transit Model

Variable	Coefficient	Standard error	t stat	Probability
Constant	-3.41117	0.06816	-50.04	0.0000
IVT	-0.00413	0.00091	-4.54	0.0000
WAIT	-0.02602	0.00143	-18.26	0.0000
WALK	-0.01414	0.00184	-7.69	0.0000
SOVTIME	0.03125	0.00214	14.57	0.0000
SOVDIST	-0.04502	0.00561	-8.03	0.0000
SQRHSM	0.00471	0.00052	9.14	0.0000
HI	0.00175	0.00021	8.20	0.0000
SQRESM	0.00165	0.00009	17.62	0.0000
EI	0.00156	0.00014	10.91	0.0000
HMETRO	0.92646	0.03727	24.86	0.0000
EMETRO	0.68134	0.03579	19.04	0.0000
INC1	2.91749	0.08710	33.50	0.0000

Walk Access HOV2+ Model

Variable	Coefficient	Standard error	t stat	Probability
Constant	-2.27678	0.02862	-79.56	0.0000
SOVTIME	0.01009	0.00179	5.65	0.0000
SOVDIST	-0.02561	0.00406	-6.30	0.0000
TIMEDIF3	0.03015	0.00151	19.91	0.0000
SQRESM	0.000826	0.00008	9.79	0.0000
EI	0.000693	0.00013	5.17	0.0000
INC1	2.09224	0.07646	27.37	0.0000

All of the coefficients in the walk access models are statistically significant at greater than the 0.01 percent confidence level.

The great majority of work trips made in the modeled area have possible ways to make a walk access transit trip. Therefore, the drive access sample size is much smaller. While many of the estimated coefficients are highly significant statistically, some are less significant. This is probably due primarily to the smaller sample size.

Drive Access Transit Model

Variable	Coefficient	Standard error	t stat	Probability
Constant	-5.34045	0.24584	-21.72	0.0000
IVT	-0.00356	0.00272	-1.31	0.1902
WAIT	-0.01440	0.00399	-3.61	0.0003
DRIVE	-0.01017	0.01336	-0.76	0.4466
SOVTIME	0.02584	0.00748	3.45	0.0006
SOVDIST	-0.03013	0.01685	-1.79	0.0738
SQRHSM	0.01121	0.00308	3.64	0.0003
HI	0.00467	0.00132	3.54	0.0004
SQRESM	0.00217	0.00046	4.74	0.0000
EI	0.00325	0.00072	4.53	0.0000
EMETRO	1.02043	0.17223	5.93	0.0000
INC1	4.32318	0.42086	10.27	0.0000

