The Maryland Public Policy Institute

REVIEW OF THE PURPLE LINE

REVIEW OF THE PURPLE LINE

The Maryland Public Policy Institute

Published by
The Maryland Public Policy Institute
One Research Court, Suite 450
Rockville, Maryland 20850
240.686.3510
mdpolicy.org

REVIEW OF THE PURPLE LINE

RANDAL O'TOOLE

MARYLAND'S PROPOSED PURPLE LINE is currently expected to cost about $2.44 billion for 16.2 miles, or $151 million per mile.[1] This is more than eight times as expensive, per mile, as America's first modern light-rail line, which San Diego opened in 1981. Built without any federal funds, that line cost less than $10 million per mile ($17 million per mile in today's dollars).[2]

Since then, the federal government has helped fund the building of almost every new light-rail line in the country, and, not coincidentally, the costs have rapidly grown. Light-rail projects in the Federal Transit Administration (FTA) 1997 New Starts report—the agency's annual recommendations for which rail projects deserve federal funding—cost an average of $40 million per mile, which is about $55 million in today's dollars, or more than three times the per-mile cost of the San Diego line.[3]

Just 19 years later, average light-rail costs in FTA's 2016 report had risen to $198 million per mile, including three extremely expensive light-rail subways. Even leaving out the subways, the average cost was $185 million per mile, or more than 10 times the cost of San Diego's 1981 line. One of the subways, a 3.3-mile line in Seattle, is expected to cost $628 million per mile.[4] Yet none of these lines will be able to carry significantly more people than the 1981 line.

These rapidly rising costs raise an important question for both rail advocates and supporters of the Purple Line: at what point does light rail become so expensive that it is not worth building? As the Seattle underground line indicates, rail advocates seem to think there is no practical limit. Yet this paper will argue that we passed that point long ago, and the Purple Line would not be worth building even at a far lower cost. Despite this, people continue to support light rail and the Purple Line, in part because some expect to make money at taxpayers' expense and in part because of a nostalgic view of the benefits of rail transit that overlooks the true cost.

Light rail is a high-cost, low-capacity form of mass transportation, which makes it an inappropriate solution for any American urban area. This paper will examine the Purple Line and show why its construction will do more harm than good to the communities it is meant to serve.

LIGHT RAIL IS OBSOLETE

Transportation improvements generate economic benefits when the transportation they supply is faster, cheaper, more convenient, and/or safer than previous forms of transportation. Streetcars were a huge improvement when they were first introduced to many American cities in the 1890s because they were so much faster than the alternatives. At the time before automobiles, most urbanites were limited to transportation on foot at average speeds of around 3 miles per hour. Since streetcars averaged about 9 to 10 miles per hour, they offered much faster transportation and gave people access to more economic, social, recreational, and other activities than ever before.[5]

Even so, the high cost of streetcars put them beyond the reach of most unskilled workers and even many skilled workers. A typical streetcar fare in 1900 was 5 cents, which when adjusted for inflation is about $1.50 today. While that sounds affordable, incomes were much lower at that time, and when measured in terms of relative wages, a 5-cent streetcar fare in 1900 would be about $10 in today's dollars.[6]

By the mid-1920s, automobiles and buses had made streetcars obsolete. More than half of American families owned their own automobiles, which were faster, cheaper, and more convenient than streetcars. For those who did not, buses were less expensive and could go to any area with streets, not just with rails. Since buses shared the streets with autos and trucks, construction and maintenance costs were negligible compared with streetcars, which usually required dedicated tracks.

Automobiles have vastly improved in the last century or so. The first cars could go just 7.5 miles per hour; a 1915 Model T Ford had a top speed of around 45 mph. Today, cars routinely travel at 75 mph and most are capable of even greater speeds. Cars are also safer, more comfortable, more fuel-efficient, and cleaner than cars of a century or even a decade ago.

By comparison, streetcar technology has hardly improved at all. The main improvement, which we call light rail, is that the cars now operate with couplers so that two or more cars can be operated together in one train. Light rail tends to be faster than streetcars only because most light-rail routes have about one station stop per mile, rather than the five or six per mile that are common with streetcars.

Still, according to the American Public Transportation Association, the average speed of light-rail lines in 2012 was just 15.6 mph.[7] Some are much slower than that. Planners promised that the Minneapolis–St. Paul Green Line, which opened in 2013, would take 35 minutes to go from downtown Minneapolis to downtown St. Paul, with an average speed of about 19 miles per hour.[8] However, the line was scheduled to have 22 stops in 11 miles, and after it opened, the trains required 53 minutes to go from downtown to downtown, for an average speed of less than 12.5 miles per hour.[9]

With 21 planned stops in 16 miles, the Purple Line would probably be a little faster than the Twin Cities' Green Line turned out to be, but not much. Purple Line planners project an average speed of less than 15.5 miles per hour.[10] Like projections made for the Green Line, this one may be optimistic.

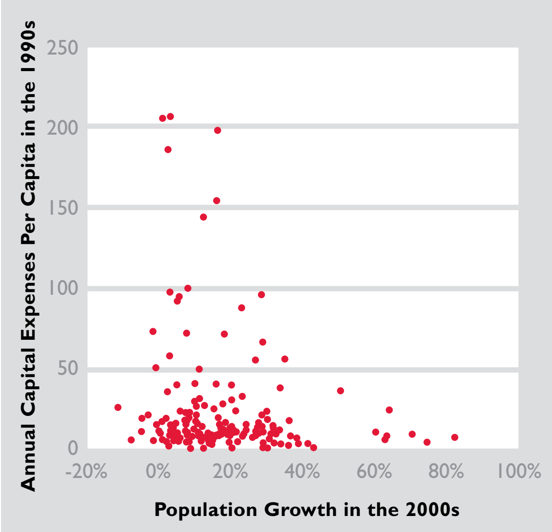
Light-rail cars today may have microprocessors under the hood and sleeker shells than streetcars of old. However, using basic transportation measures—speed, cost, convenience, and safety—they are greatly inferior to cars or buses.

THE PURPLE LINE WILL NOT PROMOTE ECONOMIC DEVELOPMENT

One of the strongest arguments for the Purple Line is that it will magically promote economic development. Buses cannot do the same, say rail advocates, because bus routes can be changed overnight. According to this argument, rail's inflexibility is actually an advantage because developers know the rail line will stay there for years, and plan their developments accordingly.

New transportation infrastructure promotes economic development only if the transportation it supports is faster, cheaper, and/or more convenient than previous transportation. Light-rail transit is slower, far more expensive, and less convenient than the door-to-door service offered by

FIGURE 1 TRANSIT SPENDING AND URBAN GROWTH



"Out of 300 major urban areas, the fastest-growing urban areas in the 2000s (lower right portion of the chart) spent the least on transit capital improvements in the 1990s. On the other hand, those that spent the most on transit capital improvements (upper left portion of the chart) ended up among the slowest-growing urban areas."

automobiles, so it will do little to promote economic development.

