NEW TOLL ROAD VS. TOLL MANAGED LANES ON EXISTING MOTORWAYS: ALTERNATIVES AND IMPACTS IN METRO WASHINGTON, DC

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Abstract

The design of managed toll lane networks raises a number of important issues with major implications for the environment, transportation system performance, traffic congestion, and transportation finance. These are discussed in the context of the metropolitan Washington, DC area, where a regional task force has defined goals for the managed toll lane network plan and where corridor-level analyses have been completed or are underway.

Debate is growing over how toll lanes might be designed and operated. Will tolls solely pay for new highway lanes or help finance expanded public transport services? Will such lanes be optimized to support Bus Rapid Transit (BRT) with efficient access to adjacent centers and public transport lines or will bus use of toll lanes be an afterthought? Will toll lane BRT stations facilitate walking and bicycling access and transit-oriented development? What are the implications for transportation costs, revenues, and environmental performance? This paper reviews these issues in the Washington region and summarizes findings from several corridor studies.

A study by the authors compares a proposed $2 billion Intercounty Connector tolled outer beltway in suburban Maryland with less costly investment and management strategies serving the area, with project concepts drawn from official planning studies. Using official regional travel and emission models, the study analyzes and compares changes in travel time, mode choice, traffic volume, emissions, revenues, and other attributes.

A new outer beltway with express bus service is less effective in relieving traffic than connecting the end-points of the proposed outer beltway with High Occupancy Toll (HOT) lanes converted from general purpose lanes on existing freeways, supporting new BRT services, but this HOT conversion leaves local roads more congested. Better performance at higher cost comes by adding a new toll managed lane to existing motorways while converting some existing general purpose motorway lanes to toll managed lanes, combined with new BRT services. Yet these alternatives are surpassed in most respects by the option of expanded rail and bus public transportation in the corridor and redirected new job and housing growth to areas with a high level of public transportation access with better balancing of jobs and housing in subareas. The best performance generally results from converting some existing motorway lanes to HOT/BRT lanes in combination with the public transportation oriented investment and land use scenario.

These study findings are largely consistent with other recent research done by Federal Highway Administration staff concerning toll lane and BRT strategies on the Capital Beltway in northern Virginia, summarized in the paper.

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1. CONTEXT FOR THE CASE STUDY

1.1 Governance and Funding for Transportation in DC Region

The metropolitan transportation system in the Washington, DC region faces growing stress from rising traffic congestion, inadequate funding for system maintenance and expansion, fractured governance structures, and poor coordination between transportation, land use, air quality, and natural resource planning. Area employment grew 17% between 1990 and 2000, to 2.7 million jobs, spurring population and traffic growth. Zoning and land subdivision approvals are under the control of local governments that independently pursue development to boost their tax base, with little or no state and regional growth management. The majority of transportation funding is controlled by state Departments of Transportation (DOT) spread among Virginia, Maryland and the District of Columbia, which often pursue conflicting approaches to system management. Some regional coordination of transportation policy and plans is achieved through a metropolitan planning organization, the Transportation Planning Board (TPB), composed of state and local officials. Under federal law TPB approves every three years a fiscally constrained 20-year regional transportation plan that must conform to pollution control limits established in air quality State Implementation Plans designed to attain federal health standards. Every two years, federal law also requires the TPB to update a fiscally constrained and conforming short term regional transportation improvement program drawn from the long-range plan.

Transportation system development in the metropolitan Washington, DC region traditionally has relied on pay-as-you-go state and federal gasoline tax revenue and other motorist user fees, complemented by local and state general fund revenues and modest public debt financing. But competing financial demands, pressures to cut or restrain taxes, and increasing traffic congestion and demand for public transportation services have prompted growing interest in tolls, public-private partnership ventures, and long-term borrowing to finance transportation.

Virginia's General Assembly in 1988 first authorized private toll road development, following with the Public-Private Transportation Act (PPTA) of 1995. Tolls have been used to finance several projects administered by the Maryland and Virginia state transportation authorities (the Dulles Toll Road and several major crossings of the Chesapeake Bay and its tributaries at the edges of the metropolitan region) as well as the privately financed Dulles Greenway in the western suburbs in Virginia. Prior tax cuts and transportation revenue shortfalls led to an $800 million cut in the proposed 5-year capital program for northern Virginia in 2002. In recent years both Maryland and Virginia have tapped revenues traditionally thought of as transportation funds to pay for education and other needs deemed more pressing by elected officials. While federal funding for transportation increased significantly for the region under 1991 and 1998 federal transportation laws, the level of funding effort from state and local sources declined, especially in recent years, as in many other states (U.S. General Accountability Office, 2003).

1.2 The Intercounty Connector - Proposed Outer Beltway

The idea of an outer circumferential freeway in the Washington, DC area originated in the early 1950s. But as scientists and lawmakers learned more about the importance of protect-

ing natural areas, federal environmental laws were enacted to protect against building roads through parks, wetlands, and sensitive resources. By the 1970s, the concept of an Outer Beltway had been dropped from planning documents, but the portion of such a facility in Maryland between I –270 and the Baltimore Washington Parkway known as the "Intercounty Connector" or "ICC" was retained. The general location of the proposed ICC in the region can be seen as facility #6 in Figure 1. Environmental impact reviews of the ICC undertaken in the 1980s and mid 1990s found the impacts of the proposed highway on parks, stream valleys to be unacceptable, leading state and federal agencies to reject the proposal (Sipress, 1999), but it remained on County master plans.

After being elected in 2002, Maryland Governor Robert Ehrlich reopened the debate on the ICC, initiating a new study of a 6-lane, 18-mile (29 kilometer), tolled ICC in 2003. The U.S. Department of Transportation designated the ICC a "priority project" for expedited environmental review under President George W. Bush's Executive Order 13274, "Environmental Stewardship and Transportation Infrastructure Project Reviews" (US DOT, 2003).

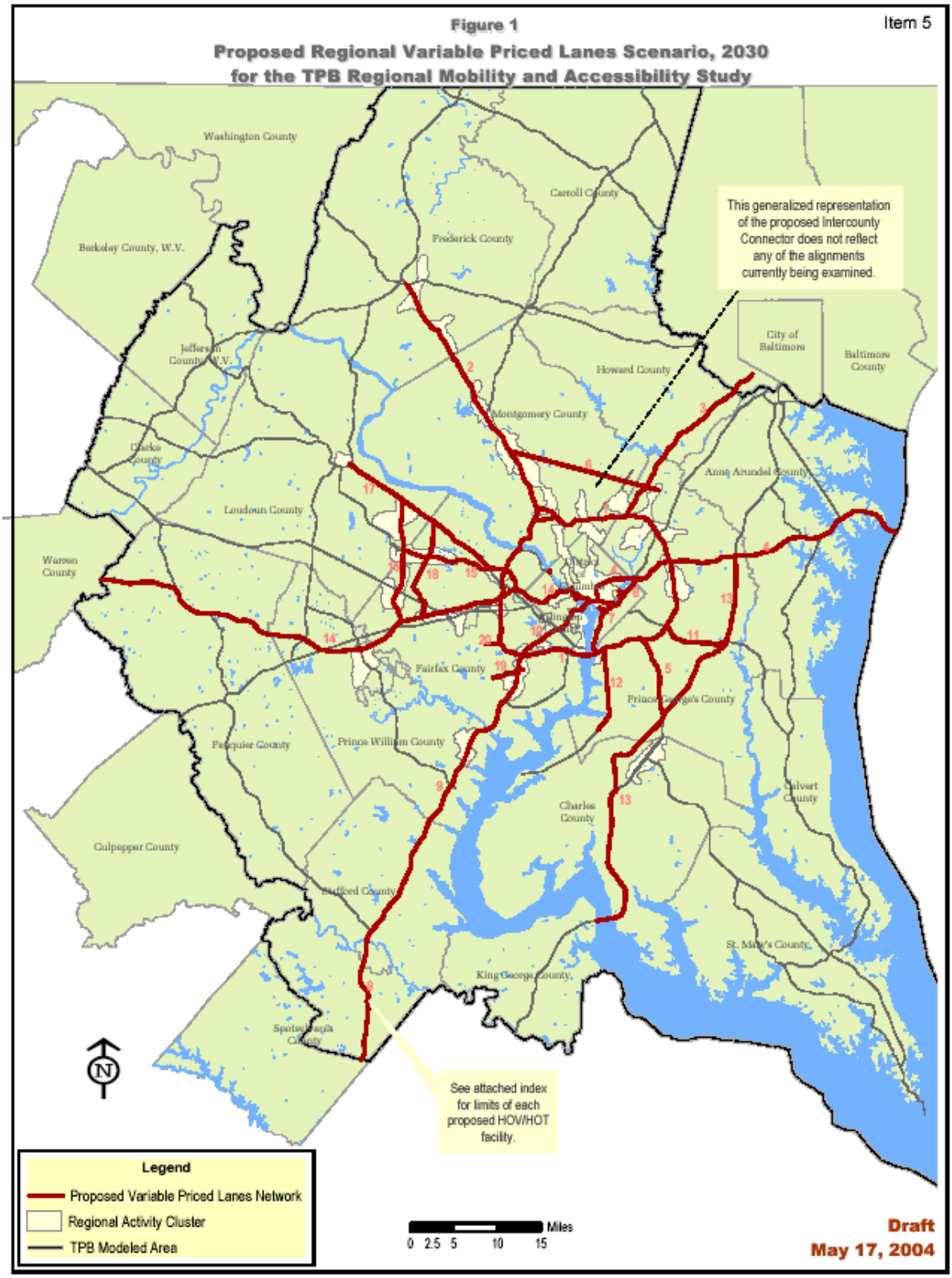
Overcoming substantial opposition, Maryland officials got the ICC added to the regional transportation plan in November 2004 while avoiding any evaluation of the air quality impacts of the ICC itself. Instead, the air quality analysis considered the addition of the ICC together with many other projects, and extensively altered travel and air quality models and land use growth assumptions. In this exercise, the region took advantage of relaxed clean air rules promulgated by the U.S. Environmental Protection Agency in 2004 as part of the transition to a more stringent ozone (smog) air quality standard, with officials ignoring the impending challenge of setting much more stringent air pollution emission limits for mobile sources in the region by 2007 to meet the new standard by a 2010 attainment deadline. A draft Environmental Impact Statement for the ICC was issued in November 2004, and relies on the concurrent TPB regional emission analysis for its assertion that the ICC will not pose an air quality problem (Maryland SHA, 2004). Federal laws require consideration of alternatives and prudent and feasible options that might avoid adverse impacts of highway projects on parks and public health. However, the state and federal highway agencies adopted a "Purpose and Need" definition for the ICC EIS that excluded from consideration any alternatives other than building a new motorway on a new right-of-way connecting the end points of the proposed road, so only a no-build option and two alternative alignments for the road are being considered in the environmental review process as viable options.

Other outer beltway proposals for the metro Washington region continue to surface every several years under different names, such as the Western Bypass, the Western Transportation Corridor, the Eastern Bypass, and the Techway, generating studies and controversy. Opponents of the ICC fear that if built, the ICC will soon be extended into a full outer beltway system, fueling more sprawl and traffic growth.

1.3 Regional Consideration of Toll Managed or High Occupancy Toll (HOT) Lanes

The Maryland DOT in 1997 sought and won a federal grant to evaluate how market incentives, such as HOT lanes, might be used to manage traffic and support improved transit services in the state. HOT lanes allow solo drivers to buy their way into managed lanes that are free or discounted for carpools, with tolls adjusted to ensure free flow conditions in the lanes. As a federal value pricing pilot program partner, Maryland and 14 other states are exempt from federal restrictions on tolling Interstate highway lanes. By 1999, based on

stakeholder input and analysis, the Maryland Value Pricing Study found HOT lanes might be promising in a number of freeway corridors.



