THE MAGLEV REVISITED: PART 5

The Federal Railroad Administration falls for an excessively high forecast of how many trips would be made on the maglev

Reference data suggest that the official ridership forecast is more than a factor of ten too high for the proposed Baltimore-Washington maglev

BY OWEN KELLEY (okelley@gmu.edu), MAY 20, 2021

It would be a scandal to spend 17 billion dollars to build a new rail line if one could predict that the train would run mostly empty. There are hints that this disaster might unfold if a magnetic-levitation rail line were built between Baltimore and Washington, DC. Most people call this train, the "maglev." [1]

The official ridership forecast for the Baltimore-Washington maglev is stated in the project's draft environmental impact statement. The draft impact statement, however, merely copies its ridership forecast from a contractor's report, a report that the public is not allowed to read. This secrecy makes it more difficult to double-check the official ridership forecast but it does not make it impossible. If an approximate answer is sufficient, then only a few mathematical steps are needed to derive a ridership forecast that is independent of the official forecast.

The accuracy of the official ridership forecast matters because the maglev's draft impact statement relies on the ridership forecast in order to quantify the various benefits of operating the maglev. The number of people riding the maglev determines the revenue from ticket sales, the financial solvency of the maglev operator, the amount of road-congestion prevented, the reduction in car-generated air pollution, and the number of jobs created because of maglev operations.[2]

It is unclear how low ridership would have to be to make the maglev worthless. The draft impact statement ignores this question. Would this threshold be crossed if the official ridership forecast were, say, twice as high as would be reasonable? The analysis below suggests that the official ridership forecast is more than ten times greater than can be supported by several datasets that describe the region's travel patterns.[3]

[1] $15–17 billion: Appendix D4, Table D4-8, pg. D-21.

[2] Revenue from maglev ticket sales in "SCMAGLEV annual fare cost" row of Appendix D4, Table D4-28, pg. D-44. Road congestion: Kelley 2021 Feb 10. Air pollution: Appendix D4, Table D4-40, pg. D-51, and Kelley 2021 April 11. 390–440 jobs created by maglev operations: Chapter 4.6, pg. 4.6-8.

[3] Many ridership forecasts off ±30%: Hartgen (2013). A factor of 10 error would be unusually large.

Background

In January 2021, the Federal Railroad Administration published the maglev's draft environmental impact statement. The document describes ridership as a "key metric" for determining impacts of operating the proposed maglev. Bizarrely, the document uses only 6 out of its 3,000 pages to describe its ridership forecasting method. Such a brief discussion of such an important topic is odd. The draft impact statement provides so little detail that the official ridership forecast is not reproducible.[4]

Worse yet, it appears that the Federal Railroad Administration merely copied its ridership numbers from a contractor's report. The contracting company is named Louis Berger.

In the draft impact statement, there is no evidence that the Federal Railroad Administration commissioned an independent review of the Louis Berger ridership report or had its own staff perform an internal review of it. The draft impact statement does mention one review of the Louis Berger ridership report, but that review suffers from at least the appearance of a conflict of interest. That review was conducted by the company that wants to built the maglev, i.e., Baltimore Washington Rapid Rail (BWRR).[5]

By republishing Louis Berger's numbers in the draft impact statement, the Federal Railroad Administration has transformed Louis Berger's numbers into the project's official ridership forecast.

During most of the public-comment period for the maglev's draft impact statement, the Louis Berger ridership report was completely hidden from the public. The company that wants to build the maglev, BWRR, was allowed to see the Louis Berger report, but not the public or elected officials. Toward the end of the comment period, the Federal Railroad Administration made public a heavily redacted copy of the Louis Berger report. The information relevant to the present article, for example, was completed blanked out in this redacted copy.[6]

Downtown to Downtown

The proposed maglev would have only three stops: downtown Washington, downtown Baltimore, and the Baltimore/Washington International (BWI) airport. The present paper examines travel between the two urban centers first and

[4] Six-page-long ridership-model description citing zero references: Appendix D2, pg. B-104 to D-109. Key metric: Chapter 4.2, pg. 4.2-6. 654 pages in main text and 2399 pages in the appendices, so the total page count is 3,053. To count pages, use the mdls command in the MacOS terminal: mdls -n kMDItemNumberOfPages *.pdf | awk '{print $3; sum += $3} END {print sum}'.