"Urban rail transit investments rarely 'create' new growth, but more typically redistribute growth that would have taken place without the investment," according to a study commissioned by the Federal Transit Administration. "The greatest land-use changes have occurred downtown, in the form of new office, commercial, and institutional development…The strengthening of downtowns stems in part from the fact that downtowns are the hubs of all rail systems."[11] The study's authors—University of California, Berkeley, planning professor Robert Cervero and Parsons Brinckerhoff consultant Samuel Seskin—are far from hostile to rail transit; indeed, Cervero is a strong proponent of transit-oriented development, while Parsons Brinckerhoff was the leading consulting author of the Purple Line environmental impact statement (EIS).[12]

In other words, rail transit does not stimulate economic development, but it might shuffle it around. In this shuffle, the main winners are property owners near the busiest light-rail stops, while other property owners who might have benefited from development that would have occurred without the rail line end up losing. At best, the overall tax base does not change.

At worst, the rail lines actually slow economic development. One indicator of economic growth is population growth. If rail lines truly promoted economic development, then urban areas that invest most heavily in rail construction should tend to grow faster than ones that do not. In fact, the opposite appears to be true.

Many factors affect urban growth, but Figure 1 shows that urban areas that spent the most on transit capital improvements in the 1990s tended to grow the slowest in the 2000s. Meanwhile, the regions that grew the fastest in the 2000s were among those that spent the least on transit capital improvements in the 1990s. Spending less on transit does not guarantee rapid growth, but spending more on transit practically does guarantee slower growth.

Most places that claim rail transit has stimulated economic development are concealing the fact that they had to provide subsidies to developers to attract new development to the rail lines. When Portland, Oregon's first light-rail line opened in 1986, for example, it rezoned all of the land around its rail stations for redevelopment. Ten years later, planners admitted to the city council that "we have not seen any of the kind of development—of a mid-rise, higher-density, mixed-use, mixed-income type—that we would've liked to have seen" along the light-rail line.[13] Council members noted that Portland at that time was in the midst of an economic boom, yet a high percentage of the city's remaining vacant land consisted of rezoned parcels near light-rail stations.[14]

As a result, Portland's city council decided to start subsidizing development along its light-rail and, later, streetcar lines. To date, the city has given developers more than $1.4 billion worth of subsidies in the form of below-market land sales, infrastructure improvements, tax breaks, and other incentives.[15] Even more subsidies are given to developers along rail lines in Portland's suburbs.

For example, the city built several parking garages along the route of its first streetcar line, then claimed that all of the development around the parking garages was due to the streetcar. A city list of developments that were supposedly inspired by the streetcar includes numerous structured parking garages with more than 7,000 parking spaces, many of which were built with city money.[16] Meanwhile, a segment of the streetcar line that received no subsidies also attracted almost no new development, showing that subsidies, not the streetcar, generate development.

Other cities around the country that have built light-rail lines in the hope that they will spur economic development have been disappointed unless they subsidized that development. Norfolk, Virginia's light-rail line, for example, has done so little to promote economic development that the *Virginian-Pilot* proposed to reduce fares by two thirds to stimulate ridership.[17] The newspaper was probably unaware that, even though the nominal fare on the light-rail line is $1.50, the actual fares collected are only 50 cents per ride, the second-lowest of any light-rail system in the country. By comparison, Norfolk bus riders pay an average of 91 cents per ride for transportation that costs taxpayers less than the light rail.[18]

If the Purple Line were to have any effects on economic development, they would only be in Bethesda and Silver Spring, the two stations that are expected to have the most use.[19] But these two stations are already served by the Metro rail system, and so have already experienced most of the changes they are going to have from transit. In any case, as already noted, any benefits enjoyed by property owners at these stations will likely be more than offset by losses to property owners elsewhere in the region.

LIGHT RAIL PROJECTS SUFFER FROM OPTIMISM BIAS

The high construction costs quoted in the FTA New Starts reports represent only the projected costs. Actual light-rail costs are often much greater, because of cost overruns and several hidden costs not included in the FTA projections.

The Maryland Purple Line has already experienced inflating costs. The selected alternative is supposed to be midway between the medium- and high-cost alternatives in the draft environmental impact statement (DEIS), which means the 2008 cost estimate (in 2007 dollars) was about $1.4 billion.[20] At 2 percent annual inflation assuming the project would be midway to completion in 2017, this would equal about $1.7 billion. In 2011, the estimated cost had risen to $1.925 billion.[21] This has since grown to $2.448 billion, for a 44 percent rise to date, and is likely to grow more.[22] For example, a rail line currently being built in Honolulu has already gone $910 million, or 17.5 percent, over the budget that was set when it was at the current stage of the Purple Line.[23] The cost estimate made at the time of the DEIS is most relevant because at that stage all major alternatives were discarded.

Cost overruns for light rail are the rule rather than the exception. Table 1 shows that, while a few lines have been built for less than their projected cost, most have gone well over the original projection, with an average cost overrun of about 44 percent. Moreover, the record is not improving: lines completed in the last few years have had greater overruns than the average. Table 1 does not include every federally funded light-rail line ever built, but all but four of the lines in the table are from a series of U.S. Department of Transportation reports on predicted and actual costs, so presumably those lines are a representative sample.

Two projects in Table 1 appear to have been finished for less than their original projected cost. However, the Tasman West was originally supposed to be 12.2 miles long, but the final project was just 7.6 miles, while the St. Clair project was supposed to be 25 miles long, but as built it was only 17.4. If the projected average cost per mile is applied to the miles actually built, the Tasman West line cost 16 percent more than projected, while the St. Clair line cost 32 percent more than projected.

Rail advocates sometimes argue that some or all of the high construction costs of light rail can be recovered by its low operating costs. On average, light-rail systems do cost less to operate than buses: 65 cents per passenger mile for light rail versus 94 cents per passenger mile for buses in 2012. But these operating costs exclude the costs of maintenance and capital replacement. In 2012, transit agencies spent an average of 24 cents a passenger mile on light-rail maintenance but only 18 cents on bus maintenance.

