Making the Dulles Rail System Cost Effective Report FAC/FCTA-01

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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, FCTA, and WMATA will find the results of this study to be useful.

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 around the station must be 25 riders per acre. If there is one non-rider per rider, the total population density around the station must be at least 50 people per acre (i.e., FAR=50). Because the most desired FAR is 10, the residential buildings must be 5 stories high.
2. For every business station, 100 rail stations that are surrounded by residences can be serviced if all employees ride rail. If only 20% ride the rail system, one business station could provide enough employment for 20 residential stations. The Dulles system has 16 stations serving Tysons Corner. Mixing residential and commercial units at a single station will not support 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 ridership must be more than 56,000 per day. The Draft Environmental Impact Statement (DEIS) used 85,000. The lower fare associated wtih this higher ridership is presented below.
4. The rail stations must be approximately 1.4 miles apart so the commute time does not exceed one hour. Because the commuters come from at most 0.25 miles of the station, 0.9 miles between the stations can be filled with stores or lower-density housing. The current Dulles design has these characteristics.
5. The average user must pay $16 per day in fare to cover construction, operation and maintenance costs. Some of the $16 can be paid by businesses to which the commuter rides. Some of the $16 can be paid by highway users; however, the Supplementary EIS shows an increase in automotive pollution due to the Dulles rail system because more cars will be on the road. Although $16 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 at $3 per day.
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 an automobile and the garage it requires. This saving partially offsets what the rider pays for the rail fare.
8. Street parking and parking-lot parking must not accommodate the automobile the rider might 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 are no plans to increase the population density around all residential rail stations. 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. Most of the commercial buildings are already built; therefore, the owners would realize no cost saving. Although business owners might be convinced to subsidize riders $3 per day, a considerable marketing effort will be required to convince consumers that a $13/day fare is cost effective for them. If the ridership is 85,000, as the DEIS suggests, the fare could be decreased to $11/day, less by whatever the businesses subsidize. Difficulty may be experienced in convincing the rider to forego his automobile and live without street and parking-lot parking, as required under the last two items above.

The fare can be decreased further if those whose land values are increased by the presence of rail are forced to share their profits. Only existing owners will realize this profit. The profit will amount to at most $1/day per rider if all of the profit is given to the riders. The profit may be zero if riders must pay $16/day.

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 number of Dulles drivers will decrease by only 5%, which, if the saving is given to the riders, would reduce rail-rider fares by $0.25 per day. Metro rail plus VRE provides at the very most 7.3% decrease in congestion along I-66. Regions outside the immediate corridor will benefit less. There is no logical reason to have a special tax district. The business owners can subsidize the rail directly if they want to induce employees to ride the rail. 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 A).

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 of riding 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. For now, we assume that the number of riders we will calculate will be approximately equal to the number used in the DEIS.

Because the people who use mass transit must live within 0.25 miles of the stations, we must have development that has all residences and all businesses within 0.25 miles of each mass-transit station. We can use this fact to determine what the population density must be to afford a mass-transit system. The most controversial assumptions are shown in bold.

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

The Dulles Corridor rail will cost $3.4 billion for 23.4 miles. In addition, the expected operation-and-maintenance cost of the Dulles Rail system is $0.27 per mile, based on 85000 trips per day and, probably, 250 days per year. We can combine these to get the annual cost per mile. We use a non-zero discount rate because a zero discount rate would be omitting the hidden cost associated with the time value of money, the opportunity cost.

$$\text{DullesRailConstruction} := 3400000000\,\text{dollars}$$

$$\text{DullesRailMiles} := 23.4\,\text{m}$$

Of this cost, we estimate that the cost of a station is:

$$\text{DullesStationCost} := 100000000\,\text{dollars}$$

$$\text{DullesStations} := 13$$

From this assumption we can calculate the cost of the rail road:

$$\text{DullesRailroadCost} := \frac{\text{DullesRailConstruction} - \text{DullesStations} \cdot \text{DullesStationCost}}{\text{DullesRailMiles}}$$

$$\text{DullesRailroadCost} = 89.744\times 10^{6}\,\frac{\text{dollars}}{\text{mi}}$$

This figure is not used in the following computations.

