Updated to 2011: Making the Dulles Rail System Cost Effective Report FAC/FCTA-04

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Introduction: This work was taken out of personal interest in determining if the proposed Phases I and II of the Dulles Rail system are economically worthwhile. If worthwhile, those who benefit should provide all of the funds, with no subsidy required from those who do not benefit. In particular, no tax support would be required to pay for the system. We hope that organizations such as the government, WMATA, and advocacy groups will find the results of this study to be useful.

This report updates and improves upon our 2003 report FCTA-01: Making the Dulles Rail System Cost Effective**,** in several ways. That report can be seen at http://www.fcta.org/data/dulles-rail. We have incorporated much data that was not available in 2003, when we had to make many guesses. In addition, we have become more skillful in finding data via the Internet. The conclusions of this report differ greatly from those of the earlier report because our guess of the land value was low by a factor of ten, being based on land values far from the business district. Herein we use land values in Tysons Corner.

Summary: The rail system can be economically worthwhile, without tax support, if certain conditions are met. These conditions are derived (logically deduced) from the analysis presented in the Discussion section of this report. The conditions are:

1. The population density within 0.25 miles of each of the six residential stations must be 101 people per acre. If there is one non-rider per rider, the total population density around the station must be at least 203 people per acre. If there are two people per dwelling unit, there would be 101 dwelling units per acre. If each dwelling had a floor plan of 1000 sq.ft.per person and 50% of the land area was covered by buildings, the buildings would be 9 stories high. Each station would board 14,167 riders per day. (The computations are in Appendix A.)
2. For every station surrounded by businesses with a FAR of 2 and 300 sq.ft. per person, 36493 workers would be accommodated, the equivalent of 2.5 stations surrounded by residential units. If only 30% ride the rail system, one business station could provide enough employment for 0.75 residential stations. Mixing residential and commercial units at a single station will take away from the support of the rail system. Mixing units is clearly a better economic strategy than rail because the residents will walk to work, no rail will be needed, and the potential riders would save the most.
3. The Draft Environmental Impact Statement (DEIS) used 85,000, which value we used in this report..
4. If the costs are borne by the beneficiaries in proportion to their benefit, the following split is equitable:
   - $8.18 average daily fare for rail riders on the Silver Line extention past East Falls Church
   - $0.40 daily toll for toll-road drivers
   - 77% of the increase in land value near the Metro must be paid as a tax by the owners

The current Metrorail fare structure would call for an average daily (round trip) fare of $8.88, varying from $2.92 to $14.28, depending on distance traveled.

5. The Supplementary EIS shows an increase in automotive pollution due to the Dulles rail system because more cars will be on the road. Although $10 per day seems excessive, the rider will save money relative to driving to work, if the next three conditions are met.
6. Commercial-property owners must not build parking space to accommodate rail riders, so that the business owners save construction costs that can be passed to the rider.
7. The rider must forego owning an automobile and a house with a garage. The rider's spouse may own a car and a garage at the house. The rider saves money by not owning the one automobile and the garage it requires. This saving more than offsets what the rider pays for the rail fare.
8. Street parking and parking-lot parking must not accommodate the automobile the rider might otherwise own. Because 90% of the riders live within 0.25 miles of a station, this characteristic is not severely restricting. If such parking were permitted, the rider would not save on a garage cost because he could use this free parking.

Present plans do not meet several of these conditions. There is no rush by developers to build housing with such limited parking space and by businesses to build office buildings with fewer parking spaces. Many of the commercial buildings are already built; therefore, the owners would realize no cost saving.

The foregoing is based on having no taxpayer subsidy (called a government subsidy) for the rail system. There is little logical reason to provide such a subsidy because the three classes of beneficiaries can carry the cost. Construction costs would be paid not by taxes but by, for example, a rail-revenue bond similar to the highway bonds issued in the past. Although plans call for most of the construction cost to be borne by the Federal and State governments, these monies are taken from those who do not benefit; therefore, they are unfair (Appendix C).

The foregoing is also based on no escalation of construction costs. Projects of this type frequently have cost overruns of 100% to 200%. The fare must be increased to compensate for any such escalation.