Index to Figure 1: Proposed Variable Priced Lane Scenario, 2030
For the TPB Regional Mobility and Accessibility Study
Draft of May 17, 2004

1. The entire Capital Beltway (I-495/I-95)
2. I-270 from I-70 to the Capital Beltway (I-495)
3. I-95 from the Capital Beltway (I-495) to the Baltimore Beltway
4. US Route 50 from MD 2 to I-395
5. MD Route 5 from US 301 at MD Route 5 to I-495
6. The Intercounty Connector, Entire Length
7. I-295 from Capital Beltway to Anacostia Freeway
8. Anacostia Freeway/Kenilworth Avenue from I-295 to Route 50
9. I-95 from Caroline / Spotsylvania County Line to Capital Beltway (I-495/I-95)
10. I-395 from the Capital Beltway (I-495/I-95) to I-295
11. MD Route 4 from US 301 to I-495
12. MD Route 210 from MD 228 to I-495
13. US 301 from the Nice Bridge to US 50 (includes the proposed Waldorf Bypass)
14. I-66 from Warren / Fauquier County Line, over the Theodore Roosevelt Bridge, to Rock Creek Parkway to Independence Avenue, to Maine Avenue, SW to SE/SW Freeway
15. Dulles Toll Road (VA 267) from VA 28 to I-66
16. VA 28 from I-66 to VA 7
17. VA 7 from US Route 15 to the Dulles Toll Road
18. Fairfax County Parkway from I-66 to VA 7
19. Franconia-Springfield Parkway from Sydenstricker Road to Frontier Drive
20. Braddock Road from Burke Lake Road to I-95

Note: DDOT has requested that all D.C. river crossings be included in the scenario. In addition to the bridges part of the segments listed above, the following bridges are included:

Chain Bridge
Key Bridge
Memorial Bridge
South Capitol Street Bridge (Frederick Douglass Bridge)
Pennsylvania Avenue Bridge (John Phillip Sousa Bridge)
East Capitol Street Bridge (Whitney Young Memorial Bridge)
Benning Road Bridge

In 2000 the Maryland DOT Secretary proposed a test of HOT lanes on soon-to-open HOV lanes on U.S. Route 50, in Prince George's County, an affluent majority African-American suburban jurisdiction east of Washington, DC, with toll revenues paying for new bus services. As the proposal faced final approval by the TPB, despite demonstrated diverse stakeholder support built over three years of organizing and outreach, it was suddenly withdrawn by liberal Democratic Governor Parris Glendening, who renounced toll lanes as "Lexis Lanes" that would harm the poor, echoing accusations made by both the Maryland Sierra Club, an environmental activist group, and the local AAA, a motorists organization.

However, in 2003 a new Republican Maryland Governor, Robert Erlich, after having declared his top priority to be building the ICC outer beltway, also revived the toll study with a new plan to create Toll Express Lanes on a network of existing freeways around the

greater Washington-Baltimore region, building some new toll lanes and converting some existing general purpose lanes to toll lanes. Maryland DOT is expected to release environmental impact studies on several of these toll managed lane corridor projects in early to mid 2005, including the Capital Beltway and I-270, which adjoin the ICC study area and might logically be included as feasible and prudent alternatives to the ICC. The new Governor put on a slow track a well advanced proposal for an east-west "Purple Line" light rail connection between a number of moderate and high density inner suburban centers slightly inside the Capital Beltway towards the metro region's core, which had been the top priority of the prior Governor,. He abandoned the previous Governor's nationally heralded "Smart Growth" initiatives giving preference to urban infill and redevelopment over sprawl.

At the same time, Virginia officials in 2003 received public-private partnership (PPP) proposals to widen the Capital Beltway, including one aimed at building two new central median HOT lanes that would be largely toll financed. This HOT lane proposal by Fluor Corporation was recommended by Virginia officials for further detailed project design in 2004 while the environmental review process moved towards completion, expected in 2005. In 2004, several additional PPP toll-financed proposals were submitted for other northern Virginia highway corridors. One of these, also from Fluor Corporation, for the I-95/395 corridor, south of Washington, includes a concept for providing Bus Rapid Transit (BRT) service on the toll lanes, funded in part using dedicated toll revenues, echoing the practice of San Diego's I-15 corridor HOT lanes. Virginia also applied for and won a federal grant to study value pricing and toll strategies which exempts the state from the current federal restriction on tolling Interstate highways.

At the regional level, state and local elected officials who make up the Transportation Planning Board (TPB) had expressed dissatisfaction with the performance of the regional transportation plan they adopted in 2000. In response, they established a Regional Mobility and Accessibility Study to evaluate options to improve mobility and access between regional activity centers and the regional core, including study of alternative land use growth strategies, investments, and pricing policies. A conference on Value Pricing in 2003 led to appointment of a high-level task force to evaluate regional value pricing strategies, which is evaluating a regional system of HOV/HOT lanes, as shown in Figure 1.

Major conflicts surfaced in the Value Pricing Task Force between states and local jurisdictions over how to approach toll system design, in a debate similar to one playing out in the U.S. Congress and many other states and regions. Should carpools and fuel-efficient hybrid vehicles pay to use managed lanes? Will tolls go solely to pay for new highway lanes and new motorways or help finance expanded public transport services? Will such lanes be designed and optimized to support Bus Rapid Transit (BRT) with in- line stations or slip ramps that efficiently access adjacent centers and intersecting public transport lines or will bus use of toll lanes be an afterthought in designs that maximize traffic flow and toll revenue? Will toll lane BRT stations be designed to facilitate walking and bicycling access and transit-oriented development or only park-and-ride access? Will trade-offs be evaluated to explicate the cost of adding more new toll lanes vs. adding fewer new toll lanes and converting some existing general purpose lanes to toll managed lanes? What are these trade-offs in capital costs, toll revenue potential, and use of scarce right-of-way?

The Task Force of elected officials and state and regional transportation agency executives recently adopted *Goals for a Regional System of Variably-Priced Lanes,* which resolved many of these issues in favour of more public transport-optimized approaches (Transportation Planning Board, 2005). The full set of adopted goals are shown in Table 1.

Table 1: Goals for a Regional System of Variably-Priced Lanes (adopted January 2005)

As the Washington region moves forward with plans to develop variably-priced lanes, it is anticipated that a system of variably-priced lanes will be implemented in phases, likely with onecorridor or segment at a time. The following goals can help guide the regional development of variably-priced lanes that work together as a multi-modal system, while addressing the special policy and operational issues raised by the multi-jurisdictional nature of this area.

1. Operations, enforcement, reciprocity, technology, and toll-setting policies should be coordinated to ensure seamless connections between jurisdictional boundaries. The region should explore options for accommodating different eligibility requirements in different parts of the system of variably-priced lanes without inconvenience to the users.

2. The variably-priced lanes should be managed so that reasonably free-flowing conditions are maintained.

3. Electronic toll collection devices should be integrated and interoperable among the District of Columbia, Maryland and Virginia, and should work with other multi-state electronic toll collection systems, such as E-Z Pass.

4. To ensure safety and to maintain speeds of variably-priced lanes on high-speed facilities, one lane with a wide shoulder consistent with applicable FHWA guidelines should be provided at a minimum. Optimally, two lanes should be provided in each direction (or two lanes in the peak direction by means of reversible lanes) where possible.

5. Given the significant peak-hour congestion in the Washington area, transit bus service should be an integral part of a system of variably-Priced lanes, beginning with project planning and design, in order to move the maximum number of people, not just the maximum number of vehicles.

6. Transit buses should have reasonably free-flowing and direct access to variably-priced lanes from major activity centers, key rail stations, and park-and-ride lots, so that transit buses do not have to cross several congested general purpose lanes.

7. Transit buses using the variably-priced lanes should have clearly designated and accessible stops at activity centers or park-and-ride lots, and signal priority or dedicated bus lanes to ensure efficient access to and from activity centers.

8. The region urges that the Congress and the Federal Transit Administration (FTA) recognize variably-priced lanes as fixed guideway miles so that federal transit funding does not decrease as a result of implementing variably-priced lanes.

9. The Washington region currently has approximately 200 miles of HOV lanes and a significant number of carpoolers, vanpoolers and other HOV-eligible vehicles. If the introduction of variably-priced lanes changes the eligibility policies for use of existing HOV facilities, transitional policies and sunset provisions should be set and clearly stated for all the users.

10. As individual phases of a system of variably-priced lanes are implemented, users of the lanes should be able to make connections throughout the region with minimal inconvenience or disruption.

11. Toll revenues from variably-priced lane projects may finance construction, service debt, and pay for operation and maintenance of the priced lanes. Should toll lanes operate at a revenue surplus, consideration should be given to enhancing transit services.

2. TOLL MANAGED LANE ALTERNATIVES IN DC REGION

There have been a number of studies evaluating toll managed lanes in the Washington, DC region. Among the notable papers in recent years are evaluations by Pat DeCorla-Souza of the Federal Highway Administration and a recent study carried out by Smart Mobility under the management of Environmental Defense on behalf of a consortium of area environmental and civic organizations. These are summarized below.

2.1 Northern Virginia Capital Beltway HOT Lane Analysis

In a paper presented at the 2003 Transportation Research Board evaluating various toll and HOV lane configurations on the now 8-lane Capital Beltway in northern Virginia, Pat DeCorla-Souza of the Federal Highway Administration demonstrated that creating toll lanes as entirely new capacity is more costly and produces lower revenue than adding fewer new toll lanes and converting some of the existing general purpose lanes to toll lanes (DeCorla-Souza, 2003). This finding is key to the question of whether funding will be available to support improved public transport in the tolled corridor.

The study shows adding two new lanes in each direction (to produce a 12-lane facility with 4 HOT lanes) increases traffic by 12 percent (36,000 vehicles per day) in the corridor. Adding only one new HOT lane in each direction and better managing two existing lanes by converted them to HOT lanes (yielding a 10-lane facility with 6 HOT lanes), is estimated to induce only 2 percent more traffic (6,400 vehicles per day) while producing nearly equal traffic delay reductions at lower capital costs. Adding no new lanes while converting existing lanes to HOT lanes produces the greatest benefits at the lowest costs, but faces higher political implementation obstacles, though DeCorla-Souza has proposed a potential solutions with the evolving concept for FAIR lanes, which enable compensation or benefit spreading to non-toll lane users.

DeCorla-Souza's analysis reveals that the 10-lane, add-and-convert alternative produces three times as much toll revenue as the 12-lane, add all new lanes alternative, at lower capital cost. The 10-lane option would also leave more of the scarce right-of-way available to accommodate Bus Rapid Transit stops or drop ramps to enable buses or transit passengers rapid entry and exit or transfers to connect to adjacent activity centers and intersecting transit lines. Fluor and Virginia DOT have said that the 12-lane HOT alternative will be unable to cover full capital costs out of projected toll revenues, requiring at least $200-300 million in public subsidy for construction, or more if additional transit access infrastructure is included in the design to enable direct links to nearby Metro stations, commuter rail, arterial bus services, or activity centers.

While there is talk of the toll lanes accommodating new express buses, the regional transit agency WMATA faces a continuing capital and operating budget shortfall that has led to repeated fare increases in recent years, service cutbacks and declining service reliability caused by deferred maintenance. Virginia's state and local funded transit agencies have faced their own budgetary pressures.