$$\text{DullesRailOandMCost} := 0.27\cdot\frac{\text{dollars}}{\text{mi}}$$

$$\text{DiscountRate} := 5\%$$

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

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

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

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

$$\text{AnnualizedRailConstructionCost} = 198\times 10^{6}\,\frac{\text{dollars}}{\text{yr}}$$

$$\text{RoundTrips} := 85000\,\frac{1}{\text{day}}$$

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

$$\text{AnnualOandMRailCost} := \text{DullesRailOandMCost}\cdot\text{RoundTrips}\cdot\text{BusinessDays}\cdot\text{DullesRailMiles}$$

$$\text{AnnualOandMRailCost} = 134.258\times 10^{6}\,\frac{\text{dollars}}{\text{yr}}$$

$$\text{AnnualRailCost} := \text{AnnualizedRailConstructionCost} + \text{AnnualOandMRailCost}$$

$$\text{AnnualRailCost} = 332.403\times 10^{6}\,\frac{\text{dollars}}{\text{yr}}$$

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

We can now calculate the annual cost per automobile driver. We use the IRS automobile allowance ($0.36/mile). The automobile cost must be augmented by the cost of garaging at each end of the trip. The cost of a garage is $20000 per parking space in a commercial parking garage. The cost of a residential garage is on the order of $10,000 per parking space. **We assume that street parking is not permitted at the residence and that no commercial parking garages would be built. We also assume that each commuter will forego one automobile.**

$$\text{CarOandMCost} := 0.13\cdot\frac{\text{dollars}}{\text{mi}}$$

$$\text{CarOwnershipCost} := 0.23\cdot\frac{\text{dollars}}{\text{mi}}\cdot 15000\,\frac{\text{mi}}{\text{yr}}$$

$$\text{CommericalParkingConstruction} := 20000\,\text{dollars}$$

$$\text{ResidentialParkingConstruction} := 10000\,\text{dollars}$$

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

$$\text{AnnualizedParkingConstruction} = 2 \times 10^{3}\,\frac{\text{dollars}}{\text{yr}}$$

Based on the round-trip miles, averaging half the rail miles, the total automobile cost is:

$$\text{DistanceToWork} := 0.5 \cdot \text{DullesRailMiles}$$

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

$$\text{AnnualCarOandMCost} := \text{CarOandMCost} \cdot \text{DistanceToWork} \cdot \text{BusinessDays} \cdot \text{Trips}$$

$$\text{TotalCarCost} := \text{AnnualCarOandMCost} + \text{AnnualizedParkingConstruction} + \text{CarOwnershipCost}$$

$$\text{TotalCarCost} = 5959\,\frac{\text{dollars}}{\text{yr}}$$

$$\text{TotalCarCost} = 16.315\,\frac{\text{dollars}}{\text{day}}$$

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.

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 will 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.

$$\text{BreakevenNumberOfRiders} := \frac{\text{AnnualRailCost}}{\text{TotalCarCost}}$$

$$\text{BreakevenNumberOfRiders} = 55783$$

If the DEIS estimate of 85000 riders per day is correct, the fare would decrease to:

$$\text{TotalCarCost} \cdot \frac{\text{BreakevenNumberOfRiders}}{85000} = 10.707\,\frac{\text{dollars}}{\text{day}}$$

On the Metro, the fare is:

$$\text{MetroFare}(\text{Distance}) := 0.789 + 0.177 \cdot \frac{\text{Distance}}{\text{mi}}$$

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

$$2 \cdot \text{MetroFare}(\text{DistanceToWork}) = 5.72\,\text{dollars}$$

If the riders own cars, then

$$\text{BreakevenNumberOfRidersOwningCars} := \frac{\text{AnnualRailCost}}{\text{AnnualCarOandMCost}}$$

$$\text{BreakevenNumberOfRidersOwningCars} = 437085$$

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.

$$\text{PercentWithinQuarterMile} := 90 \cdot \%$$

$$\text{BenefitRadius} := 0.25 \cdot \text{mi}$$

The station spacing in the current Metro rail in Virginia averages 1.4 miles. We use this distance in our analysis, although we realize that doing so results in **many residences between the stations are not therefore serviced by the Metro rail**.

$$\text{StationSpacing} := 1.4 \cdot \text{mi}$$

$$NumberOfStations := \frac{DullesRailMiles}{StationSpacing}$$

$$NumberOfStations = 16.714$$

$$RidersPerStation := \frac{BreakevenNumberOfRiders}{NumberOfStations}$$

$$RidersPerStation = 3337$$

This number can be compared to the existing Metro ridership (half the number of boardings, because we assume each rider is taking a round trip):