The 23-cent-per-passenger-mile savings on operations and maintenance does not begin to compensate for rail construction costs that are typically around one hundred times as much as the cost of starting comparable bus service. As just one example, amortizing the cost of the Charlotte, North Carolina light-rail line at a low 2 percent interest rate over 30 years results in an annualized cost of more than $20 million per year. This line carried 25.7 million passenger miles in 2012, meaning each passenger mile's share of capital

TABLE 1 PROJECTED AND ACTUAL COSTS OF LIGHT-RAIL LINES (Millions of dollars)

URBAN AREA	RAIL LINE	DATA SOURCE	YEAR COMPLETED	PROJECTED COST	ACTUAL COST	% COST OVERRUN
PORTLAND	EASTSIDE	P	1988	172	266	55%
SACRAMENTO	INITIAL	P	1988	165	188	14%
BUFFALO	INITIAL	P	1989	478	722	51%
SAN DIEGO	EL CAJON	F3	1989	114	103	-10%
LOS ANGELES	BLUE	D	1990	561	877	56%
SAN JOSE	GUADALUPE	F3	1991	258	380	47%
ST. LOUIS	INITIAL	F3	1993	317	387	22%
ST. LOUIS	ST. CLAIR	F3	1995	368	339	-8%
DALLAS	S. OAK CLIFF	F3	1996	325	360	11%
BALTIMORE	BWI-HUNT VLY.	F3	1997	82	116	42%
SAN JOSE	TASMAN WEST	F3	1997	452	325	-28%
PORTLAND	WESTSIDE	F3	1998	454	782	72%
SALT LAKE	I-15	F3	1999	206	299	45%
DENVER	SOUTHWEST	F3	2000	150	178	19%
NEW JERSEY	HUDSON-BERGEN	F7	2001	930	1,756	89%
DALLAS	NORTH CENTRAL	F7	2002	333	437	31%
SACRAMENTO	SOUTH	F7	2003	202	219	8%
MINNEAPOLIS	HIAWATHA	F7	2004	244	697	186%
PORTLAND	INTERSTATE	F8	2004	283	350	24%
SAN DIEGO	MISSION VALLEY	F7	2005	387	506	31%
DENVER	SOUTHEAST	F7	2006	585	851	45%
NEW JERSEY	NEWARK	F7	2006	181	208	15%
CHARLOTTE	LYNX	F11	2007	331	463	40%
PHOENIX	EAST VALLEY	F13	2008	1,076	1,405	31%
SAN DIEGO	SPRINTER	F11	2008	214	478	124%
LOS ANGELES	GOLD EXT.	F13	2009	760	899	18%
SEATTLE	LINK	F13	2009	1,858	2,558	38%
DENVER	WEST	M	2012	350	707	102%
NORFOLK	TIDE	N5	2012	198	338	71%
MINNEAPOLIS	GREEN	N96, N13	2013	581	957	65%

The projected and actual costs for most projects are in "year of expenditure" dollars, meaning adjusted for inflation to the year they would be or were built. Sources: See endnote 24.

costs was 80 cents, far more than any savings on operations and maintenance.

OPTIMISM BIAS INFLATES RIDERSHIP ESTIMATES

Light-rail planners not only have a history of underestimating costs; they also have a similar history of overestimating ridership. Of the 31 light-rail lines listed in Table 2, planners for 24 overestimated ridership by an average of 54 percent, while planners for seven underestimated ridership by an average of 21 percent. The average overestimate for all of them together is 35 percent.

Ridership estimates for the Purple Line are almost certainly overestimated. The final EIS projects that the line will attract nearly 65,000 riders per day in 2030 and more than 69,000 per day in 2040.[25] By comparison, the average light-rail line in America carried only 23,000 trips per day in 2012, just a third of what is projected for the Purple Line in 2040.[26]

The only light-rail lines that approach the numbers projected for the Purple Line are in Boston and Los Angeles. These lines are productive due to a combination of high population densities and a high concentration of jobs at one end of the lines. As a line that serves the suburbs of a downtown rather than the downtown, the Purple Line more closely resembles New Jersey's Hudson–Bergen line. But even that line serves a very

TABLE 2 PROJECTED AND ACTUAL LIGHT RAIL RIDERSHIP (Average weekday riders)

CITY	ROUTE	SOURCE	YEAR	PREDICTED	ACTUAL	OVERESTIMATE
BALTIMORE	SUBWAY*	P	1987	103,000	43,044	139%
PORTLAND	EASTSIDE	P	1988	42,500	32,146	32%
SACRAMENTO	INITIAL	P	1988	50,000	30,326	65%
BUFFALO	METRO	P	1989	9,200	19,398	-53%
PITTSBURGH	RECON.	P	1989	90,500	25,733	252%
SAN DIEGO	EL CAJON	F3	1989	21,600	24,950	-13%
SAN JOSE	GUADALUPE	F3	1991	41,200	21,035	96%
ST. LOUIS	INITIAL	F3	1993	41,800	42,381	-1%
DALLAS	S. OAK CLIFF	F3	1996	34,170	26,884	27%
BALTIMORE	BWI-HUNT VLY	F3	1997	12,230	8,272	48%
SAN JOSE	TASMAN WEST	F3	1997	14,875	8,244	80%
PORTLAND	WESTSIDE	F3	1998	60,314	43,876	37%
SALT LAKE	I-15	F3	1999	26,500	22,100	20%
DENVER	SOUTHWEST	F3	2000	22,000	19,083	15%
ST. LOUIS	ST. CLAIR	F3	2001	20,274	15,976	27%
DALLAS	N. CENTRAL	F7	2002	17,033	16,278	5%
SACRAMENTO	SOUTH	F7	2003	12,550	10,543	19%
SLC	UNIVERSITY	F7	2003	10,050	21,811	-54%
MINNEAPOLIS	HIAWATHA	F7	2004	37,000	33,477	11%
PITTSBURGH	RECON.	F7	2004	49,000	25,733	90%
PORTLAND	INTERSTATE	F8	2004	13,900	11,800	18%
SAN DIEGO	MISSION VLY	F7	2005	10,795	8,895	21%
BALTIMORE	DOUBLE TRACK	F7	2006	44,000	28,541	54%
DENVER	SOUTHEAST	F7	2006	38,100	31,320	22%
NEWARK	ELIZABETH 1	F7	2006	12,500	2,500	400%
NEW JERSEY	H-B 1 & 2	F7	2006	66,160	41,525	59%
CHARLOTTE	LYNX	F11	2007	9,100	11,678	-22%
PHOENIX	EAST VALLEY	F13	2008	26,000	34,800	-25%
SEATTLE	LINK	F13	2009	34900	23400	49%
DENVER	WEST	M	2012	19,500	13,800	41%
NORFOLK	TIDE	N5	2012	10,400	4,347	139%
MINNEAPOLIS	GREEN	N96, N13	2013	34,300	37,000	-7%

**One heavy-rail line, the Baltimore Subway, is shown to provide a third example of Maryland Department of Transportation overestimates of transit ridership.*
Source: See Table 1.

high-density population and has nine stations in Jersey City, which has 123,000 jobs.

As Table 3 shows, Montgomery County does not have the density or concentration of jobs found in these other three areas. Bethesda has about 82,000 jobs, but they are far more spread out than in Jersey City, so only a small fraction will be near a Purple Line light-rail station. Thus, Purple Line ridership is likely to be well below that of the Hudson–Bergen line (about 44,000 per day in 2012), much less than the Los Angeles and Boston lines. As Table 2 shows, the Maryland Department of Transportation has already demonstrated its tendency to overestimate ridership with the Baltimore light-rail projects, both of which overestimated ridership by about 50 percent, as well as the Baltimore subway, which overestimated ridership by well over 100 percent.