In short, a decision to add two new HOT lanes in each direction on the Capital Beltway would likely mean there will be no surplus toll revenues to pay for improved transit services in the corridor for many years to come. While Fluor has suggested HOT lanes on I-

95 and I-395 could produce sufficient surplus toll revenues to pay for some transit operating costs for buses on the Capital Beltway, as well as I-95 and I-395, this is by no means assured. A more system-level analysis of options and trade-offs is needed to fully explicate the matter and should be required as part of PPTA, environmental, and planning reviews.

A new paper by DeCorla-Souza, presented at the 2005 TRB meeting, further studies options in the northern Virginia Capital Beltway, which is presented as a "prototypical suburban corridor in a major metropolitan area," using the same SMITE model analysis framework that was used to support analysis for his 2003 TRB paper (DeCorla-Souza, 2005). This new paper explores some of the trade-offs between HOT lanes vs. express toll (ET) managed lanes and what role is appropriate for bus rapid transit (BRT) services on these lanes. It concludes that,

> *the best choice, from the point of view of congestion mitigation and economic efficiency, is HOT lanes with BRT. If HOV enforcement is an issue, ET lanes with BRT may be the next best choice. If both HOV enforcement and public tax support for new BRT service are issues, ET lanes without BRT would be the next best choice.*

The paper notes that value of time assumptions can have a big impact on toll revenue estimates and estimates of induced demand which are important to financial and environmental appraisal of projects. But it concludes that,

> *Adding Bus Rapid Transit service to priced lanes may increase benefits and economic efficiency (i.e., net present value), but reduces financial feasibility due to the need for public tax support for transit. Express Toll lane alternatives tend to be more financially feasible than HOT alternatives primarily due to the additional revenues generated from tolls since HOVs are not exempt. These conclusions hold up under extreme assumptions with regard to demand elasticity and value of time.*

2.2 ICC Outer Beltway vs. Other Toll Lane, Transit, and Smart Growth Options

Alternatives Considered. In the wake of the refusal of Maryland and federal agencies to study alternatives to the ICC as part of the environmental review process in 2004, civic and environmental non-profit groups commissioned a expert peer-reviewed study of alternatives drawn from current and recent planning studies in the corridor, as discussed below (Environmental Defense, 2005):

1. **No Build.** The No Build alternative includes the 2003 adopted Constrained Long Range Plan (CLRP) and corresponding growth forecast.

2. **ICC Build.** The ICC Build alternative includes the 2003 CLRP, the 108 lane-miles of new toll motorway represented by the ICC, and uses the corresponding official growth forecast, which added 58,000 jobs to the region. Both high occupancy and single occupancy vehicles would pay tolls of $0.15/mile off-peak and $0.20/mile peak in all lanes. Operating on the ICC would be 200 route-miles of new express bus services compared to the CLRP.

3. **Transit Oriented Land Use and Investment.** The "Transit Oriented" alternative includes the 2003 CLRP, and adds the "Purple Line" light rail from Bethesda to

College Park shown in Figure 2 below, a 2-mile Red line Metro extension beyond Shady Grove to Metropolitan Grove, and 134 additional express bus route-miles, plus modest local road improvements. The pattern of study area growth forecasts are modified to shift some jobs and houses to produce a better local balances to reduce the need for longer commuting and increase transit-oriented development as shown in Figure 3, but keeps the 2003 CLRP regional growth total constant.

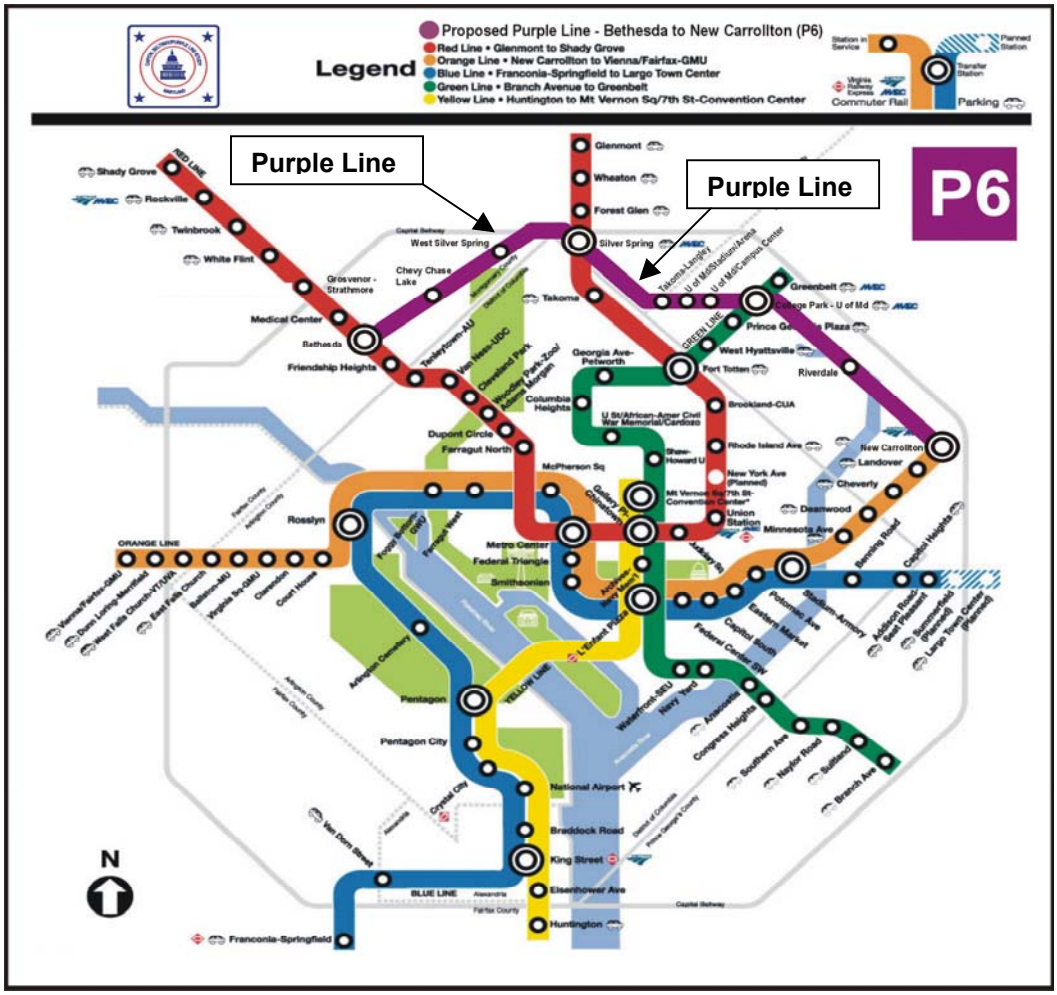


Figure 2: Washington Area Metro System Including Proposed Purple Line Light Rail

4. **Add Toll Lanes-Express Bus.** The "Add Toll" alternative includes the CLRP land use and networks plus a network of toll lanes including both newly constructed lanes and converted existing lanes on I-270, the Capital Beltway, and I-95, as shown in Figures 4 and 5. Both high occupancy and single occupancy vehicles would pay tolls of $0.20 per mile off-peak and $0.40 per mile peak. The alternative would add 68 new lane-miles of toll express lanes and convert 35 lane-miles of the region's existing or planned HOV-only lanes and 166 lane-miles of existing or planned general-purpose freeway lanes into non-barrier separated toll express lanes, with provision for BRT stations in the median as depicted in Figure 6 or direct access ramps enabling rapid on-and-off operations for buses to enable efficient access to adjacent transit stops and activity centers. New express bus services on the toll roads would add 357 express bus route-miles beyond those planned in the CLRP.

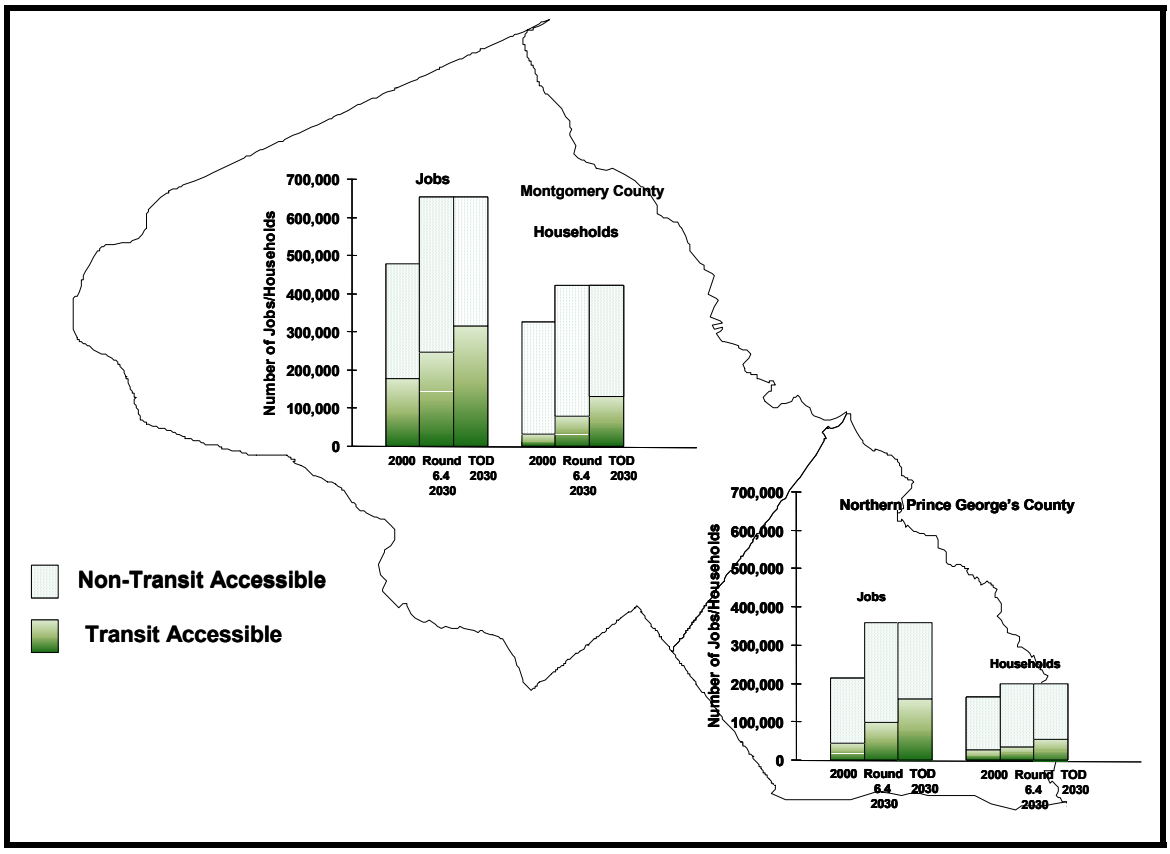


Figure 3: Changes in Development Pattern Assumptions: 2000 vs. 2030 Base Case Growth Scenario (Round 6.4) vs. Transit Oriented Development (TOD) Scenario