Discussion: The supporting computations for the foregoing conclusions are given in the following paragraphs.

For the rail to be cost effective to the user, the ridership must be high enough to reduce the unit cost of riding to the unit cost of owning and operating an automobile. We have assumed that the rail-system cost is independent of the number of people who ride it; therefore, if the ridership were infinite, the cost per rider would be zero. For our cost of the rail system, we have used the DEIS and the ridership stated in the DEIS, 85000 per day. If the calculated ridership differs greatly from this number, the cost of the rail system must be adjusted because more rail cars must be included. The number of stations must also increase to handle the number of riders.

Because 90% of the people who use mass transit must live within 0.25 miles of the stations, we consider only the residences and businesses that are within 0.25 miles of each mass-transit station. We can use this distance to determine what the population density must be to afford a mass-transit system.

$$\text{dollars} := 1$$

Annualized Cost of Rail

The 2011 estimate of the construction cost is reported at:
http://washingtonexaminer.com/opinion/columnists/2010/12/new-lower-rider-estimates-dulles-rail-expose-big-costs

$$\text{DullesRailConstruction} := 6500000000 \cdot \text{dollars}$$

A breakdown of the cost, based on earlier estimates, can be found at
http://www.gobrt.org/Vincent-RothJeffersonInstitutePaperFinal.pdf

Per the FEIS (http://www.dullesmetro.com/community/impact_report.cfm):

$$\text{DullesRailMiles} := 23.1 \cdot \text{mi}$$

$\text{DullesStations} := 11$ including Tysons, Reston, airport, and Loudoun stations

$\text{AnnualRailOandMCost2015} := 93900000 \cdot \dfrac{\text{dollars}}{\text{yr}}$ in 2015 (Executive Summary, Page S-15)

We annualize the construction cost using the following:

$\text{DiscountRate} := 5\%$ as corrected for inflation

$$\text{AmortizationYears} := 40 \cdot \text{yr}$$

$$\text{AnnualizationFactor} := \frac{1 - (1 + \text{DiscountRate})^{\frac{-\text{AmortizationYears}}{\text{yr}}}}{\text{DiscountRate}} \cdot \text{yr}$$

$$\text{AnnualizationFactor} = 17.159 \cdot \text{yr}$$

$$\text{AnnualizedRailConstructionCost} := \frac{\text{DullesRailConstruction}}{\text{AnnualizationFactor}}$$

$$\text{AnnualizedRailConstructionCost} = 379 \times 10^{6} \cdot \frac{\text{dollars}}{\text{yr}}$$

$$\text{Inflation} := 4\%$$

$\text{AnnualRailOandMCost} := \dfrac{\text{AnnualRailOandMCost2015}}{(1 + \text{Inflation})^{4}}$ to correct to 2011

$$AnnualRailCost := AnnualizedRailConstructionCost + AnnualRailOandMCost$$

$$AnnualRailCost = 459.074 \times 10^{6} \cdot \frac{dollars}{yr}$$

This cost is independent of the ridership because the trains will run even if empty.

The cost per trip is:

$$RoundTrips := 85000 \cdot \frac{1}{day}$$ Vol 1 of Draft DEIS, Pg S-14 number of trips is twice this value

$$BusinessDays := 250 \cdot \frac{day}{yr}$$

$$CostPerTrip := \frac{AnnualRailCost}{2 \cdot RoundTrips \cdot BusinessDays} \qquad CostPerTrip = 10.802$$

Annualized Cost of Private Automobile

We assume that street parking is not permitted at the residence and that no commercial parking garages would be built for the residents. We also assume that each commuter will have at most one, rather than two, automobiles.

$$CarOandMCost := \frac{4 \cdot dollars}{gal} \cdot \frac{gal}{25 \cdot mi} + 0.2 \cdot \frac{dollars}{mi}$$

$$CarOwnershipCost := \left(0.51 \cdot \frac{dollars}{mi} - CarOandMCost\right) \cdot 15000 \cdot \frac{mi}{yr} \qquad CarOwnershipCost = 2250 \cdot \frac{dollars}{yr}$$