"The systematic tendency to over-estimate ridership and to under-estimate capital and operating costs introduces a distinct bias toward the selection of capital-intensive transit improvements such as rail lines," noted a U.S. Department of Transportation analyst in 1990. High-cost projects only make sense if the costs can be spread over large numbers of riders, so overestimating rider-

TABLE 3 POPULATION DENSITIES AND JOB CENTERS

REGION	POPULATION DENSITY	JOBS AT CENTER
URBAN SUFFOLK COUNTY (BOSTON)	12,600	242,000
URBAN LOS ANGELES COUNTY	6,900	136,000
URBAN HUDSON COUNTY	13,700	123,000
URBAN MONTGOMERY COUNTY	3,500	82,000

Source: Densities from "List of 2010 Urbanized Areas," Census Bureau, http://www.census.gov/geo/reference/ua/urban-rural-2010.html; job numbers for Boston and Los Angeles from Wendell Cox, United States Central Business Districts, Belleville, IL: Demographia.com, 2014, pp. 4, 20; job numbers for Jersey City and Bethesda from U.S. Census Bureau, American Community Survey, Washington, 2015), table S0804, selected characteristics for workplace geography, for places in Maryland and New Jersey.

ship or underestimating costs makes high-cost projects appear more feasible.[27]

The near-universal optimism bias in cost estimation and preponderance of optimism bias in ridership estimation led Danish planning professor Bent Flyvbjerg to use the term "strategic misrepresentation."[28] In other words, the consulting firms that make the estimates and the agencies that pay them deliberately make the projects appear less costly and more productive than they will be in reality in order to get the funding that boosts the agencies and leads them to hire the consultants for more work.

To fix this problem, Flyvbjerg argues that transportation agencies should use "reference class forecasting." In other words, if projects typically cost 40 percent more and attract 50 percent fewer users than projected, cost estimates should be increased by 40 percent and user estimates decreased by 50 percent. If Maryland Department of Transportation planners had done this at the time of the DEIS, would they have been so quick to reject bus alternatives that cost far less than rail?

RAIL COSTS CONTINUE AFTER CONSTRUCTION COMPLETE

Rail transit projects include a large hidden cost that is never mentioned by rail proponents. Rail systems, including the tracks, power facilities, signals, and stations, have a useful life of about 30 years. After that, keeping them in a state of good repair essentially means completely rebuilding them from the ground up. The recent numerous problems on the Washington Metro system, from broken rails to smoke in the tunnels and the 2009 accident that killed nine people, can be directly attributed to the failure of the Washington Metropolitan Area Transit Authority (WMATA) to find the funds for such rehabilitation.

According to the Federal Transit Administration, as of 2010, America's rail transit systems suffered from a $59 billion maintenance backlog.[29] The backlog has only grown since then as transit agencies are spending less on maintenance than is needed to keep their rail systems from deteriorating any further, much less enough to restore them to a state of good repair (which also suggests that the 24 cents per passenger mile spent on light-rail maintenance may be inadequate). "There will never be enough money" to bring rail transit systems up to a state of good repair, a New York transit official lamented in 2007.[30]

Nearly all the maintenance backlog documented by the FTA in 2010 was in heavy-rail systems such as New York and Washington subways. In 2010, the only light-rail lines older than 30 years were those in Boston, Cleveland, New Orleans, and Philadelphia (New Orleans' and Philadelphia's have since been reclassified as streetcars; Pittsburgh has older streetcar lines that were reconstructed to light-rail standards less than 30 years ago).

Today, Portland's earliest light-rail line, opened in 1986, is nearly 30 years old and is already experiencing maintenance issues. A 2014 audit by the Oregon Secretary of State found that TriMet was only spending 53 percent as much as needed to keep its light-rail tracks in good repair and only 72 percent as much as needed to keep signals in good repair.[31] As a result, Portland's light-rail lines suffer frequent delays from breakdowns. In May 2013, Portland's transit agency tweeted an apology to riders for having breakdowns three times in three days. Within 22 minutes of the apology, the system suffered another breakdown.[32]

Construction of the Purple Line would obligate Maryland to find a source of funds to rebuild it in about 30 years, something the WMATA has failed to do for the Metro rail system. The alternatives would be to let it deteriorate, with increasing hazards to public safety, or tear it out after 30 or so years.

THE PURPLE LINE IS NOT COST EFFECTIVE

"Any transportation improvement must be a cost-effective investment," says the Purple Line's DEIS.[33] Indeed, at the time the DEIS was written, the law authorizing federal grants for transit capital improvements required that the applicant agency demonstrate that the project is "justified based on a comprehensive review of its mobility improvements, environmental benefits, cost effectiveness, operating efficiencies, economic development effects, and public transportation supportive land use policies and future patterns."[34]

At that time, the Federal Transportation Administration measured cost-effectiveness in terms of the cost per hour of transportation users' time saved by a transportation improvement. In 2012, Congress amended the law to read that a project must be "justified based on a comprehensive review of the project's mobility improvements, the project's environmental benefits, congestion relief associated with the project, economic development effects associated with the project, policies and land use patterns of the project that support public transportation, and the project's cost-effectiveness as measured by cost per rider."[35]

The DEIS proved without a shadow of a doubt that light rail is not cost-effective by either definition. Both the cost per rider and the cost per hour saved for light rail were far greater than for bus improvements. A table on page ES–10 shows that the cost per hour saved for various bus alternatives ranged from $14.01 to $19.34, while the cost per hour saved for rail alternatives ranged from $22.82 to $26.51.[36] The table also shows that the cost per new rider for the bus alternatives ranged from $8.98 to $19.76 while the rail alternatives ranged from $21.72 to $24.57. Thus, the most cost-effective rail alternatives were less cost-effective than the least cost-effective bus alternatives.

The most-expensive rail alternative cost about 20 times as much as the least-expensive bus alternative.[37] Therefore, for the price of the rail alternative, Maryland could have implemented bus projects in 20 different corridors around the region. Since the most-expensive rail alternative was estimated to attract about two-and-one-half times as many new transit riders as the least-expensive bus alternative, implementing 20 different bus projects might have attracted eight times as many new riders as the high-cost rail alternative.

Worse, the cost of the final selected alternative is now expected to be almost 50 percent greater than the most-expensive alternative in the DEIS. Since the selected alternative is actually midway between the most-expensive and second-most-expensive rail alternatives in the DEIS, it is actually more than 50 percent more expensive than estimated in the DEIS. That means it is that much less cost-effective. Unfortunately, the final EIS did not bother to estimate cost-effectiveness, but the cost per hour and cost per rider both must be greater than $32.[38] If ridership also turns out to be far lower than predicted, the cost-effectiveness will be lower still.