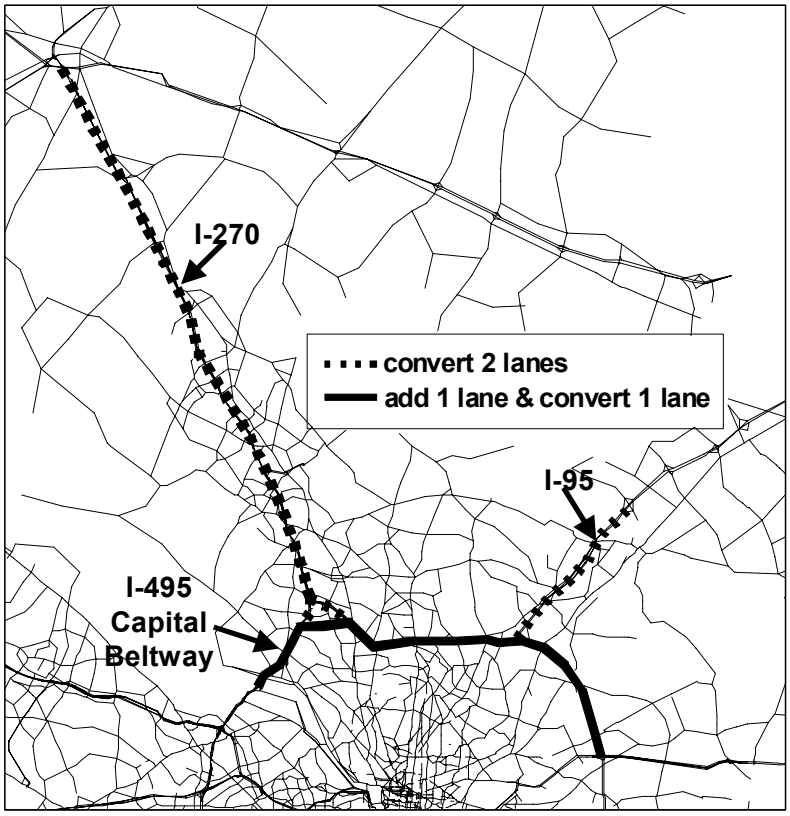


Figure 4: "Add Toll" Managed Toll Lanes

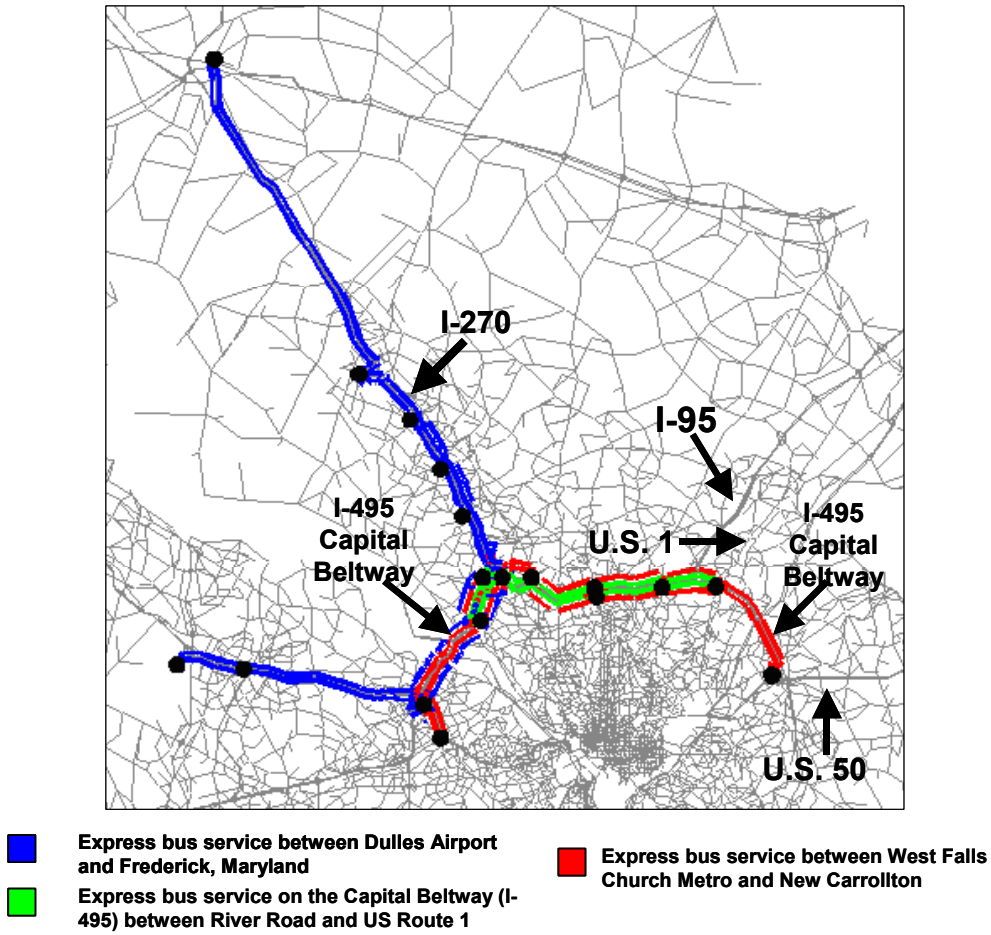


Figure 5: "Add Toll" Bus Rapid Transit Network

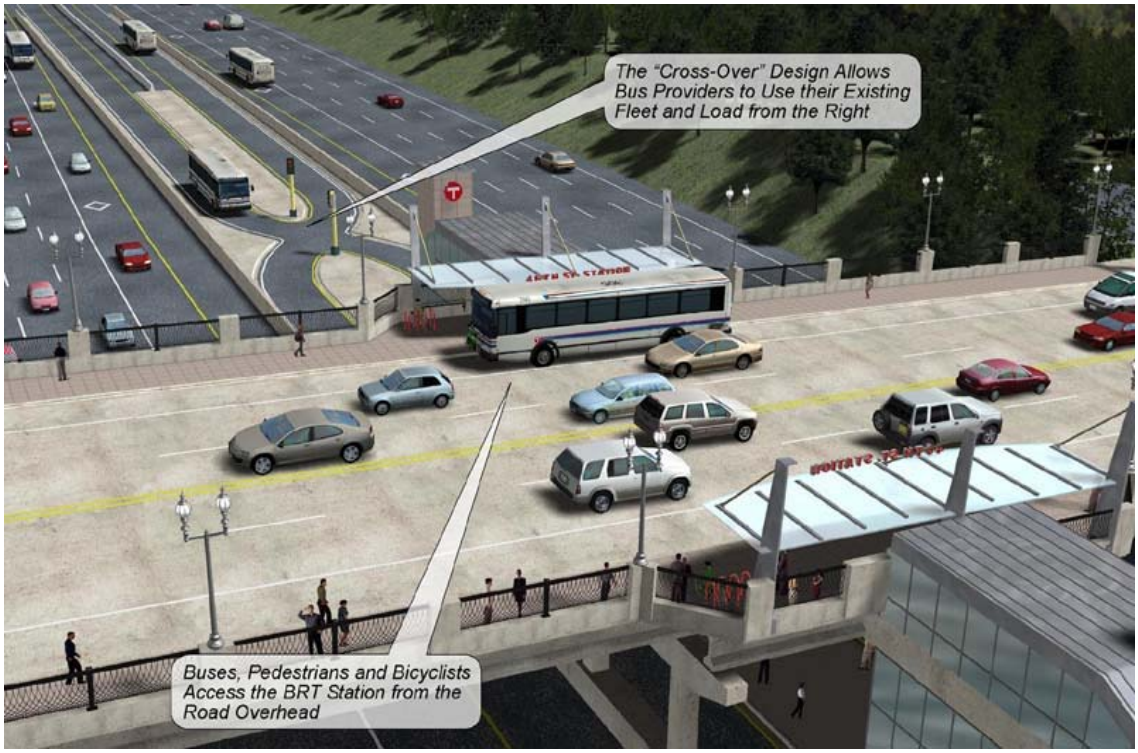


Figure 6A: Possible Concept for an In-Line Toll Managed Lane Bus Rapid Transit Station (Courtesy of Minnesota Department of Transportation, I-35W Project, 2004)

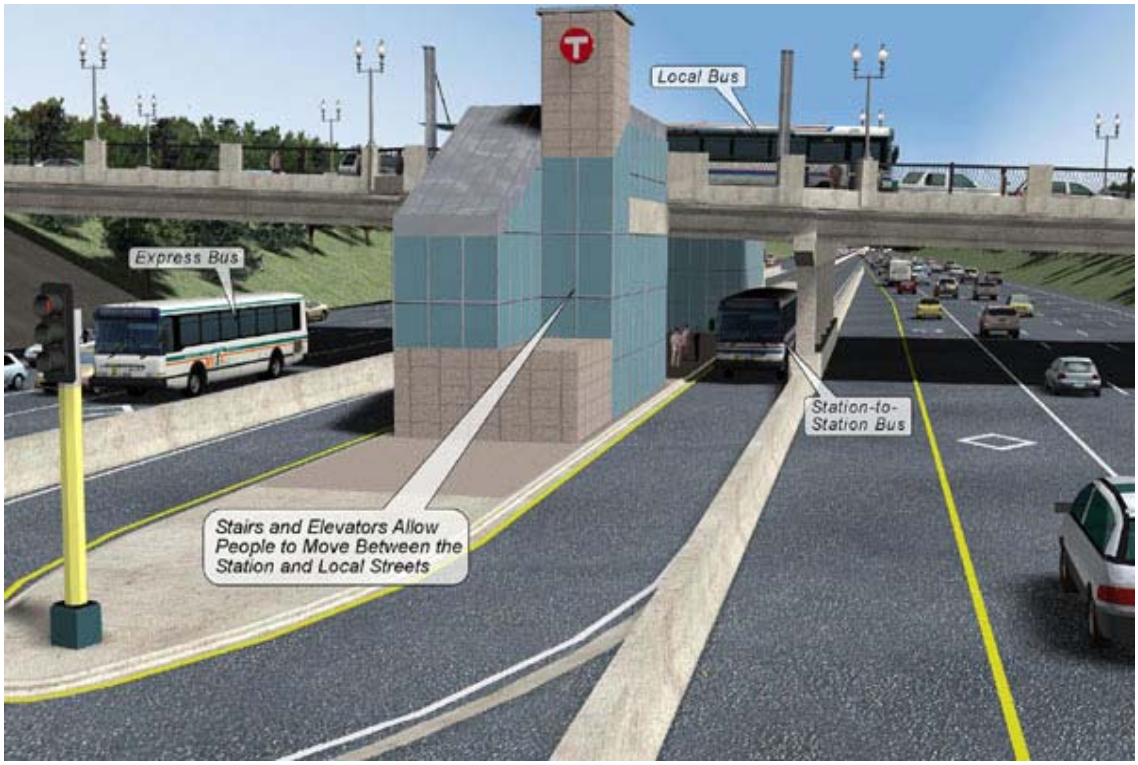


Figure 6B: Possible Concept for an In-Line Toll Managed Lane Bus Rapid Transit Station (Courtesy of Minnesota Department of Transportation, I-35W Project, 2004)