We use data on the Wiehle Avenue parking garage to compute the cost of a commercial parking garage. (See http://washingtonexaminer.com/transportation/2009/05/fairfax-may-pay-garage-wiehle-ave-metro-station)

$$WiehleCost2009 := 90000000 \cdot dollars \qquad WiehleCarCapacity := 2300 \qquad InflationTo2011 := 3.2\%$$

$$CommercialParkingConstruction := \frac{WiehleCost2009 \cdot (1 + InflationTo2011)}{WiehleCarCapacity}$$

$$CommercialParkingConstruction = 40383 \cdot dollars$$

We compute the cost of an attached garage using http://www.building-cost.net:

$$ResidentialParkingConstruction := (435112 - 407677) \cdot dollars$$

$$ResidentialParkingConstruction = 27435$$

$$AnnualizedParkingConstruction := \frac{(CommercialParkingConstruction + ResidentialParkingConstruction)}{AnnualizationFactor}$$

$$AnnualizedParkingConstruction = 3952 \cdot \frac{dollars}{yr}$$

The average distance from Falls Church to the eleven stations is (23.4 miles corresponds to 7.91 inches on the map we used)::

$$TripLength := \frac{23.4 \cdot mi}{7.91} \cdot mean(1, 1.27, 1.54, 1.76, 3.66, 4.16, 4.86, 5.31, 6.36, 7.36, 7.91)$$

$$TripLength = 12.153 \cdot mi$$

We will use this average trip length to estimate the cost of driving an automobile to work.

$$DistanceToWork := TripLength$$

$$Trips := 2 \cdot \frac{1}{day}$$

$$AnnualCarOandMCost := CarOandMCost \cdot DistanceToWork \cdot BusinessDays \cdot Trips$$

$$AnnualCarOandMCost = 5.989 \cdot \frac{dollars}{day}$$

A poll by Stephen Fuller of GMU (Washington Post, 11/23/03, Pg C-5) shows that drivers commuting from Fredericksburg are willing to drive 59 minutes. They value their travel time at between $7/hr and $14/hr. We will use $10/hr, corrected by inflation from 2003 to 2011. The rail travel time is well within the commuter's travel limit.

$$HourlyRate := 10 \cdot 1.209 \cdot \frac{dollars}{hr}$$

The transit time for the automobile driver is (approximately, of course):

$$CarTime := \frac{DistanceToWork}{35 \cdot \frac{mi}{hr}} + 5 \cdot min$$

$CarTime = 25.834 \cdot min$ each way

$$CarTimeCost := CarTime \cdot \frac{2}{day} \cdot HourlyRate \qquad CarTimeCost = 10.411 \cdot \frac{dollars}{day}$$

$$TotalCarCost := AnnualCarOandMCost + AnnualizedParkingConstruction + CarOwnershipCost + CarTimeCost$$

$$TotalCarCost = 12192 \cdot \frac{dollars}{yr} \qquad TotalCarCost = 33.382 \cdot \frac{dollars}{day}$$

If the rider owns an automobile even though he does not use it to ride to work, his incremental cost of using his car for commuting is equal to the AnnualCarOandMCost plus the cost of parking at work.

$$TotalCarVariableCost := AnnualCarOandMCost + \frac{CommercialParkingConstruction}{AnnualizationFactor} + CarTimeCost$$

$$TotalCarVariableCost = 22.844 \cdot \frac{dollars}{day}$$

Annualized Cost of Riding Rail

The Metrorail transit time from the farthest Dulles station is given by the equation (as derived from Metro's data):

$NumberOfResidentialStations := 6$ (all but the Tysons stations and Reston Town Center)

$$TransitTime := 2.8 \cdot min \cdot (NumberOfResidentialStations - 1) + \frac{(TripLength - 1.3 \cdot mi)}{70 \cdot \frac{mi}{hr}}$$

$$TransitTime = 0.388 \cdot hr$$

The time to walk 0.25 miles is approximately 5 minutes and the average wait time is the time between trains (3 minutes); therefore, the total door-to-door time is

$RailTime := TransitTime + 5 \cdot min \cdot 2 + 3 \cdot min$ each way

$$RailTime = 36.303 \cdot min$$

The time-value cost of riding the Metro per day is:

$$\text{TimeCostOfRail} := \text{HourlyRate} \cdot \frac{2}{\text{day}} \cdot \text{RailTime}$$

$$\text{TimeCostOfRail} = 14.63 \cdot \frac{\text{dollars}}{\text{day}}$$

We must next establish that the rail user would pay in fares.