Until recently, that would have been a fatal problem for the Purple Line. Under rules adopted in 2005, any project that cost more than about $25 per hour of time saved was automatically excluded from consideration.[39] The Obama administration, however, wrote new rules effectively eliminating the cost-effectiveness requirement, opening the door to especially wasteful projects such as the Purple Line.[40]

However, the law still requires that projects be shown to be cost-effective, and the Purple Line clearly is not. The analysis in the DEIS proves that buses, not rail, are the best way to improve transit service in the Bethesda–New Carrollton corridor.

LIGHT RAIL IS LOW-CAPACITY TRANSIT

Rail advocates often claim, incorrectly, that one light-rail track can move as many people as an eight-lane freeway. The term "light" in light rail does not refer to weight; light-rail cars actually weigh more than heavy-rail cars. Instead, it refers to capacity: due to various operational considerations, light-rail trains must be shorter and operate less frequently than heavy-rail trains. In other words, contrary to frequent descriptions of light rail as "high-capacity transit," it is by its very name low-capacity transit.

Because most light-rail trains operate in streets, they cannot be longer than a city block; otherwise they would obstruct traffic every time they stop. Since light-rail cars are typically about 90 to 95 feet long and most city blocks are about 300 feet long, trains in most cities can be three cars long. For safety reasons, most light-rail systems can only handle about 20 trains per hour. Each light-rail car has about 70 seats and room for about 80 people standing. Twenty three-car trains with 150 people in each car per hour represents a capacity of 9,000 people per hour.

By comparison, a freeway lane can move about 2,000 vehicles per hour. If the average automobile has five seats, the lane can move 10,000 people per hour. Some may object that cars rarely fill all available seats, but the same is true for light rail: the average light-rail car in America operates with about 25 passengers on board, or about one-sixth of capacity.[41] A five-seat car with only one occupant is operating at a higher percentage of its capacity than the average light-rail line.

In actual practice, the typical light-rail track moves about 16 percent as many people per day as the typical urban freeway lane.[42] Considering that a mile of track costs many times more to build than a mile of highway lane, it is an extremely wasteful form of transportation.

Even higher capacities can be obtained by dedicating highway lanes to buses. A typical freeway lane can move about 1,000 buses per hour. Standard buses have about 40 seats and room for 25 standing passengers, resulting in an hourly capacity of 65,000 people. If that is not enough, double-decker transit buses have about 80 seats and room for at least 25 standing passengers, resulting in an hourly capacity of more than 100,000 people.

Buses can also move large numbers of people on city streets. Portland had a bus mall with staggered stops on which it scheduled 160 buses per hour.[43] Given standard 40-seat buses with room for 25 standees, the bus mall could move more than 10,000 people per hour, more than a three-car light-rail line. This number could be increased still further using articulated or double-decker buses. Sadly, Portland actually reduced the capacity of this mall by building a light-rail line through it, as the capacity of the light-rail trains is less than of the buses they displaced.

THE PURPLE LINE WILL INCREASE CONGESTION

In preparation for the DEIS, Maryland prepared a detailed traffic analysis report for the alternatives then being considered. The report concluded that if no rail transit line were built, auto travel in the region would average 25.4 miles per hour in 2030. If any of the rail alternatives were built, however, average travel speeds would fall to 24.5 miles per hour.[44] A tenth of a mile per hour may not sound like much, but considering it is for the entire region, it represents a huge increase in congestion in the Purple Line corridor.

The traffic analysis also estimated the number of miles of vehicle travel under each of the alternatives, showing that either the medium- or high-cost light-rail alternatives would reduce regional vehicle travel by about 0.07 percent. Multiplying the number of miles of daily vehicle travel by average travel speeds reveals that the rail alternatives would increase the time motorists waste sitting in traffic by about 36,000 hours per day.

The traffic analysis made at the time of the final environmental impact statement (FEIS) did not bother estimating average traffic speeds with and without the project. Instead, it focused on the project's effects on congestion at a few intersections in the corridor. The analysis concluded that, with the rail project, congestion would be worse at some intersections but better at others than without the rail project, with the number of intersections where congestion declined outnumbering those where congestion increased.[45]

However, this traffic analysis contained a significant bias. The no-build alternative assumed that there would be "no roadway projects" to relieve traffic congestion in the corridor between now and 2040.[46] By contrast, in addition to rail construction, the rail alternative "includes traffic mitigation to allow the intersections to operate to the most efficient conditions."[47] These mitigation measures included turning some two-way streets to one-way streets and diverting traffic onto other streets (thus increasing congestion on those streets).[48] Given that the DEIS projected that rail would drastically increase overall congestion, these mitigation measures, not the rail project itself, are likely responsible for the declines in congestion at specific intersections identified in the traffic analysis.

Nothing in the FEIS traffic analysis specifically contradicts the DEIS traffic analysis. Since the selected alternative is midway between the medium- and high-cost alternatives in the DEIS, it is reasonable to expect that the Purple Line will add about 36,000 hours of delay per day to vehicles in 2030.

THE PURPLE LINE WILL WASTE ENERGY

The Purple Line DEIS calculated transportation-related energy consumption for the entire region under each of the alternatives. The analysis found that the daily energy consumption for the light-rail alternatives would be more than either the bus alternatives or the no-build alternative. The differences between alternatives are small because the proposed rail corridor is only a small part of the region, but they are significant.

In particular, the rail alternatives consumed between 400 million and 500 million more British thermal units (BTUs) of energy per day than the bus alternatives. That is equal to more than 300,000 barrels of oil per year.[49] In addition, the DEIS found that merely constructing the rail line would use between 722 billion and 934 billion BTUs of energy, which equals between 124 million and 160 million barrels of oil.[50]

The FEIS, however, reached a different conclusion. It estimated the energy consumed during construction would be about 684 billion BTUs, which is slightly less than estimated by the DEIS. But it also concluded that the rail alternative would use 139 billion fewer BTUs per year than the no-build alternative.[51] This would quickly repay the energy cost of construction and then earn a net savings in energy.

In reaching this conclusion, however, the FEIS made two critical errors in analyzing energy consumption by motor vehicles and light-rail cars. For motor vehicles, the FEIS assumed that cars in 2040 would consume the same amount of energy per vehicle mile as they did in 2010.[52] Yet cars are rapidly becoming more fuel-efficient. Just between 2010 and 2012, the fuel-economy of the average car on the road improved by more than 3 percent.[53]

The Environmental Protection Agency's current corporate average fuel economy standards, which require that the average car made in 2025 achieve 54.5 miles per gallon of fuel, guarantees that cars in 2040 will use far less energy than cars in 2010.[54] Assuming that manufacturers achieve the 54.5 miles-per-gallon rating on a straight line from 2010 and make no further improvements after 2025, and that Americans continue to replace their automobiles at the historic rate of about one-eighteenth of the fleet each year, then the average car on the road in 2040 will consume less than half the energy of the average car in 2010 even if auto manufacturers make no effort to improve fuel economy after 2025.