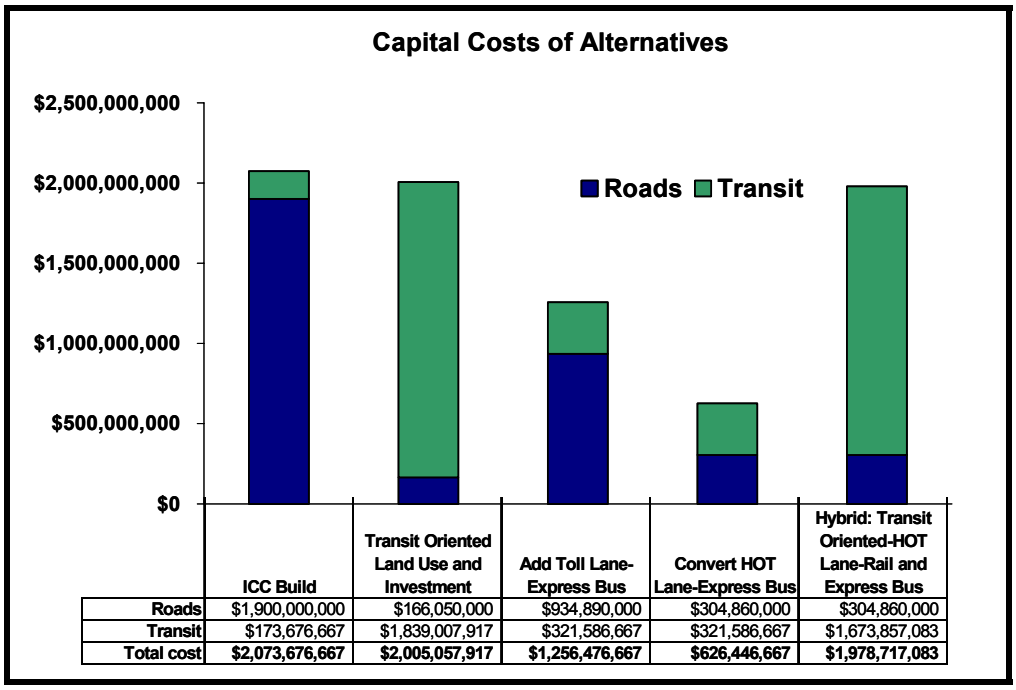
5. **Convert to High Occupancy Toll ("HOT") Lanes-Express Bus**. The "Convert to HOT" alternative includes the 2003 CLRP land use and network, and along the same roadway network as the Add Tolls Alternative, converts 35 lane-miles of the region's existing or planned HOV-only lanes and 234 miles of existing or planned general-purpose freeway lane-miles into HOT lanes. It provides a continuous HOT lane network of two lanes in each direction along the western, southern, and eastern edges of the ICC Study Area, with all the transit improvements of the Add Toll Alternative, including BRT stations. No new lanes are added. This alternative would add 396 express bus route-miles beyond those planned in the 2003 CLRP. A large share of net revenues from the tolls would be dedicated to expanding or improving transit service, traffic management, and pedestrian and bicycle access in the corridor, with a portion available to pay for HOT lane conversion. The comparatively much lower capital cost of this alternative could these lanes to operate as "Fast and Intertwined Regular ("FAIR") Lanes," as proposed for the Capital Beltway by Patrick DeCorla-Souza of the Federal Highway Administration (DeCorla-Souza 2003 and 2004). Under this strategy frequent travelers on the more congested unmanaged lanes would earn credits on their toll transponders, enabling them to use the priced, managed lanes occasionally for free, boosting public acceptability of the convert-to-managed lanes strategy.

6. **Transit Oriented-HOT Lane-Rail and Express Bus.** The "Hybrid" alternative is a combination of components most closely drawn from alternatives 3 and 5. It includes the 2003 CLRP, most of the rail transit improvements from the Transit Oriented alternative, including the Purple Line light rail and Metrorail extension to

Metropolitan Grove, and the converted HOT-express bus lanes from the Convert to HOT alternative. It uses the same land use component as the Transit Oriented alternative. The alternative would add 396 express bus route-miles.

Performance Measures. All alternatives were designed to be less costly than the ICC outer beltway, as shown in Figure 6. The study used the Metropolitan Washington Council of Government's TPB's latest computer-based transportation and air quality models to analyze the alternatives. The alternatives were tested by Smart Mobility, Inc. using a variety of measures of effectiveness commonly reported in travel studies. These measures include:

- Vehicle Miles Traveled
- Vehicle Miles Traveled on Major Arterials and Local Roads
- Time Spent in Vehicle
- Vehicle Delay
- Total Number of Vehicle Trips
- Number of Transit Trips
- Traffic on Local Roads
- Time Taken by Typical Trips
- Air Quality/Public Health Impacts



	ICC Build	Transit Oriented Land Use and Investment	Add Toll Lane-Express Bus	Convert HOT Lane-Express Bus	Hybrid: Transit Oriented-HOT Lane-Rail and Express Bus
Roads	$1,900,000,000	$166,050,000	$934,890,000	$304,860,000	$304,860,000
Transit	$173,676,667	$1,839,007,917	$321,586,667	$321,586,667	$1,673,857,083
Total cost	**$2,073,676,667**	**$2,005,057,917**	**$1,256,476,667**	**$626,446,667**	**$1,978,717,083**

Figure 6: Capital Cost Split Between Highways and Transit for Alternatives

The results of this analysis, analyzed for a very local study area, a broader sub-regional study area, and across the full metropolitan region, demonstrate that all of the alternatives to doing nothing performed better than the ICC outer beltway on most measures. Figure 7 shows the definitions of the study areas. Though the relative ranking of the alternatives varied from measure to measure, the ICC consistently ranked at or near the bottom, in some cases worse than the No Build baseline alternative. The results for the air quality and public health impacts were particularly noteworthy since the ICC Build alternative is the only alternative examined that would increase air pollution over the levels in the No Build

alternative. All other alternatives would reduce air pollution emissions. The figures and tables below summarize these findings.

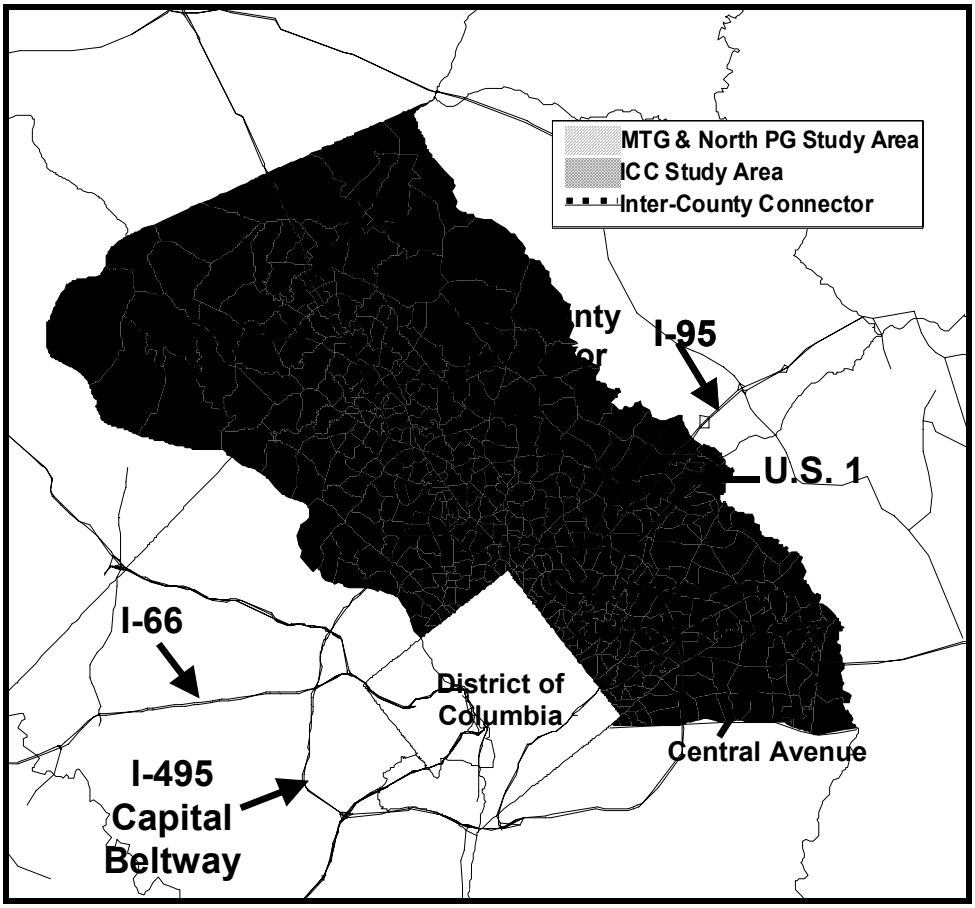


Figure 7: Study Area Boundaries Used For Analysis of Scenario Performance

Vehicle Hours of Travel. All of the alternatives to the ICC including the No Build option reduced hours spent by motorists in cars by more time than the ICC for both study areas, as Table 2 shows.

Table 2: Total Hours Spent in Cars

Total Hours Spent in Cars (Vehicle Hours of Travel)	Montgomery & Northern Prince George's	ICC Study Area
No Build	2,078,792	1,090,022
ICC Build	2,115,496	1,125,627
Transit Oriented Land Use and Invest-ment	1,982,576	1,026,844
Add Toll Lane – Express Bus	1,976,736	1,034,214
Convert HOT Lane – Express Bus	1,993,079	1,016,483
Hybrid: Transit Oriented – HOT Lane – Rail and Express Bus	1,925,611	980,493

The Convert to HOT alternative showed approximately 10 percent fewer hours of vehicle travel than the ICC Build alternative in the ICC Study Area and approximately 6 percent

fewer hours in the Montgomery and Northern Prince George's County Study Area. In addition, the ICC actually increased VHT over the No Build alternative in both study areas. Figure 8 illustrates these changes from the No Build baseline, which generated approximately 2.1 million hours of vehicle travel in the Montgomery and Northern Prince George's County Study Area and 1.1 million hours of travel in the ICC Study Area.

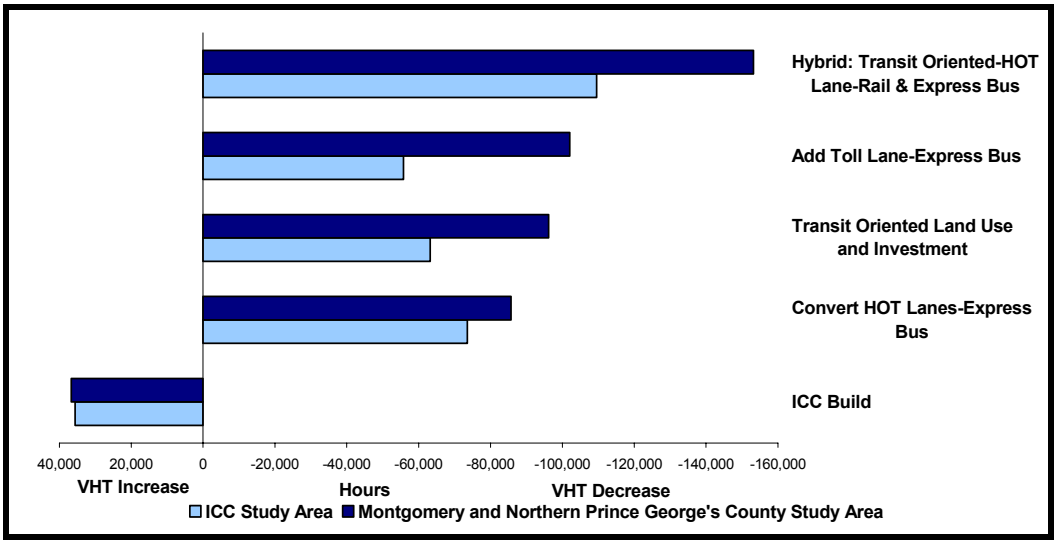


Figure 8: Vehicle Hours of Travel Change Compared to the No Build Alternative

Congestion Delay. Congestion delay, or daily vehicle hours of delay ("VHD"), means how much longer a trip takes than it would in uncongested conditions. Only the ICC increased delay compared to the No Build alternative. All other alternatives reduced hours of delay, as Figure 9 shows. The ICC Build alternative increased delay by 1.1 and 2.1 percent in the Montgomery and Northern Prince George's County and ICC Study Areas, respectively, compared to the No Build alternative. The Hybrid alternative had the least delay, saving 83,400 hours or 15 percent of delay in the ICC Study Area beyond that predicted in the No Build alternative. This was followed by the Transit Oriented alternative and the Add Toll alternative, both of which reduced delay by nearly 9 percent in the ICC Study Area. In the other study area, the Hybrid alternative also reduced delay the most—by more than 11 percent, followed again by the Transit Oriented and Add Toll alternatives.