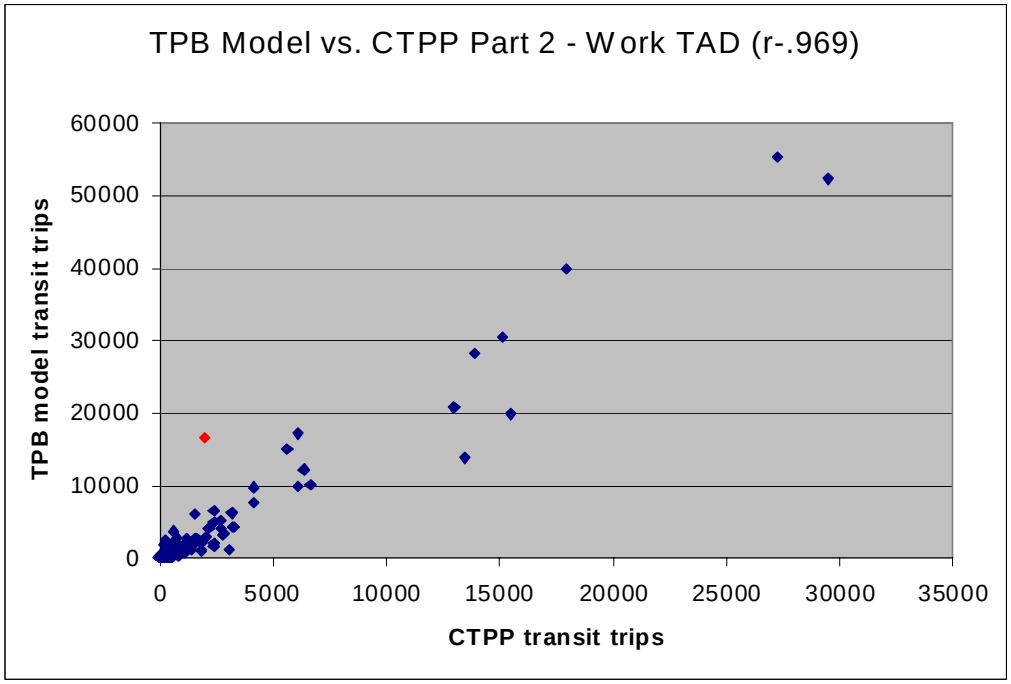
Drive Access HOV2+ Model

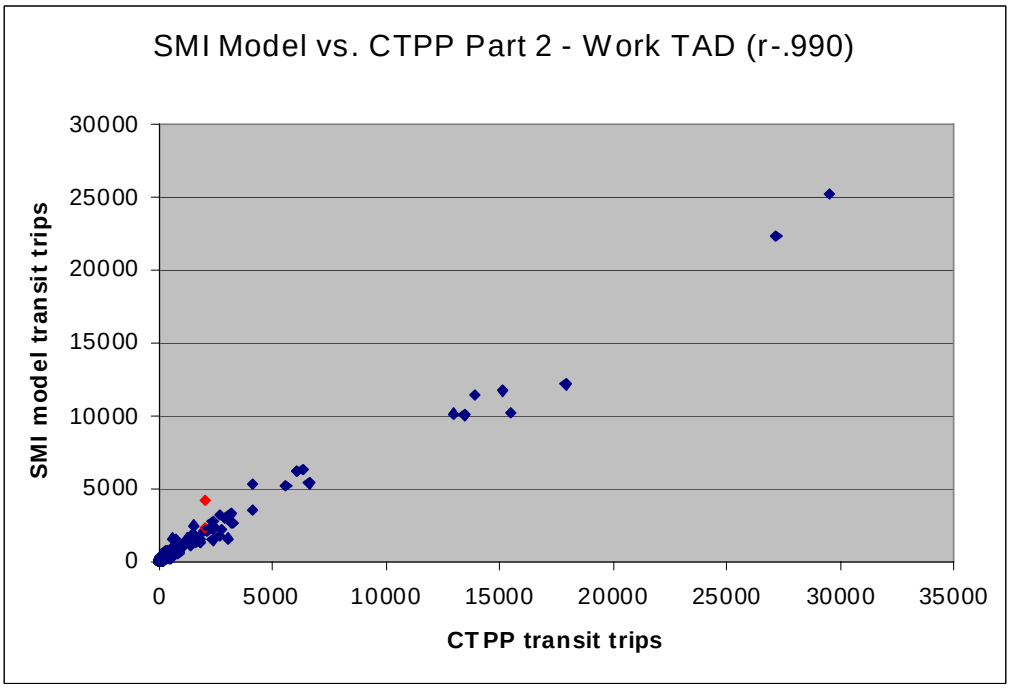
Variable	Coefficient	Standard error	t stat	Probability
Constant	-2.44897	0.06494	-37.71	0.0000
SOVTIME	0.00120	0.00439	0.27	0.7838
SOVDIST	-0.00320	0.00887	-0.36	0.7183
TIMEDIF3	0.03547	0.00364	9.74	0.0000
SQRESM	0.001046	0.00030	3.50	0.0005
EI	0.000504	0.00046	1.10	0.2713
INC1	2.80865	0.23377	12.02	0.0000

The strong significance of the land use variables is striking given that these variables are not included in the MWCOG TPB model or most other regional travel demand models in the U.S. The Metro variables that are highly significant are not included in the MWCOG TPB model either. The rationale for excluding a Metro preference is that people should care only about travel time and cost – and not whether the vehicle is a train or a bus. However, Metro is more than just a mode – it is a major brand that has much higher brand recognition than the rest of the regional transit system. It also is possible that the Metro variables are picking up additional land use effects because Metro stations often are in areas with good pedestrian infrastructure and transit-oriented land uses.