If the rail user gives no value to the convenience of an automobile, so that he does not own an automobile, or perhaps a second automobile, then he should be willing to pay a fare that equals what he now pays in total automobile cost. A key factor is the number of people using the rail system each day, because the cost of construction is allocated to this number.

If the DEIS estimate of 85000 people using the rail system is correct, the rail system would cover its costs if the fare were:

$$\text{DEISridership} := \text{RoundTrips} \cdot 1 \cdot \text{day}$$

$$\text{BreakevenFare} := \frac{\text{AnnualRailCost}}{\text{DEISridership}} \qquad \text{BreakevenFare} = 14.787 \cdot \frac{\text{dollars}}{\text{day}}$$ round trip

We can compare this fare with the current Metro fare rate. The current fare (2011) from Metro Central to the following stations is:

Vienna	$d_1 := 14.02\,\text{mi}$	$f_1 := 4.95\,\text{dollars}$
Foggy Bottom	$d_2 := 1.28\,\text{mi}$	$f_2 := 1.95\,\text{dollars}$
Dunn Loring	$d_3 := 11.54\,\text{mi}$	$f_3 := 4.3 \cdot \text{dollars}$
Clarendon	$d_4 := 4.01 \cdot \text{mi}$	$f_4 := 2.25\,\text{dollars}$
East Falls Church	$d_5 := 7.41 \cdot \text{mi}$	$f_5 := 3.2 \cdot \text{dollars}$

A least-squares fit to this data yields:

$$\text{MetroFare}(\text{Distance}) := 1.46 + 0.245 \cdot \frac{\text{Distance}}{\text{mi}}$$

For our average commuter and the current fare scale, the daily fare, at 2 trips per day, would be

$$\frac{2}{\text{day}} \cdot \text{MetroFare}(\text{DistanceToWork}) = 8.875 \cdot \frac{\text{dollars}}{\text{day}}$$

Clearly, this fare rate does not cover the cost of the rail system.

Below, we will compute a fare that allocates the rail costs according to the benefit. Here, we make our first guess:

$$\text{Fare} := 8 \cdot \frac{\text{dollars}}{\text{day}}$$

The total cost to the rail rider, with the fare at Breakeven and the cost of the extra commute time, is:

$$\text{RailRiderCost}(\text{Fare}) := \text{Fare} + \text{TimeCostOfRail}$$

$$\text{RailRiderCost}(\text{Fare}) = 22.63 \cdot \frac{\text{dollars}}{\text{day}}$$

Notice that at the BreakevenFare, riding is less expensive than driving if the rider has one car fewer than he would without rail but more expensive if he has the same number of cars. Grocery and drug stores may be needed near the residences to enable the rider to forego one car unless such shopping can be done in the one car that he does keep (instead of two)..

Toll-Road-User Profit

There is some benefit to those who choose not to ride the Metro rail system, because highway traffic is less when some people ride the rail; however, the effect is not great. The DEIS estimates only a 5% reduction in the number of people who would be driving on the toll road. As a check on this percentage, we looked at 2003 Vienna Metro and VRE riders. If they switched to automobiles and all used I-66 -- a somewhat unrealistic supposition, the traffic on I-66 would increase only 7.3%. The AADT traffic count provides an estimate of the number of users. See http://virginiadot.org/info/resources/AADT_029_Fairfax_2008.pdf

For this small decrease in traffic, we will assume that the trip time is reduced by the same 5%.

$$NumberOfTollRoadUsers := 280000$$

$$TollRoadUserSaving := 5\% \cdot CarTimeCost \qquad TollRoadUserSaving = 0.521 \cdot \frac{dollars}{day}$$

Developer Profit

The people who currently own land around the rail stations will realize an increase in the value of their land, but probably not in the value of their buildings because these must be replaced by high-density buildings.