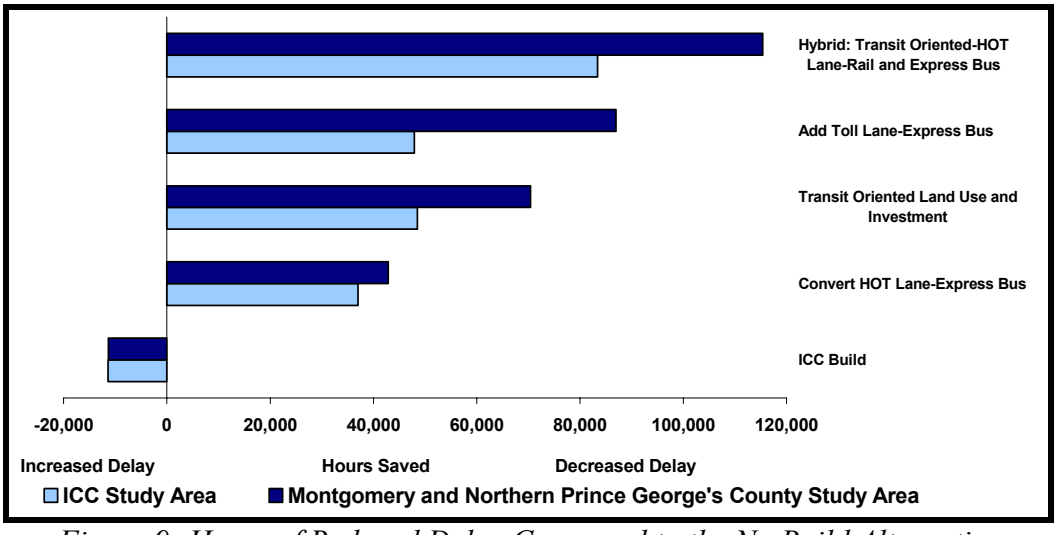


Figure 9: Hours of Reduced Delay Compared to the No Build Alternative

Vehicle Miles of Travel (VMT). VMT is largely proportional to mobile source emissions released by cars and trucks, energy consumption, and greenhouse gas emissions. In addition, the number of vehicle crashes increases as VMT, particularly non-freeway VMT, increases. The ICC is the only alternative considered that increases daily VMT relative to the No Build alternative, and it does so in both study areas, as Table 3 shows.

Table 3: Daily Vehicle Miles of Travel (0.61km=1mile)

Daily Vehicle Miles of Travel ("VMT")	Montgomery & Northern Prince George's	ICC Study Area
No Build	40,128,690	21,795,446
ICC Build	41,451,514	23,082,275
Transit Oriented Land Use and Investment	39,367,766	21,488,701
Add Toll Lane – Express Bus	39,660,759	21,515,590
Convert HOT Lane – Express Bus	37,262,854	19,543,075
Hybrid: Transit Oriented - HOT Lane – Rail and Express Bus	38,249,938	20,475,526

The ICC Build alternative increases VMT above the No Build alternative by more than 1 million miles in both study areas, representing a 3.3 percent increase in the Montgomery and Northern Prince George's County Study Area and by 6 percent in the ICC Study Area. In both study areas, the Convert to HOT, Hybrid, and Transit Oriented alternatives have lower VMT. In addition, the ICC would cause 12 percent more VMT in the ICC Study Area and 8 percent more VMT in the Montgomery and Northern Prince George's County Study Area than the Hybrid alternative. In comparison, the Add Toll and the Transit Oriented alternatives reduced VMT by 1 to 2 percent compared to the No Build alternative in both study areas. And, the Covert to HOT alternative reduced VMT compared to the No Build by 7 to 10 percent in both study areas, as shown in Figure 10.

As Figures 11 and 12 show, for both local and regional arterial roads, the Transit Oriented alternative led to the fewest vehicle miles traveled. The Convert to HOT alternative would cause some diversion of traffic from the expressway corridors, increasing traffic on local

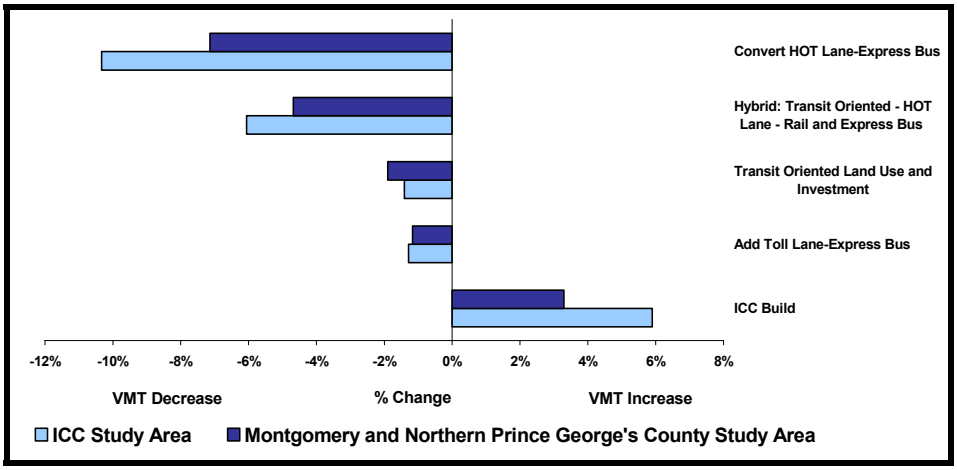


Figure 10: Percent Change in Total VMT Compared to the No Build Alternative

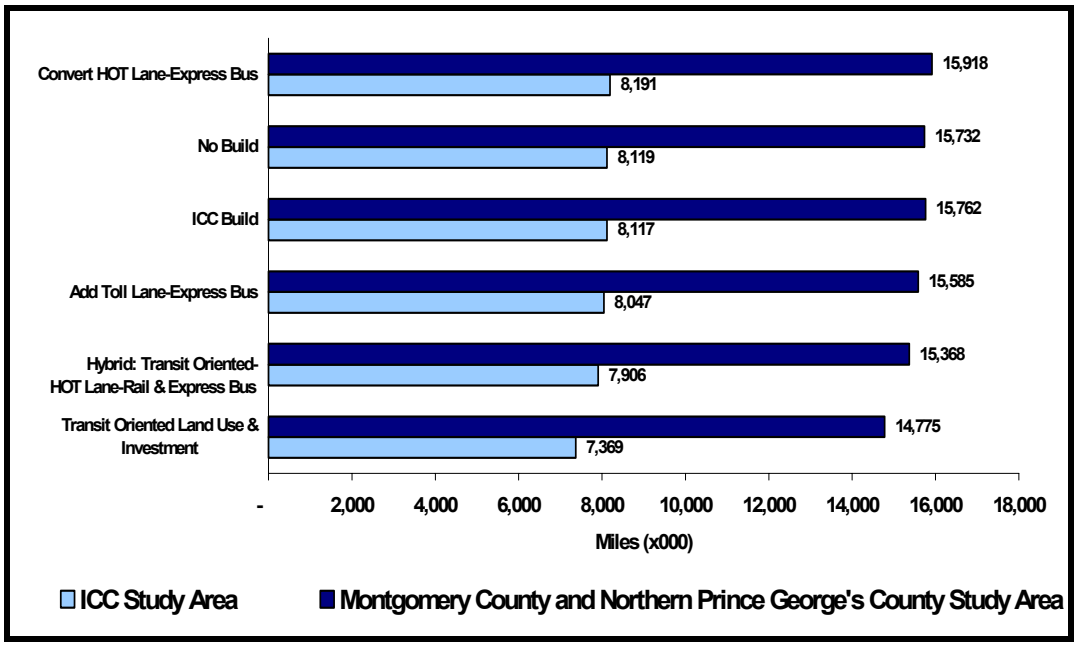


Figure 11: Daily VMT on Major Arterials

and arterial roads. However, this increase is offset when implemented in the context of TOD and improved transit investment in the Hybrid alternative, since traffic on local and arterial roads decreases significantly as a result of this changed land use pattern.

Daily Motor Vehicle Trips. The ICC Build alternative is the only one that increases the number of vehicle trips made each day. The transit oriented land use alternatives – Hybrid and Transit Oriented Investment - on the other hand, lead to the greatest reduction in daily vehicle trips, as Figure 13 shows, by shifting job and housing growth in ways that increase travel by walking, cycling, and public transportation.

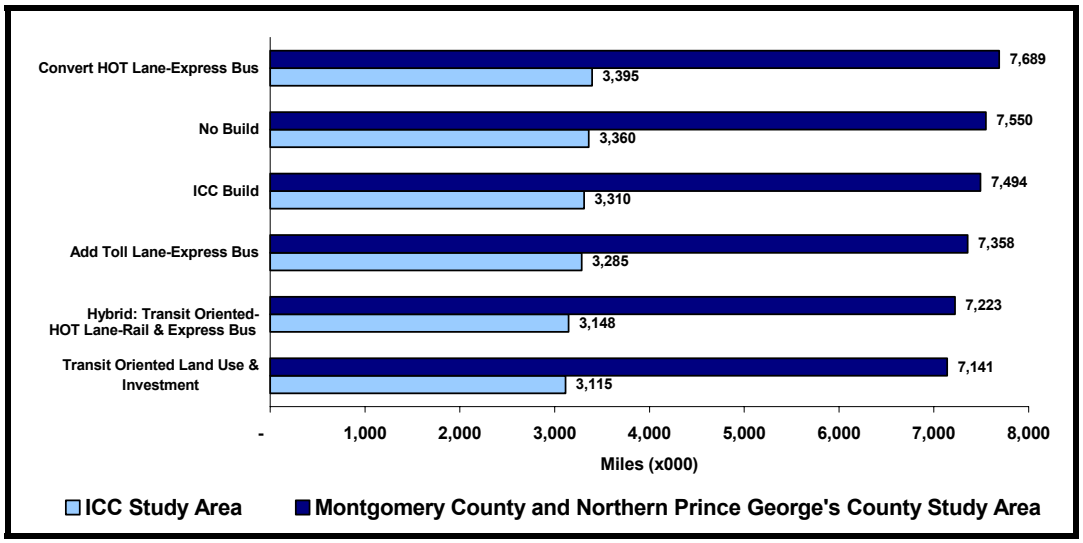


Figure 12: Daily VMT on Local Roads

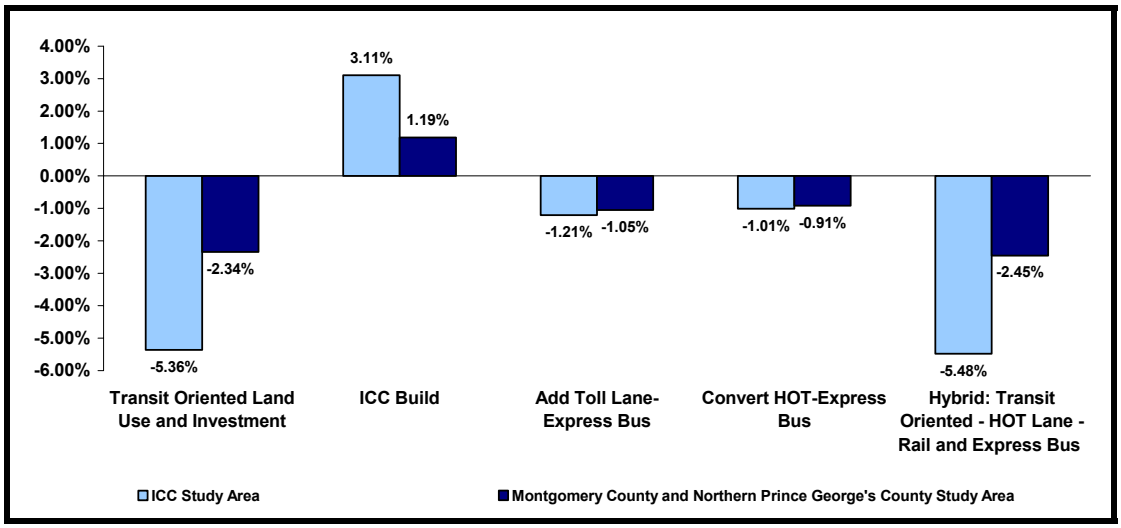


Figure 13: Percent Change in Daily Vehicle Trips Compared to the No Build Alternative