Model Validation

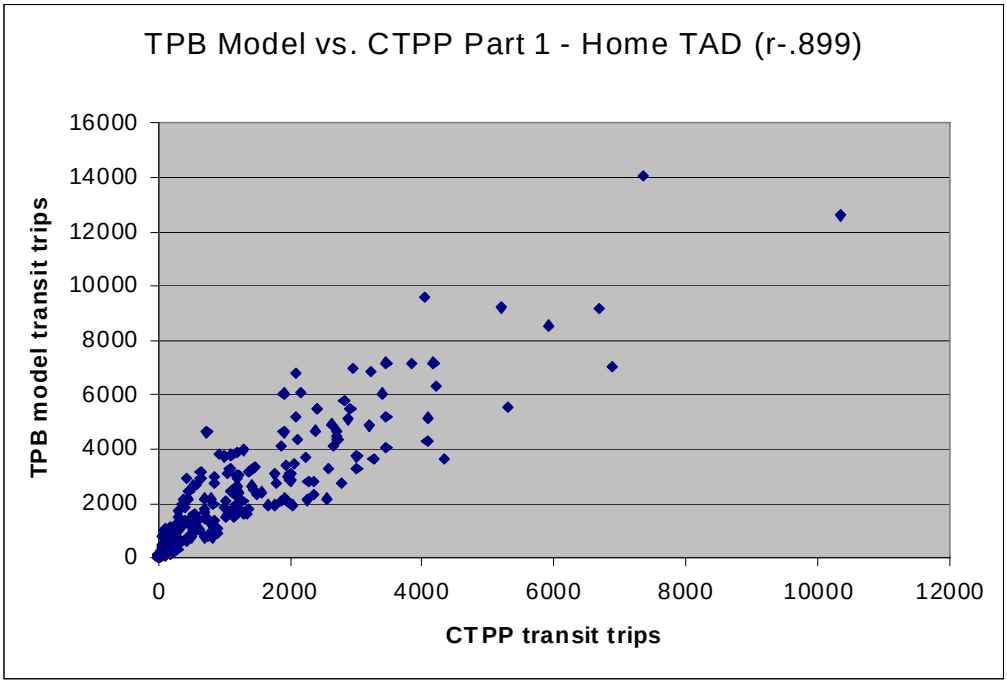
The model fits the Census data much better than does the MWCOG TPB model. The graphics below compare model vs. Census for both models for the work end at the Transportation Analysis District (TAD) level. (TADs are groupings of TAZs.)

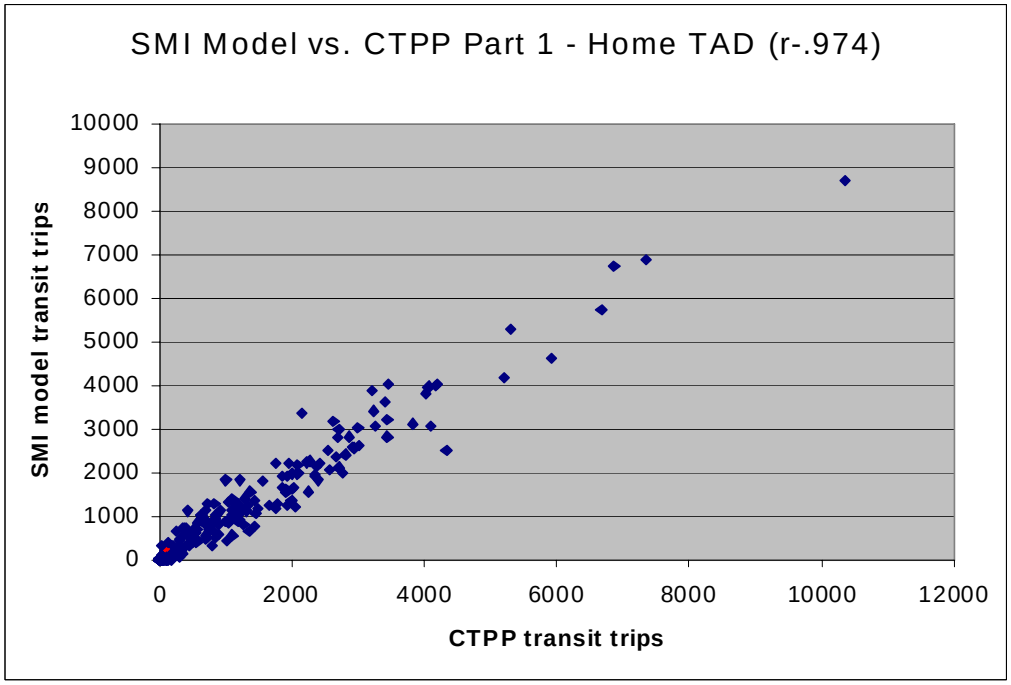




The SMI model outperforms the MWCOG TPB model overall but especially in suburban areas such as those of interest in this project. The red dots in the graphics above represent Tysons Corner. The TPB model greatly overestimates transit ridership there.