The following data shows the increase in land values between 2001 and 2010 for properties in Tysons, along Route 123, and in shopping centers around the County. The first column gives the address; the second, the ratio between the assessed land value in 2010 to that in 2001 (as corrected by inflation to 2010, with prices in 2001 being 80.6% of those in 2010). The third column gives the assessed value per acre in 2001 (as corrected for inflation).

Leesburg Pike		
8448	2.149	$1,621,340
8595	1.985	$1,625,939
8500	1.612	$1,742,940
8526	1.842	$1,999,264
8525	1.827	$1,621,340
8359	2.469	$1,139,590
Average	1.981	$1,625,069

Maple Ave, Vienna		
535 NW	2.187095	$1,294,604
226 W	1.906539	$ 906,659
314 W	2.182913	$1,297,074
Chain Bridge Rd, Oakton		
2959	1.751717	$1,117,596
2975	2.013862	$ 910,419
2923	2.264435	$ 452,157
Average	2.051094	$ 996,418

Shopping Centers				
Sears	1.267	$ 810,670	at Fair Oaks Mall	Fair Oaks Mall
2401	1.190	$ 639,808	CENTREVILLE RD	Clocktower Shopping Center
3919	1.174	$ 663,141	CENTREVILLE RD	Sully Plaza Shopping Center
6436	1.329	$ 589,844	SPRINGFIELD PZ	Springfield Mall
2521	1.123	$ 556,954	JOHN MILTON DR	Fox Mill Shopping Center
9525	1.190	$6,548,341	BRADDOCK RD	Twinbrook Shopping Centre
Average	1.212	$1,634,793		

The effect of Metrorail seems to extend down Route 123. Taking the ratio of the Leesburg Pike average and the shopping center average to be the effect of Metrorail yields:

$$PreMetroLandValue := 1625069 \cdot \frac{dollars}{acre}$$

$$PostMetroLandValue := \frac{1.981}{1.212} \cdot PreMetroLandValue$$

We consider the profits to be significant only within the BenefitRadius of the stations:

$$BenefitRadius := 0.5 \cdot mi$$

$$TotalIncrease := (PostMetroLandValue - PreMetroLandValue) \cdot DullesStations \cdot \pi \cdot BenefitRadius^2$$

$$TotalIncrease = 6 \times 10^9 \cdot dollars$$

$$LandTotalIncrease := \frac{TotalIncrease}{AnnualizationFactor} \qquad LandTotalIncrease = 332.249 \times 10^6 \cdot \frac{dollars}{yr}$$

This is $\frac{TotalIncrease}{DullesRailConstruction} = 88 \cdot \%$ of the cost of the rail system.

Rents have been found to be 10% higher near rail stations. See:
http://business.fullerton.edu/finance/journal/papers/pdf/past/vol12n01/v12p001.pdf

These higher rents are due to the proximity to the rail station and could be added to the land profit; however, they are more properly assigned to the infrastructure payment, as should any excess in the value of land improvements (e.g., buildings) above what would be realized away from the Metro stations..

An Equitable Fare

In summary, the gain from a driver who switches to a rider and fooregoes one car is:

$$SavingDueToSwitchToRail(Fare) := DEISridership \cdot BusinessDays \cdot (TotalCarCost - RailRiderCost(Fare))$$

$$SavingDueToSwitchToRail(Fare) = 228.475 \times 10^6 \cdot \frac{dollars}{yr}$$

$$SavingsByTollRoadUsers := TollRoadUserSaving \cdot NumberOfTollRoadUsers \cdot BusinessDays$$