The second error made by authors of the FEIS was in calculating the energy required to power light-rail cars. Table 4–41 says that light-rail cars will require 8.4 million kilowatt-hours of energy, which, the table says, is equal to 28.67 billion BTUs of energy. This works out to 3,412 BTUs per kilowatt-hour, a number taken from table B.6 of the 31st edition of the *Transportation Energy Data Book*, a publication cited by the FEIS in the notes to table 4-41.[55] However, if the FEIS authors had read the footnote to Table B.6, they would have known that "this figure does not take into account the fact that electricity generation and distribution efficiency is approximately 33 percent. If generation and distribution efficiency are taken into account, 1 kWhr = 10,339 Btu."[56]

In short, the FEIS authors overestimated energy consumption of cars and underestimated energy consumption of light-rail vehicles. Correcting these two errors by cutting 2040 motor vehicle energy consumption in half and tripling light-rail energy consumption results in the rail alternative using nearly 2 billion more BTUs of energy per year than the no-build alternative in 2040.

THE PURPLE LINE WILL INCREASE POLLUTION

The serious errors made in the FEIS analysis of energy carry over into the FEIS analysis of pollution and greenhouse gas emissions. The FEIS assumes that cars in 2040 will emit as much pollution and greenhouse gases as in 2010, while it fails to account for the higher emissions of greenhouse gases from power plants that waste two-thirds of their energy in generating and transmitting electricity. Maryland gets well over half of its electricity from burning fossil fuels, and that translates into high emissions of nitrogen oxides, carbon dioxide, and other gases.[57]

The average light-rail line in the country uses more energy per passenger mile than the average car: about 3,400 BTUs per passenger mile for light rail versus less than 3,200 for cars.[58] Despite using more energy, some light-rail lines on the Pacific Coast emit less greenhouse gas than cars because most of the locally generated electricity comes from hydroelectric or other renewable sources. But in regions where most electricity comes from fossil fuels, as it does in Maryland, light rail generally emits more greenhouse gases per passenger mile than cars.

Light-rail lines that emitted particularly high amounts of carbon-dioxide-equivalents per passenger mile in 2012 include those in Salt Lake City (528 grams per passenger mile), Pittsburgh (485), Cleveland (476), Baltimore (344), Dallas

(337), Norfolk (279), and Denver (258). By comparison, the average car emits less than 230 grams of carbon-equivalents per passenger mile.[59]

Even the Washington Metro rail system, the second-most-heavily used rail system in the country, required 3,247 BTUs of energy per passenger mile in 2012, more than the average car that year. Burning the fossil fuels required to generate that electricity released 260 grams of carbon dioxide per passenger mile into the atmosphere, again more than the average car.[60]

LIGHT RAIL IS MORE DANGEROUS THAN BUSES OR CARS

Light-rail trains are heavy and difficult to stop. Between 1995 and 2011, light-rail lines carried 26.7 billion passenger miles and were involved in accidents that killed 333 people, for a fatality rate of 12.5 deaths per billion passenger miles.[61] By comparison, the fatality rate for accidents in which transit buses are involved is less than 4.5 deaths per billion passenger miles.

Light rail is also more dangerous than automobiles. In 2012, automobiles were involved in accidents that caused 15,404 fatalities in urban areas.[62] Cars and light trucks drove 1.84 trillion vehicle miles in 2012, which at 1.67 occupants per vehicle equals 3.07 trillion passenger miles.[63] That means there were just five fatalities per billion passenger miles in urban areas.

Rail advocates often point to data showing that light rail is very safe for rail riders. That is true; the people who are most vulnerable are those who are outside the railcars (including rail riders before they board or after they get off railcars). Transit agencies blame most fatalities on the victims, but if the agencies had not placed super-heavy railcars and trains in the same rights-of-way as autos and pedestrians, the conflicts never would have happened. Putting railcars that weigh around 100,000 pounds or, worse, three-car trains that weigh around 300,000 pounds, on the same streets as 3,000-pound cars and 150-pound pedestrians is asking for an increase in injuries and deaths.

RAIL IS INFLEXIBLE

The breakdowns of Portland light-rail trains described previously reveal one of the major flaws of rail transit: when a railcar breaks down, all of the railcars on that line must stop. If the breakdowns take place on tracks shared by several rail lines, then all of the cars on all of the lines must stop. Buses do not have this problem.

This is just one of the drawbacks of the inflexibility of rail transit, which is why rail transit loses out to buses on the convenience scale. Thirty urban areas in the United States have light-, heavy-, or commuter rail. Between them, they have 5,700 route miles of rail lines. Those same urban areas have more than 66,000 miles of freeways and arterials and more than 300,000 miles of other roads and streets, all of which are accessible by bus. The Washington, D.C. urban area has about 215 miles of rail lines, including the Maryland and Virginia commuter trains, compared with more than 2,100 miles of freeways and arterials and more than 10,000 miles of other roads and streets.[64] Buses can clearly reach far more destinations than rail.

Light-rail construction not only costs far more today than it did in 1981; it costs far more than highway construction. Given the right of way, freeway lanes basically cost about $2.5 million per mile. If a lot of excavation and/or overpasses are required, these costs can rise to as much as $20 million per mile. Even the Boston Big Dig, possibly the most expensive single highway project ever, cost just $90 million per lane mile, or less than two-thirds as much as the per-mile cost of the Purple Line.[65]

CONCLUSION

To the extent that the Bethesda–New Carrollton corridor needs improved transit service, buses, not rail, are the best ways to provide that transit service. Even those bus improvements need not be expensive; simply increasing the frequency of bus service running on existing streets will increase ridership. Operating buses on existing streets that make fewer stops than current buses will increase their speeds, which will also increase ridership. The comparison of alternatives in the DEIS showed that these improvements—which were considered under the "TSM" alternative—are the most cost-effective way of gaining new transit riders.

Building the Purple Line will do more harm than good to the region. Its high cost, especially the cost of rehabilitating the system every 30 years, will burden taxpayers for decades to come. The line will use more energy and emit more greenhouse gases than the cars it takes off the road. It will also increase safety hazards for motor vehicles and pedestrians in the corridor—and every light-rail rider becomes a pedestrian as soon as they get off the train.

Projections made for the Purple Line are highly optimistic. The cost of the line has already risen more than 40 percent since the DEIS was written. Ridership projections also appear highly optimistic, especially considering the Maryland Department of Transportation's track record for ridership projections of Baltimore light- and heavy-rail projects.