The model also fits the Census data much better than the MWCOG TPB model at the home end.





The SMI model outperforms the MWCOG TPB model overall but especially in suburban areas such as those of interest in this project. The red dots in the graphics above represent Tysons Corner. The TPB model greatly overestimates transit ridership there.

Factoring to Daily Trips

The Census only includes work trips and only includes them in the home-to-work direction. On average, there are 1.8 daily one-way work trips for each Census work trip (not every worker commutes every weekday). In the Washington region, total transit trips are about 1.7 times total work transit trips. Multiplying the two factors together (1.8 * 1.7) results in 3.1. We use a multiplier of 3.0 in order to be conservative.

Test Scenario and Results

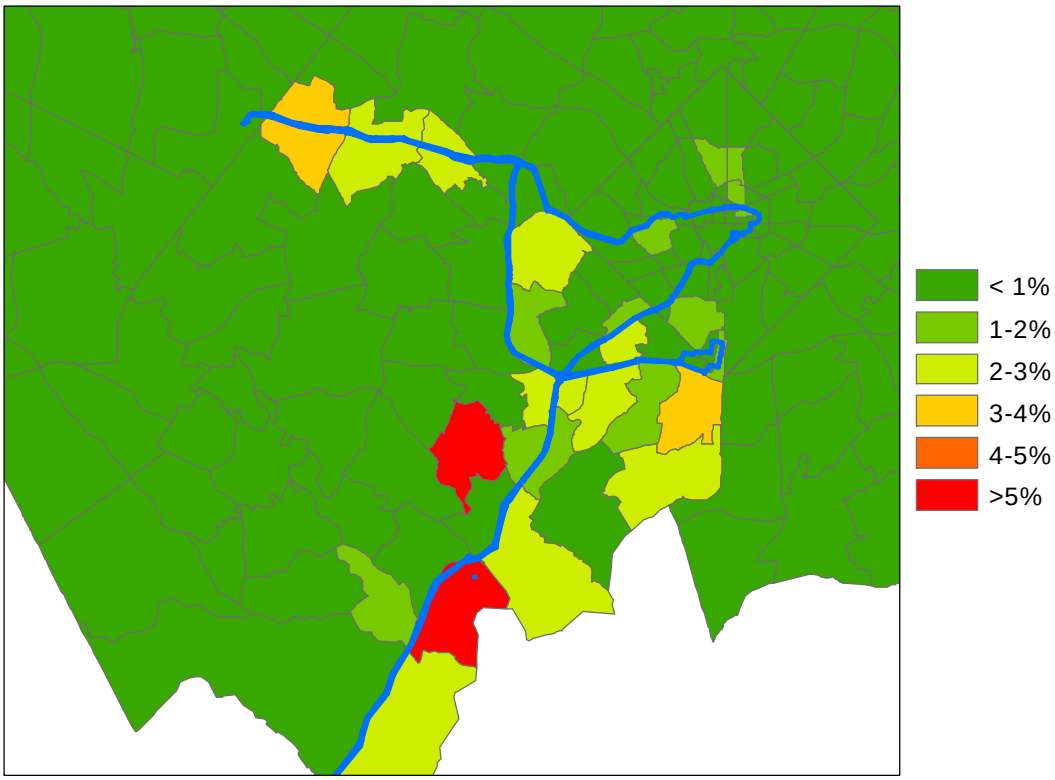
A BRT network making extensive use of the proposed HOT lanes was modeled.

The test network assumes that BRT operatives on the express lanes on I-95/I395 and the Capital Beltway, plus extensions to Dulles Airport along the Dulles Toll Road and to the District along I-66. Access to the District is provided with a loop between I-66 and I-395 using the proposed K Street Busway and other local streets.