Public Transportation Trips and Mode Share. For both study areas, the ICC alternative had the smallest number of trips using transit and the lowest public transportation mode share, reducing the number of forecast transit trips in both study areas by 10,609 and 6,157 trips, respectively, from the level produced by the adopted 2003 CLRP No Build Alternative, as shown in Table 4 and Figure 14. For the Montgomery and Northern Prince George's County Study Area, the Transit Oriented alternative increases transit use the most, with a 20 percent increase above the No Build Alternative. In the ICC Study Area, the Hybrid alternative has the greatest transit use increase, 38,922 riders more than the No Build Alternative. The Transit Oriented alternative and the Hybrid alternative, both of which include transit oriented land use and better job housing balance, increase transit share the most—from 17.2 percent to 19.3 percent in the Montgomery and Northern Prince George's County Study Area and from 15.3 percent to 18.8 percent in the ICC Study Area. The managed toll lane strategies that support new express bus services were also found to be effective in boosting transit use in the study areas.

Table 4: Total Transit Trips

Total Transit Trips	Montgomery & Northern Prince George's	ICC Study Area
No Build	291,048	106,389
ICC Build	280,439	100,232
Transit Oriented Land Use and Investment	350,615	144,038
Add Toll Lane – Express Bus	308,281	114,948
Convert HOT Lane – Express Bus	304,629	113,089
Hybrid: Transit Oriented - HOT Lane – Rail and Express Bus	349,577	145,311

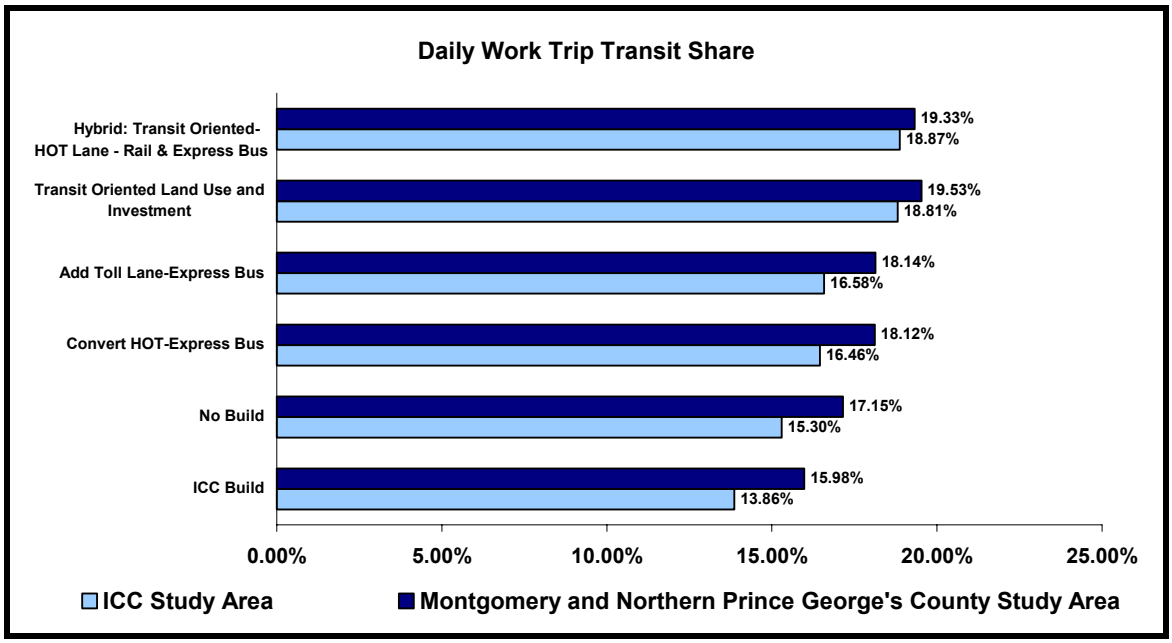


Figure 14: Public Transportation Share of All Work Trips

Average Motor Vehicle Travel Speed. The study shows that the Convert HOT Lane alternative decreases average speeds, presumably because it diverts traffic to lower speed local roads and major arterials and congests them further. The ICC will increase travel speeds compared to the No Build alternative, but three of the alternatives will increase travel speeds more than the ICC for the ICC Study Area. This includes both alternatives that include Transit Oriented Development, and the Add Toll alternative. These same three alternatives also lead to faster travel speeds than the ICC in the Montgomery and Northern Prince George's County Area, as Figure 15 shows.

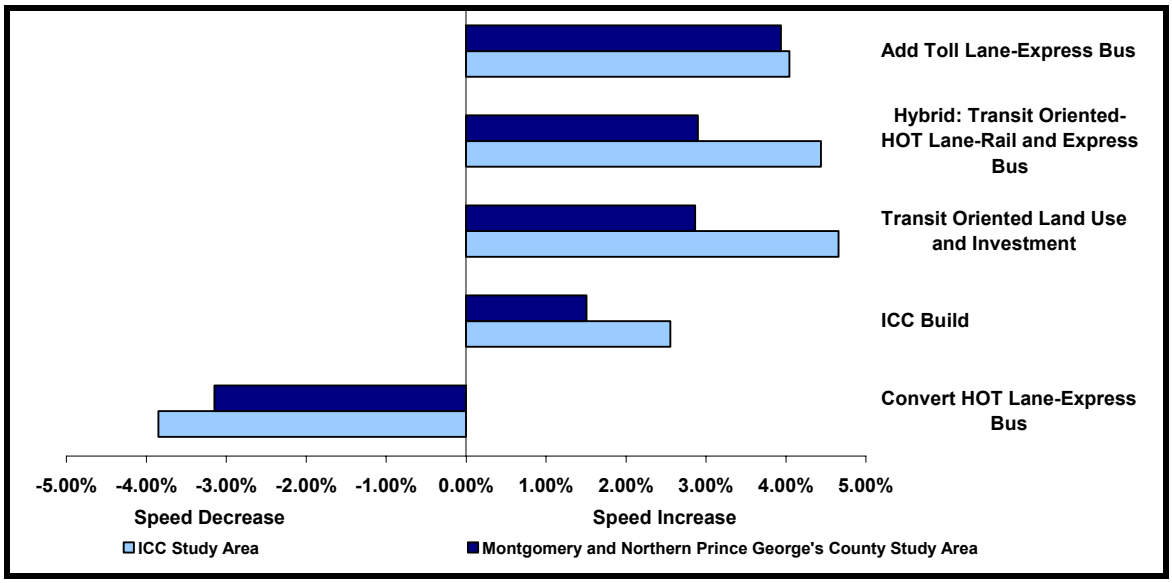


Figure 15: Percent Change in Average Speed Compared to the No Build Alternative

The study's analysis of travel times between a sample of origin-destination pairs for those paying or not paying tolls suggested that while the ICC would save a very modest amount of travel time on a few routes for toll-paying drivers, for many other routes other alternatives produce comparable savings while also giving travelers expanded travel options and leaving non-toll paying travelers better off.

Air Pollution Emissions. The study found for the region as a whole, for Montgomery and Northern Prince George's County Study Area, and for the ICC Study Area, the ICC Build alternative is the only alternative examined that would increase air pollution over the levels in the No Build alternative. All other alternatives would reduce air pollution emissions, as Figure 16 through 18 show. For all three pollutants, the Hybrid and the Convert to HOT alternatives would have the lowest levels of pollution relative to the [redacted] Build Alternative. The Hybrid alternative would result in 2.6 percent fewer emissions of hydrocarbons and 2.7 percent fewer emissions of nitrogen oxides at the full metropolitan area level in 2030, compared to the ICC, an unusually large change in emissions to be associated with a single capital project in the regional transportation program.

In the ICC Study Area, where hot spot particulate emissions[3] are of greatest concern, the ICC produces hydrocarbon emissions 7 percent higher than the No Build and 14 percent higher than the Convert to HOT and Hybrid alternatives. The ICC Build alternative

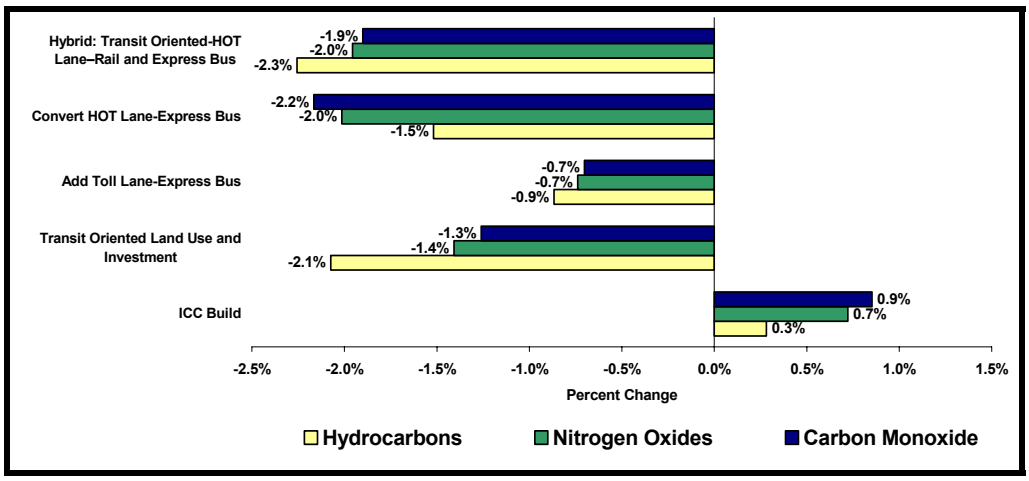


Figure 16: Percent Change in Emissions Relative to the No Build Alternative, Washington, DC Metropolitan Region

[3] Hot spot emissions refer to localized concentrations of pollution that disperse over relatively short distances, such as fine particulates and mobile source air toxics or carbon monoxide from motor vehicles, as opposed to regional pollution problems which are more related to longer distance transportation, accumulation, and persistent lingering of pollution concentrations, as typically occurs with ozone, the smog that is formed out of nitrogen oxides and volatile organic compounds reacting together over many hours in the presence of sunlight. Nitrogen oxides and volatile organic compound pollution from motor vehicles contribute to fine particulate pollution hot spot problems. A recent study in Oakland, California showed that schools located close to major highways experienced higher levels of health-threatening fine particulate pollution than schools located farther from major highways and that students in the schools closer to high traffic volume roads experienced higher adverse health impacts. (Janice J. Kim, Svetlana Smorodinsky, Michael Lipsett, Brett C. Singer, Alfred T. Hodgson, and Bart Ostro. *Traffic-related Air Pollution Near Busy Roads: The East Bay Children's Respiratory Health Study*. Am. J. Respir. Crit. Care Med. 2004; 170: 520-526.)