Vienna	12859
West Falls Church	9388
East Falls Church	4206

$$RiderPopulationDensity := \frac{RidersPerStation \cdot PercentWithinQuarterMile}{\pi \cdot BenefitRadius^2}$$

$$RiderPopulationDensity = 23.9 \frac{1}{acre}$$

The desired population density (FAR) is slightly less than what is in Fox Mill Estates. If we assume that, for each rail rider, there is, on average, one non-rail rider, then the desired rider-population density (RiderFAR) is:

$$FAR := 10 \cdot \frac{1}{acre} \qquad RiderFAR := \frac{FAR}{2}$$

$$PopulationDensity := 2 \cdot RiderPopulationDensity$$

The number of stories required to meet the rail cost is:

$$Stories := \frac{RiderPopulationDensity}{RiderFAR}$$

$$Stories = 4.781$$

If the riders owned cars, the number of stories would be

$$Stories \cdot \frac{BreakevenNumberOfRidersOwningCars}{BreakevenNumberOfRiders} = 37.458$$

The population density for commercial buildings is approximately

$$SqFtPerOccupant := 100 \cdot ft^2$$

$$BusinessStories := 5$$

$$BusinessDensity := \frac{BusinessStories}{SqFtPerOccupant}$$

$$BusinessDensity = 2178 \frac{1}{acre}$$

Of the total number of stations,

$$\frac{1}{1+\frac{\text{BusinessDensity}}{\text{RiderPopulationDensity}}} = 1.086\%$$

should be commercial. This percentage decreases as the number of stories increases.

We have not included the value people place on the commuting time because people use the time variously. For example, some value listening to the radio and some value listening to books on tape. Rail commuters have the additional option of reading books or newspapers or sleeping.

Attention should be paid to the number of stations. The Dulles system, on which the cost is based, has 12 stations, which amounts to one station every 2 miles rather than one station every 0.25 miles. Commute times might be excessive if the stations are 0.25 miles apart. The system cost will be greater with the greater number of stations.

The Metrorail transit time is given by the equation:

$$\text{TransitTime} := 2.6\cdot\text{min}\cdot\text{NumberOfStations} + \frac{(\text{StationSpacing} - 1.3\cdot\text{mi})}{70\cdot\frac{\text{mi}}{\text{hr}}}$$

$$\text{TransitTime} = 0.726\text{hr}$$

This time should be less than one hour for the transit system to be acceptable to most users. 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.

Because the rail lines are being installed down the middle of the Dulles Toll Road, unless construction over the rails is permitted, the area covered by the 0.25-mile user radius is considerably reduced by the current highway. The population density must, therefore, be increased. The increase can be estimated as follows:

$\text{NumberOfLanes} := 7$ includes on-off ramps

$\text{WidthPerLane} := 10\cdot\text{ft}$

We allow for the green space along the highway and consider the lanes in both directions:

$$\text{TotalWidth} := 2\cdot(\text{NumberOfLanes}\cdot\text{WidthPerLane} + 30\cdot\text{ft})$$

$$\text{AreaRatio} := \frac{\pi\cdot(0.25\cdot\text{mi})^2 - \text{TotalWidth}\cdot 2\cdot 0.25\cdot\text{mi}}{\pi\cdot(0.25\cdot\text{mi})^2}$$

$$\text{AreaRatio} = 0.904$$

The loss of land due to the right-of-way is seen not to be a large effect.

$$\frac{\text{PopulationDensity}}{\text{AreaRatio}} = 52.909\frac{1}{\text{acre}}$$

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

$$\text{CurrentLandValue} := 200000\frac{\text{dollars}}{\text{acre}}$$

$$IncreasedLandValue := 400000 \frac{dollars}{acre}$$

$$TotalIncrease := (IncreasedLandValue - CurrentLandValue) \cdot NumberOfStations \cdot \pi \cdot (0.25 \cdot mi)^2$$

$$TotalIncrease = 420 \times 10^6 \, dollars$$

$$\frac{TotalIncrease}{AnnualizationFactor \cdot BreakevenNumberOfRiders} = 1.202 \frac{dollars}{day}$$

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. If present Vienna Metro and VRE riders switched to automobiles and all used I-66 -- a somewhat unrealistic supposition, the traffic on I-66 would increase only 7.3%. If the tolls were increased 5%, from the current \$0.50 to \$0.525, and the increase were passed to the rider, the daily fare would be decreased by:

$$NumberOfTollRoadUsers := 28000($$

$$RevenuePerRider := \frac{0.025 \, dollars \cdot Trips \cdot NumberOfTollRoadUsers}{BreakevenNumberOfRiders}$$

$$RevenuePerRider = 0.251 \frac{dollars}{day}$$

Appendix A: 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. If all projects were thus evaluated, wasteful spending by the government would be avoided and our taxes would be lower.