$$SavingsByTollRoadUsers = 36.439 \times 10^6 \cdot \frac{dollars}{yr}$$

$$LandTotalIncrease = 332.249 \times 10^6 \cdot \frac{dollars}{yr}$$

This may be compared to

$$AnnualRailCost = 459.074 \times 10^6 \cdot \frac{dollars}{yr}$$

$$TotalGains(Fare) := SavingDueToSwitchToRail(Fare) + SavingsByTollRoadUsers + LandTotalIncrease$$

$$PctSwitcher(Fare) := \frac{SavingDueToSwitchToRail(Fare)}{TotalGains(Fare)} \qquad PctSwitcher(Fare) = 38.3 \cdot \%$$

$$PctNonSwitcher(Fare) := \frac{SavingsByTollRoadUsers}{TotalGains(Fare)} \qquad PctNonSwitcher(Fare) = 6.1 \cdot \%$$

$$PctLandOwner(Fare) := \frac{LandTotalIncrease}{TotalGains(Fare)} \qquad PctLandOwner(Fare) = 55.6 \cdot \%$$

The switcher can pay by paying a round-trip fare equal to.

$$\frac{PctSwitcher(Fare) \cdot AnnualRailCost}{DEISridership \cdot BusinessDays} = 8.266 \cdot \frac{dollars}{day}$$

Given

$$0 = \text{Fare} - \frac{\text{PctSwitcher}(\text{Fare}) \cdot \text{AnnualRailCost}}{\text{DEISridership} \cdot \text{BusinessDays}}$$

$$\text{Fare} := \text{Find}(\text{Fare})$$

$$\text{Fare} = 8.18 \frac{\text{dollars}}{\text{day}}$$

Note that this is the incremental cost for riding just the extension from East Falls Church outward.

The toll-road user should pay an additional (above the cost of the toll road prior to Metro)::

$$\frac{\text{PctNonSwitcher}(\text{Fare}) \cdot \text{AnnualRailCost}}{\text{NumberOfTollRoadUsers} \cdot \text{BusinessDays}} = 0.4 \cdot \frac{\text{dollars}}{\text{day}}$$

Businesses should be taxed

$$\frac{\text{PctLandOwner}(\text{Fare}) \cdot \text{AnnualRailCost}}{\text{LandTotalIncrease}} = 77 \cdot \%$$ of the increase in the land value

Notice that the increase in value due to improvements is not taxed.

The foregoing computations were performed for other values of the rail ridersihp. The results were:

Rail ridership	85000	70833	42500	round trips per day
Rail Fare	8.18	8.53	9.27	dollars per day
Added Toll	0.40	0.43	0.51	dollars per day
Tax on increase in land value	77%	84%	98%	

Notice how close the rail fare is to that computed by the MetroRail formula:

$$\frac{2}{\text{day}} \cdot \text{MetroFare}(\text{DistanceToWork}) = 8.88 \frac{\text{dollars}}{\text{day}}$$

Appendix A: Population Density at Residential Stations

Most (90%) of the people who use mass transit live and work within 0.25 miles of a station; therefore, in allocating costs, we can assume that all riders live within this distance.

$$PercentWithinBenefitRadius := 90 \cdot \% \qquad Radius := 0.25 \cdot mi$$

Each area within the benefit radius is: $\pi \cdot Radius^2 = 125.664 acre$

$$RidersPerStation := \frac{DEISridership}{NumberOfResidentialStations}$$

$$RidersPerStation = 14167$$

This number can be compared to the existing peak-hour Metro ridership (half the number of boardings, because we assume each rider is taking a round trip) (See : http://www.wmata.com/pdfs/planning/2009%20Metrorail%20boarding%20by%20station.pdf)

	2003	2009
Vienna	12859	13759
West Falls Church	9388	10499
East Falls Church	4206	4202

$$RiderPopulationDensity := \frac{RidersPerStation \cdot PercentWithinBenefitRadius}{\pi \cdot Radius^2}$$

$$RiderPopulationDensity = 101.5 \cdot \frac{1}{acre}$$

If we assume that, for each rail rider, there is, on average, one non-rail rider, then the population density is:

$$PeoplePerAcre := 2 \cdot RiderPopulationDensity$$

If we assume that a residence has an area of:

$$AreaPerPerson := 1000 ft^2 \qquad AreaPerPerson = 0.023 \cdot acre$$

then the ratio of living area to plan area is:

$$AreaPerPerson \cdot PeoplePerAcre = 4.658$$

This number, in commercial buildings, is called the FAR. Because roads, walks and green area reduces the area for building to approximately 50% of the gross area, the number of stories required for the residential buildings is:

$$Stories := \frac{AreaPerPerson \cdot PeoplePerAcre}{50\%} \qquad Stories = 9.317$$