Despite these facts, many will continue to support the project, especially those who expect to profit from it. Maryland can find better ways of spending these funds that will generate not just short-term construction jobs but long-term economic benefits by truly improving transportation rather than building a system that is slower, more expensive, less convenient, and more dangerous than the transportation that already exists in the region.

RANDAL O'TOOLE *is a senior fellow with the Cato Institute and a visiting fellow with the Maryland Public Policy Institute specializing in land-use and transportation issues. He has written several books, including Gridlock: Why We're Stuck in Traffic and What to Do About It, as well as numerous research papers and policy analyses on transit and transportation issues. Prior to his current positions, he taught environmental economics at Yale, University of California at Berkeley, and Utah State University*

1. "Maryland National Capital Purple Line Project Profile," Federal Transit Administration, November, 2014, http://www.fta.dot.gov/documents/MD__Maryland_National_Capital_Purple_Line_Profile_FY16.pdf.
2. Robert Lindsey, "San Diego Gets an Old-Style Trolley," *New York Times*, July 26, 1981, http://www.nytimes.com/1981/07/26/us/san-diego-gets-an-old-style-trolley.html .
3. Federal Transit Administration, *Report on Funding Levels and Allocations of Funds for Transit: New Starts (FY 1997)*, Washington, 1996, table 2, appendix A.
4. Federal Transit Administration, *Proposed Allocation of Funds for Fiscal Year 2016: Capital Investment Grant Program*, Washington, 2015, individual project profiles.
5. "Streetcars in Atlanta," RailGa.com (Link is no longer live).
6. "Measuring Worth," measuringworth.com. Most adjustments to inflation in this report rely on the GDP price deflator; the adjustment in terms of relative wages uses the "compensation of production workers" measure.
7. American Public Transportation Association, *Public Transportation Fact Book 2013*, Washington, 2014, p. 39.
8. Metropolitan Council, *Central Corridor Draft Environmental Impact Statement*, St. Paul, Minn., 2006, p. 7–19.
9. Frederick Melo, "Green Line Thrown Behind Schedule by Traffic Lights," *St. Paul Pioneer Press*, July 20, 2014, http://www.twincities.com/localnews/ci_26185459/green-line-thrown-behind-schedule-by-traffic-lights?source=email.
10. Maryland Department of Transportation, *Purple Line Travel Forecast*, Annapolis, 2013, p. 30.
11. Robert Cervero and Samuel Seskin, *An Evaluation of the Relationship Between Transit and Urban Form*, Transportation Research Board, Washington, 1995, p. 3, http://www.tcrponline.org/PDFDocuments/TCRP%20RRD%2007.pdf.
12. "Transit Oriented Development: A Conversation with Professor Robert Cervero," *Berkeley Transportation Letter*, Spring 2012, its.berkeley.edu/btl/2012/spring/tod.
13. Mike Saba, Testimony before Portland City Council, October 23, 1996, https://www.youtube.com/watch?v=jRz7kPfkr2M&feature=youtu.be.
14. Quotes from the October 23, 1996 city council meeting are taken from a videotape of that meeting made by the city of Portland. Original synopsis link is no longer functional.
15. Portland Development Commission, *Adopted Budget FY 14-15, 2014*, p. 16. The $1.4 billion is calculated by adding the total indebtedness issued for urban renewal areas along light rail and streetcar lines.
16. "Portland Streetcar Development Summary," City of Portland, 2008, http://portlandstreetcar.org/pdf/development_200804_project_list.pdf.
17. "Slash Fares on Norfolk's Tide," *Virginian-Pilot*, August 24, 2014, http://hamptonroads.com/2014/08/slash-fares-norfolks-tide.
18. Calculated from 2012 *National Transit Database*, "Fare Revenue Earned by Mode" and "Service" spreadsheets.
19. Maryland Department of Transportation, *Purple Line Travel Forecasts Results Technical Report*, Annapolis, 2013, p. 55.
20. Maryland Department of Transportation, *Purple Line Alternatives Analysis/Draft Environmental Impact Statement*, Annapolis, 2008, p. 5-2.
21. Federal Transit Administration, *Proposed Allocation of Funds for Fiscal Year 2013* Washington, 2012), "Maryland Purple Line Profile," p. 1, http://www.fta.dot.gov/documents/MD_Maryland_Purple_Line_Profile_final_pdf.pdf .
22. Ibid.
23. Andrew Pereira, "Rail Deficit Grows to $910 Million Without Bus Funds," KITV.com, January 20, 2015, http://www.kitv.com/news/rail-deficit-grows-to-as-much-as-910-million-without-bus-funds/30830144.
24. P: D.H. Pickrell, *Urban Rail Transit Projects: Forecast versus Actual Ridership and Cost*, U.S. Department of Transportation, Washington, 1990, p. xi.
D: Nasiru A. Dantata, Ali Touran, and Donald C. Schneck, *Trends in U.S. Rail Transit Project Cost Overrun*, paper presented to the Transportation Research Board, 2006, table 2, http://www.mdt.mt.gov/research/docs/trb_cd/Files/06-0897.pdf. Except for the inclusion of the Los Angeles Blue Line, all of the data in this paper are identical to F3, so they presumably used the same source documents.
F3: Federal Transit Administration, *Predicted and Actual Impacts of New Starts Projects–2003*, Washington, 2003, table 2, http://www.mdt.mt.gov/research/docs/trb_cd/Files/06-0897.pdf.
F7: Federal Transit Administration, *The Predicted and Actual Impacts of New Starts Projects–2007*, Washington, 2008, p. 11, http://www.fta.dot.gov/documents/NSPA2007_Final(1).pdf.
F11: Federal Transit Administration, *Before and After Studies of New Starts Projects: Report to Congress*, Washington, 2011, http://www.fta.dot.gov/documents/2011_Before_and_After_Studies_of_New_Starts_Projects.pdf.
F13: Federal Transit Administration, *Before and After Studies of New Starts Projects: Report to Congress*, Washington, 2013, http://www.fta.dot.gov/documents/FY2013_Before_and_After_Studies_Report_to_Congress_Final.pdf.
M: Uses the cost projection from BRW, Inc., *West Corridor Major Investment Study Final Report* (Denver, CO: RTD, 1997), p. 108 (adjusted for inflation) and the actual cost from "Denver's Ambitious Light Rail to Open This Month," *Governing*, April 4, 2013.
N5: Uses the cost projection from the project profile from the 2005 *New Starts* report and the actual cost from Joe Lawlor, "Light Rail for the Peninsula Discussed," DailyPress.com, February 23, 2012, http://gohrt.com/light-rail-for-the-peninsula-discussed/.
N96: Is the project profile from the 1996 *New Starts* report; N13 is the project profile from the 2013 *New Starts* report.