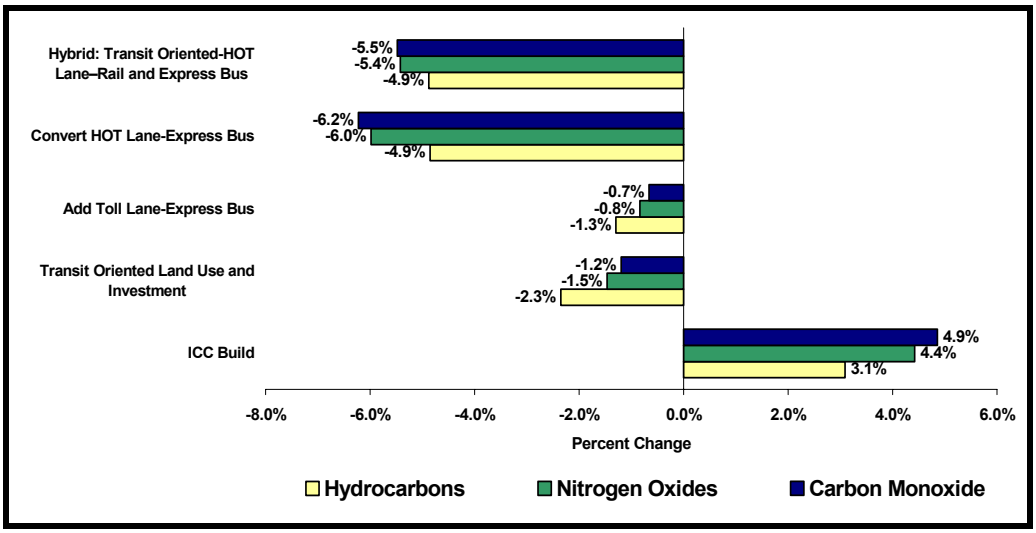


Figure 17: Percent Change in Emissions Relative to the No Build Alternative for Montgomery and Northern Prince George's County Study Area

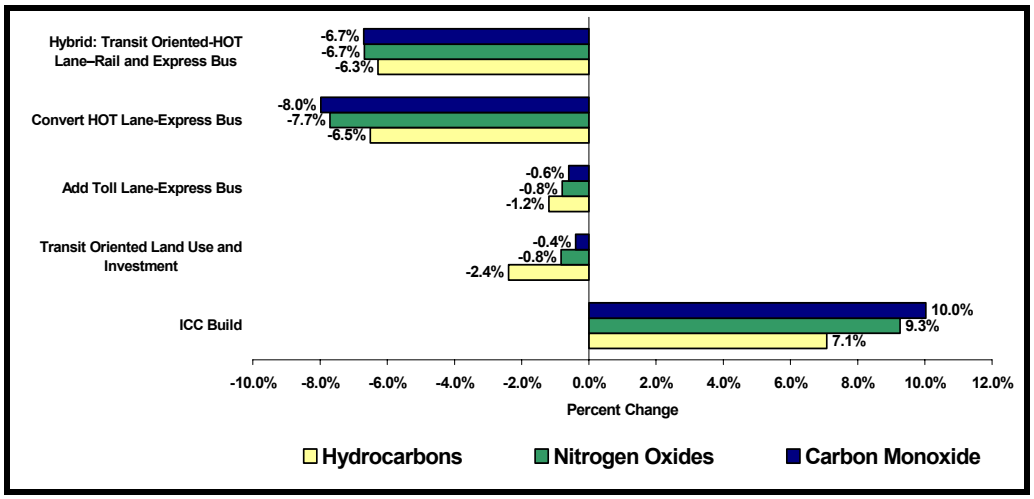


Figure 18: Percent Change in Emissions Relative to the No Build Alternative, ICC Study Area

produces nitrogen oxide emissions 9.3 percent higher than the No Build and approximately 17-18 percent higher than the Convert to HOT and Hybrid alternatives. As these pollutants are important precursors and contributors to fine particulate pollution, these results suggest the need for more detailed future microscale analysis of fine particulate and mobile source air toxic emissions and exposures for those living or working in close proximity to the ICC. A similar analysis would also be advisable for the Add Toll Lanes scenario.

Toll Revenues. Most of the alternatives involve tolls on selected facilities or lanes, which would produce revenues available to pay for project capital and operating costs, financing costs, impact mitigation, or other purposes. It was beyond the scope of this study to undertake a full financial analysis of the alternatives. Instead, a preliminary evaluation was made of toll revenue potential based on the peak and non-peak vehicle miles of travel on toll lanes in three of the alternatives, multiplied by the same per mile toll rates used to evaluate the level of facility use.

Table 5 shows that, even with lower tolls, the ICC carries far less traffic, while the Add Toll and Hybrid alternatives carry more toll traffic demand at higher assumed toll rates. The result is that the Add Toll and Hybrid alternatives can be anticipated to produce roughly four times more gross toll revenue per year compared to the ICC Build alternative (revenues and tolls are expressed in 2004 dollars).

Table 5: Daily VMT and revenue from tolls

Alternative	Toll Paying AM VMT	Toll Paying PM VMT	Toll Paying Off Peak VMT	Toll Paying 24hr VMT
ICC Build	242,881	406,813	505,225	1,154,919
Add Toll Lane-Express Bus	511,394	929,251	1,133,882	2,574,528
Hybrid: Transit Oriented-HOT Lane–Rail and Express Bus	546,895	925,093	1,617,092	3,089,080

Per Mile Toll Rates	AM Peak	PM Peak	Off Peak
ICC Tolls	$ 0.20	$ 0.20	$ 0.15
Express Lane Tolls	$ 0.40	$ 0.40	$ 0.20

Alternative	Gross 2030 Daily Revenue	Gross Yearly Toll Revenue (day x 300)
ICC Build	$205,723	$61,716,791
Add Toll Lane-Express Bus	$803,035	$240,910,382
Transit Oriented-HOT Lane–Rail and Express Bus[4]	$912,214	$273,664,125

The cost of toll collection, operations, and enforcement as a percent of revenues would be higher for the Add Toll and Hybrid alternatives, compared to the ICC, since the latter is a fully tolled facility and the former would involve more complex toll management issues related to non-barrier separated toll facility operations. But even after accounting for this, the Add Toll and Hybrid alternative net revenues available for debt service, transit operating support, and impact mitigation or transfer payments through a FAIR lane system would likely amount to several times more than the net revenues available from tolls collected on the ICC, and might amount to more than $200 million per year by 2030.

Summary of Performance Measures. Table 6 summarizes the relative rank order performance of the alternatives against various criteria, showing that the combination of transit-oriented balanced land use, transit investment, and toll managed lanes performs best in most respects, while the new toll outer beltway on its own right-of-way performs worst in most respects. The scenario that creates toll managed lanes in existing motorway corridors out of a combination of new capacity and converted general purpose lanes and which includes new BRT services on those lanes, performs significantly better than the proposed new outer beltway, but not as well as the scenario that better coordinates transportation

[4] A simplifying assumption for this analysis was made, so VMT and toll revenue reported for the Hybrid alternative includes HOV3+ vehicles that would actually use the lanes for free. Thus, revenues would actually be slightly lower for this scenario.

investment and land development patterns. Converting existing motorway lanes to HOT lanes to support BRT but without ensuring more balanced and transit oriented growth patterns appears to falter because of the traffic it pushes off onto local road networks, but even this scenario performs better than the new outer beltway in many respects. The outer beltway's performance appears to be hampered by induced traffic impacts and the way that it is forecast to shift job growth to locations generally not very accessible by public transportation. Various sensitivity tests were undertaken to examine how changes in assumptions might affect these results and these showed little change in the ordering of differences.

These findings are important as they suggest potential synergy and compatibility between road pricing and "Smart Growth" transit-oriented development linked to new rail investment which has been little explored by partisans advocates of Smart Growth or partisan advocates of road pricing, who often clash and denigrate each other's approaches to transportation in public policy debates.

Table 14: Ranked Performance of Alternatives: Summary of the Results of the Analysis

	Cardinal Scale Rankings										
Scenario	VHT	VHD	VMT-All Facilities	VMT-Local Roads	VMT-Major Arterials	Total Transit Trips	Work Trip Transit Share	Travel Speed	Air Quality	Total Cost	Average Ranking
Hybrid: Transit Oriented-HOT Lane-Rail and Express Bus	1	1	2	2	2	1	1	2	2	4	**1.8**
Transit Oriented Land Use and Investment	3	2	3	1	1	2	2	1	3	5	**2.3**
Add Toll Lane-Express Bus	4	3	4	3	3	3	3	3	4	3	**3.3**
Convert HOT Lane-Express Bus	2	4	1	6	6	4	4	6	1	2	**3.6**
No Build	5	5	5	5	5	5	5	5	5	1	**4.6**
ICC build	6	6	6	4	4	6	6	4	6	6	**5.4**

(1=Best; 6=Worst)

3. CONCLUSION

With increasingly strained public sector finances, transportation infrastructure development is likely to become more dependent on toll financing and private investment. But will tolls be allowed to be used only to build new lanes, as proposed in the 2004 U.S. House of Representatives transportation bill or will states be given more flexibility to use toll revenues to invest in a variety of transportation strategies and to manage congestion, as proposed under the 2004 U.S. Senate transportation bill? At least in the context of this case study, it appears it might make more economic, financial, and environmental sense to focus on better managing existing roads than to invest in more new roads on new rights-of-way.

If public and private investments in transportation are held accountable to meet performance standards under the Clean Air Act or other statutes, or as part of community and environmental benefit agreements, what strategies will need to be bundled to get the job done? When regions like the Washington, DC metro area plan new toll managed networks, what should they consider in looking at trade-offs in system design? This paper has suggested some promising approaches that may enable reduction of traffic congestion while avoiding or mitigating adverse environmental and public health impacts.

No metropolitan area in the world has a toll managed lane network in place, although planning for such networks is underway in San Diego, Houston, metropolitan Washington, DC,

and elsewhere. A 2003 study by Bob Poole and Kenneth Orski lays out a vision for HOT networks in 8 U.S. metropolitan areas, which might cost $44 billion. While these studies suggest a promise for traffic congestion relief, new revenues for transportation, and support for public transportation development, planners and transportation stakeholders have only begun to examine the many issues raised by these proposals. As this paper has highlighted, there are multiple questions that must be answered before designing such systems.

Toll managed lane systems can be designed to maximize toll revenues, road system expansion, and traffic throughput, but such systems are likely to spur more sprawl development, traffic growth, increased pollution and greenhouse gas emissions, and worsen inequality of access to jobs and public facilities for people without cars. Toll managed lane systems can alternatively be designed to reduce traffic growth and congestion and promote more efficient public transportation, to expand transportation choices, mitigate adverse impacts from expanded mobility, and boost equitable access to jobs and public facilities for all, supporting Smart Growth and reinvestment in existing communities.

This paper suggests the need for much more intensive consideration of these options and trade offs in environmental impacts reviews, transportation planning, and decision-making regarding proposals for public-private partnerships and new transportation investments. Environmental stewardship in transportation can flow only from the more open consideration of alternatives, impacts, and performance, with public involvement and oversight.

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