Appendix B: Population Density at Commercial Stations

The population density for commercial buildings is approximately

$$\text{AreaPerOccupant} := 300 \cdot \text{ft}^2 \qquad \text{AreaPerOccupant} = 0.0069 \cdot \text{acre}$$

We assume that the floor-to-plan area ratio (BusinessFAR) is:

$$\text{BusinessFAR} := 2$$

$$\text{BusinessOccupants} := \frac{\text{BusinessFAR}}{\text{AreaPerOccupant}} \qquad \text{BusinessOccupants} = 290 \cdot \frac{1}{\text{acre}}$$

Each business station services:

$$\text{PeoplePerBusinessStation} := \pi \cdot \text{Radius}^2 \cdot \text{BusinessOccupants}$$

$$\text{PeoplePerBusinessStation} = 36493$$

If all of the workers ride the MetroRail, the number of residential stations required to service one business station is:

$$\frac{\text{PeoplePerBusinessStation}}{\text{RidersPerStation}} = 2.6$$

whereas the number of stations planned is: $\text{NumberOfResidentialStations} = 6$

$$\text{DullesStations} = 11$$

so that the planned value for this ratio is:

$$\frac{\text{NumberOfResidentialStations}}{\text{DullesStations} - \text{NumberOfResidentialStations}} = 1.2$$

We might reasonably expect 30% of the workers to ride the MetroRail, with the others either driving or walking to work, in which case the number of residential stations required to service one business station is:

$$\frac{30\% \cdot \text{PeoplePerBusinessStation}}{\text{RidersPerStation}} = 0.8$$

For the number of residential stations planned, the number of commercial stations that can be supported is:

$$\frac{\text{NumberOfResidentialStations}}{\frac{30\% \cdot \text{PeoplePerBusinessStation}}{\text{RidersPerStation}}} = 7.8$$

An alternative view is that the BusinessFAR can be increased.

Appendix C: Obtaining Funds from the Federal and State Governments

Currently the plan for funding the Dulles Rail system calls for the following amounts from the various sources. The Dulles toll income is usually lumped under State support.

Supplementary EIS (Pg 8-4) has the following:

Construction Cost	In millions	In millions	Percent
Federal		$ 1,692.1	50.0%
Non-Federal			
Commonwealth Transportation Commission	$ 8.0		0.2%
Virginia Transportation Act	$ 75.0		2.2%
Dulles Tolls	$ 768.7		22.7%
Dulles Corridor Improvement District	$ 539.2		15.9%
Loudon Public Transportation Fund	$ 2.2		0.1%
Loudon BPOL	$ 160.2		4.7%
Metropolitan Washington Airport Authority facility fees	$ 138.7		4.1%
		$ 1,692.0	
	TOTAL	$ 3,384.1	

Notice that all sources are the taxpayer rather than the user; therefore, the question arises: Is using these sources fair -- is justice being done? Should the people in the rural areas of Virginia pay for Northern Virginia's rail system? Should the people from Appalachia in Pennsylvania pay for Northern Virginia's rail system? The usual response is "Yes, because we pay for their projects when Federal and State funds are used." The idea is that if we each act in our own self-interest, justice will be done. This idea fosters the "pork-barrel projects" for which the Federal government is famous and which keep the incumbents in office for so long. The justice of this idea has no basis in theory or in fact.

Projects must be evaluated on the basis of the economic cost to the citizenry. The costs should be borne by the beneficiaries in proportion to their benefit. If all projects were thus evaluated, wasteful spending by the government would be avoided and our taxes would be lower.