25. Maryland Department of Transportation, *Purple Line Final Environmental Impact Statement* Annapolis: 2013, p. 3–5.
26. Calculated from 2012 *National Transit Database*, "Service" spreadsheet.
27. D.H. Pickrell, *Urban Rail Transit Projects: Forecast versus Actual Ridership and Cost* U.S. Department of Transportation, Washington, 1990, p. xvii.
28. Bent Flyvbjerg, "Curbing Optimism Bias and Strategic Misrepresentation in Planning: Reference Class Forecasting in Practice," *European Planning Studies*, vol. 16, no. 1, January, 2008, http://www.census.gov/geo/reference/ua/urban-rural-2010.html.
29. Federal Transit Administration, *National State of Good Repair Assessment* Washington, 2010), p. 3, http://www.fta.dot.gov/documents/National_SGR_Study_072010(2).pdf.
30. New York City Comptroller, "A Review of MTA New York City Transit 'State of Good Repair' Expenditures," 2007, p. 7, http://comptroller.nyc.gov/wp-content/uploads/documents/Feb-07_state-of-good-repair-report.pdf.
31. Oregon Secretary of State, *TriMet: General Management Review and Issues Deserving Additional Attention*, Salem, 2014, p. 41.
32. Joseph Rose, "TriMet Tweets: Sorry for the (Many) MAX Breakdowns, Portland (And Here We Go Again)," *The Oregonian*, May 15, 2014, tinyurl.com/nqcutmo.
33. Maryland Department of Transportation, Purple Line Alternatives Analysis/Draft Environmental Impact Statement, Annapolis, 2008, p. ES-6.
34. The Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users, §3011.
35. 49 U.S.C. §5309(d)(2)(A)(iii).
36 The table does not show the cost per hour for the lowest-cost bus alternative, called TSM, but based on the table on page 6-8, it is $11.01, less than half the cost of the least-cost rail alternative.
37. *Purple Line DEIS*, p. 5–2.
38. Maryland Department of Transportation, *Purple Line Final Environmental Impact Statement,* Annapolis, 2013, p. 9–1.
39. Letter from Secretary of Transportation Mary Peters regarding cost-effectiveness, April 29, 2005, http://ti.org/MaryPetersLetter4-29-05.pdf.
40. *Federal Register*, "Notice of Availability of Proposed New Starts and Small Starts Policy Guidance," January 9, 2013, p. 2038; 49 CFR 611.
41. Calculated from the 2012 *National Transit Database*, "Service" spreadsheet.
42. Calculated from the 2012 *National Transit Database*, "Service" spreadsheet and the 2012 *Highway Statistics*, table HM-72.
43. Robert L. Bertini, "Bus Facility Capacity," Portland State University, May 2, 2006, p. 5.
44. Maryland Department of Transportation, *Purple Line Traffic Analysis Technical Report*, Annapolis, 2008, pp. 41–4-2.1
45. Maryland Department of Transportation, *Purple Line Traffic Analysis Technical Report*, Annapolis, 2013, p 30.
46. Ibid, p. 27.
47. Ibid, p. 29.
48. Ibid, p. 31.
49. *Purple Line DEIS*, p. 4–87.
50. Ibid, p. 4–88.
51. *Purple Line FEIS*, p. 4–142.
52. Note 1 to table 4–41 in the FEIS refers to a Department of Energy report showing transportation energy consumption in 2010.
53. Stacy C. Davis, Susan W. Diegel, and Robert G. Boundy, *Transportation Energy Data Book, Edition 33*, U.S. Department of Energy, Oak Ridge, TN: 2014, table 2.13.
54. "Obama Administration Finalizes Historic 54.5 mpg Fuel Efficiency Standards," National Highway Traffic Safety Administration, August 28, 2012, http://www.nhtsa.gov/About+NHTSA/Press+Releases/2012/Obama+Administration+Finalizes+Historic+54.5+mpg+Fuel+Efficiency+Standards.
55. Number taken from table B.6 of the 31st edition of the *Transportation Energy Data Book*, a publication cited by the FEIS in the notes to table 4–41.
56. Stacy C. Davis, Susan W. Diegel, and Robert G. Boundy, *Transportation Energy Data Book, Edition 31*, Department of Energy, Oak Ridge, TN: 2012, table B.6.
57. Energy Information Agency, *State Electricity Profiles* Washington, 2014, Maryland electricity profile, table 5, http://www.nhtsa.gov/About+NHTSA/Press+Releases/2012/Obama+Administration+Finalizes+Historic+54.5+mpg+Fuel+Efficiency+Standards.
58. Calculated from the 2012 *National Transit Database*, "Energy Consumption" and "Service" spreadsheets; average car energy use from T*ransportation Energy Data Book, Edition 33*, table 2.13.
59. Ibid; calculations of carbon-dioxide-equivalents made from the 2012 *National Transit Database* using factors in *State Electricity Profiles* and appendix B of the T*ransportation Energy Data Book.*
60. Ibid.
61. *National Transportation Statistics* (Washington: Bureau of Transportation Statistics, 2014), tables 1-40 (passenger miles) and 2-35 (transit and grade-crossing fatalities).
62. *Highway Statistics 2012* (Washington: Federal Highway Administration, 2013), table FI-20.
63. *Highway Statistics 2012*, table VM-1. Passenger miles calculated using 1.67 occupants per vehicle based on Adella Santos, N. McGuckin, H.Y. Nakamoto, D. Gray, and S. Liss, *Summary of Travel Trends: 2009 National Household Travel Survey*, Federal Highway Administration, Washington, 2011, p. 33, nhts.ornl.gov/2009/pub/stt.pdf.
64. Roadway mileage from *Highway Statistics* 2012, table HM-71; rail mileage from *National Transit Database 2012* (Washington: Federal Transit Administration, 2013), "Fixed Guideway" spreadsheet. This spreadsheet reports "directional-route miles"; these must be divided by 2 to get route miles.
65. "The Big Dig: Facts and Figures," Massachusetts Department of Transportation, http://www.massdot.state.ma.us/highway/thebigdig/factsfigures.aspx , says the Big Dig built 161 lane-miles of highway. The cost was $14.6 billion.

ABOUT THE MARYLAND PUBLIC POLICY INSTITUTE

Founded in 2001, the Maryland Public Policy Institute is a nonpartisan public policy research and education organization that focuses on state policy issues. Our goal is to provide accurate and timely research analysis of Maryland policy issues and market these findings to key primary audiences.

The mission of the Maryland Public Policy Institute is to formulate and promote public policies at all levels of government based on principles of free enterprise, limited government, and civil society.

In order to maintain objectivity and independence, the Institute accepts no government funding and does not perform contract research. The Maryland Public Policy Institute is recognized as a 501 (C) (3) research and education organization under the Internal Revenue Code.

The Maryland Public Policy Institute

One Research Court | Suite 450 | Rockville, Maryland 20850 | mdpolicy.org