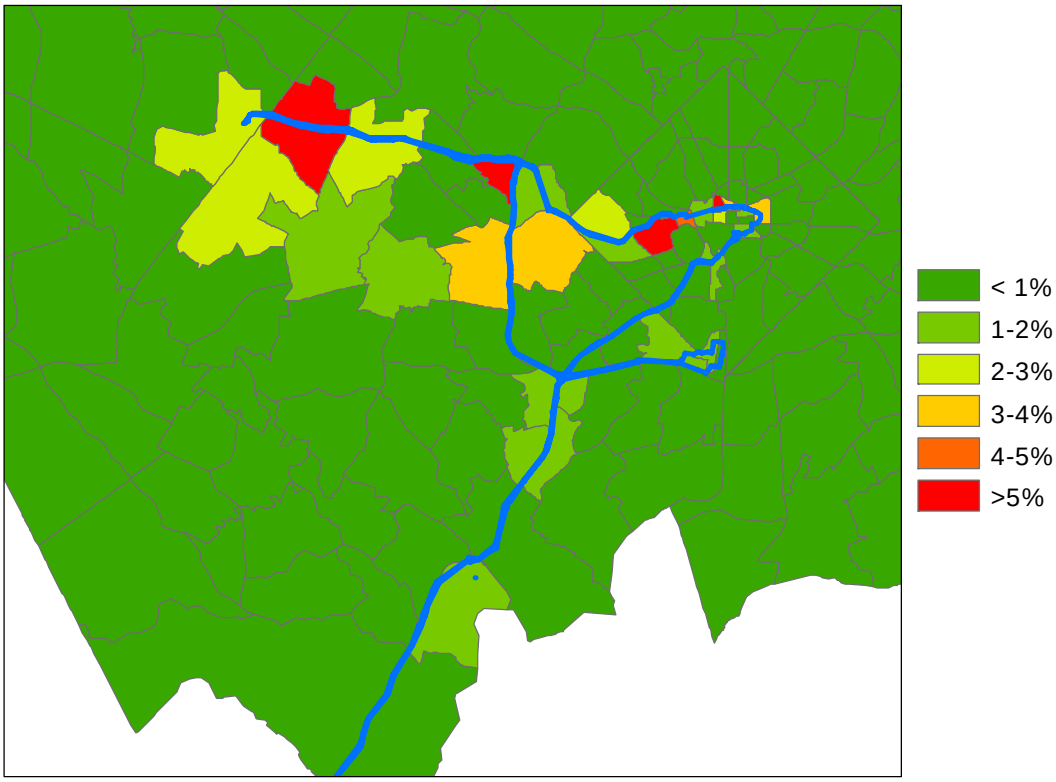
Operating assumptions are 5 minute headways in peak periods, 45 m.p.h. average speed outside the Beltway and on the Beltway, 35 m.p.h. inside the Beltway, and 15 m.p.h. in D.C. and for feeder routes. Feeder routes were assumed in suburban areas along the routes to pick up and discharge passengers.

Net new workers making trips (over base scenario) are estimated to be 7,700 per day. Using the multiplier of 3.0 discussed above, this gives a total of 23,100 total new net transit trips per day in 2010. The number of daily boardings is considerably higher due to transfers and competitions with other transit services. A refined scenario would prune out some existing routes to avoid duplicate service.

The graphics on the following page show the locations of the net new origins and net new destinations.



Work Trip Net New Origins



Work Trip Net New Destinations

Implication of Test Scenario Results

1) There is significant ridership potential for a BRT system using the managed lanes proposed in Northern Virginia.
2) Many of the home end locations for net new riders are in the I-95 corridor south of the Washington Beltway. A smaller cluster of new riders is in the Dulles corridor.
3) The majority of the net new work trip destinations are scattered in a long line from Herndon to D.C., including Tysons Corner, Vienna, Falls Church, and Arlington.
4) Demand is too low to justify 5-minute headways south of Lorton and at Dulles Airport.
5) Peak direction demand is consistent with 5-minute headways on the Washington Beltway.
6) The test modeling resulted in ridership too high for 5-minute headways on I-395 and I-66 near D.C. As much of this ridership is being attracted from existing transit services, it will be important to make sure than modeled operating assumptions are consistent across all transit services in the next refinement.
7) Serving the suburban markets is challenging due to the dispersed land uses, and probably will require a combination of point-to-point services for more significant destinations including Metro stations, Tysons Corner and the largest park-and-ride facilities, with feeder buses connecting BRT stations with final destinations.
8) Initiatives in Northern Virginia to increase density and walkability around transit stations could lead to significantly higher transit ridership than if current land use patterns continue.
9) A significant amount of the BRT travel time will be spent entering and exiting the express lane system to serve stations. This travel must be completed quickly if the BRT is to compete effectively with auto. This will require careful attention to BRT system needs during planning, and may involve a combination of in-line and off-line stations.

The amount of roadway capacity provided will have a great impact on potential toll revenue and potential transit ridership. If general purpose lanes remain faster than transit, there will be little incentive to use transit. Similarly, if time savings for autos on managed lanes relative to the general purpose lanes are small, only small toll rates can be charged and there will be little or no revenue available for transit operations.