[5] The maglev DEIS cites the 2018 Louis Berger "Baltimore-Washington SCMAGLEV Project Final Ridership Report" in Appendix D4 (footnote to Table D4-19, pg. D-36) and in Chapter 4.6 (pg. 4.6-3, footnotes 9). The DEIS describes 3 steps that the "project sponsor" took to check the ridership forecast (Appendix D2, pg. B-104), but no steps that the Federal Railroad Administration took. The Federal Railroad Administration is a regulatory agency, so one of its essential functions is to double-check statements made by project sponsors, i.e., by the industry that the agency is supposed to be regulating. From the page following the title page of the draft impact statement: "The Project Sponsor, Baltimore Washington Rapid Rail, LLC proposes to construct and operate an SCMAGLEV system between Baltimore, MD and Washington, D.C." See the discussion in Voulgaris (2019) on how a forecast can be affected by the biases of the forecaster.

[6] The maglev DEIS public comment period was January 23 through May 24, 2021: Maryland Transit Administration (MTA) 17 March 2021, press release, https://www.mta.maryland.gov/articles/304. Redacted copy of the 2018 Louis Berger ridership report released on April 23, 2021, at https://bwmaglev.info/index.php/project-documents/deis#ridership-studies.

subsequently examines travel from urban center to BWI airport.

The maglev's draft impact statement says that most of the maglev's ridership would be people traveling between the two cities rather than people who are flying out of or in to BWI airport.

In addition, the draft impact statement says that most maglev trips would be "diverted" not "induced." A diverted maglev trip is a maglev trip that the customer would make by another form of transportation if the maglev were not built. In contrast, an induced maglev trip is a trip that would only occur if the maglev were built. As a practice, transportation planners divide total ridership into diverted and induced travel. The present article examines only diverted trips because they are easier to estimate than induced trips.

The calculation of diverted trips starts with a recent travel survey. The travel survey states how many trips are made between Washington and Baltimore, and the survey was published in 2020 by the Metropolitan Washington Council of Governments.[7]

The relevant number to extract from the travel survey is the number of trips within the maglev service area: 18,956 one-way trips per day. As discussed in the Appendix of the present article, this number depends on which jurisdictions are determined to be within the maglev's ridership area. These jurisdictions are listed in an article that the present author wrote titled "The Maglev would serve a small geographic area." In these jurisdictions, most residents could save time by riding the maglev rather than driving between Baltimore and Washington. In this way, the maglev would serve three jurisdictions at the southern end of the maglev line: the District of Columbia, the City of Alexandria, and Arlington County. The maglev would serve two jurisdictions at northern end of the line: the City of Baltimore and Baltimore County.[8]

The 18,956-trip estimate is based on data collected in 2018, but this number can be extrapolated to 2045, the year for which the maglev's official ridership forecast is intended to apply. To extrapolate from 2018 to 2045 one may use a 0.93% increase in travel per year between Baltimore and Washington as proposed in the maglev's draft impact statement.[9]

The next step is to multiply by the fraction of the population that makes enough money that the travel time saved on the maglev would seem worth the maglev ticket price. In an earlier article titled "Maglev riders would come from the wealthiest 2% of the Baltimore-Washington population," the author showed that about 2% of the population earns this much.[10]

Figure 1 shows how these factors are combined to arrive at an unofficial forecast that 178,000 one-way trips would be diverted to the maglev in 2045. Figure 1 also shows the official forecast for this portion of the maglev ridership: 17.6 million one-way maglev trips. To be clear, both the official forecast and the just-derived unofficial forecast are both forecasts for diverted maglev trips in 2045, excluding BWI airport customers. The official forecast is approximately

[7] See the Appendix of the present article for details about the Regional Travel Survey.

[8] Ridership area article: 25 March 2021: https://www.greenbeltonline.org/the-maglev-would-serve-a-small-geographic-area/.

[9] 0.93% annual growth: Appendix D2, pg. C-106.

[10] 2% article: 2 May 2021: https://www.greenbeltonline.org/maglev-wealth/.

one hundred times greater than the independent, unofficial forecast (100 ≈ 17.6 ÷ 0.178).[11]

Downtown to Airport

The preceding section considered non-airport travel and this section considers airport travel. In both cases, the official ridership forecast in the draft impact statement is much higher than the unofficial forecast derived in the present article.

At the Baltimore/Washington International (BWI) airport, a maglev station is proposed immediately adjacent to the airport's main terminal where the hourly parking garage now stands. The Maryland Aviation Administration reported that BWI airport had 26.933 million arrivals and departures in 2019.[12]

The first task is to determine what portion of BWI customers would save time if they used the maglev to travel to or from the airport. Those Washington area residents who would save time

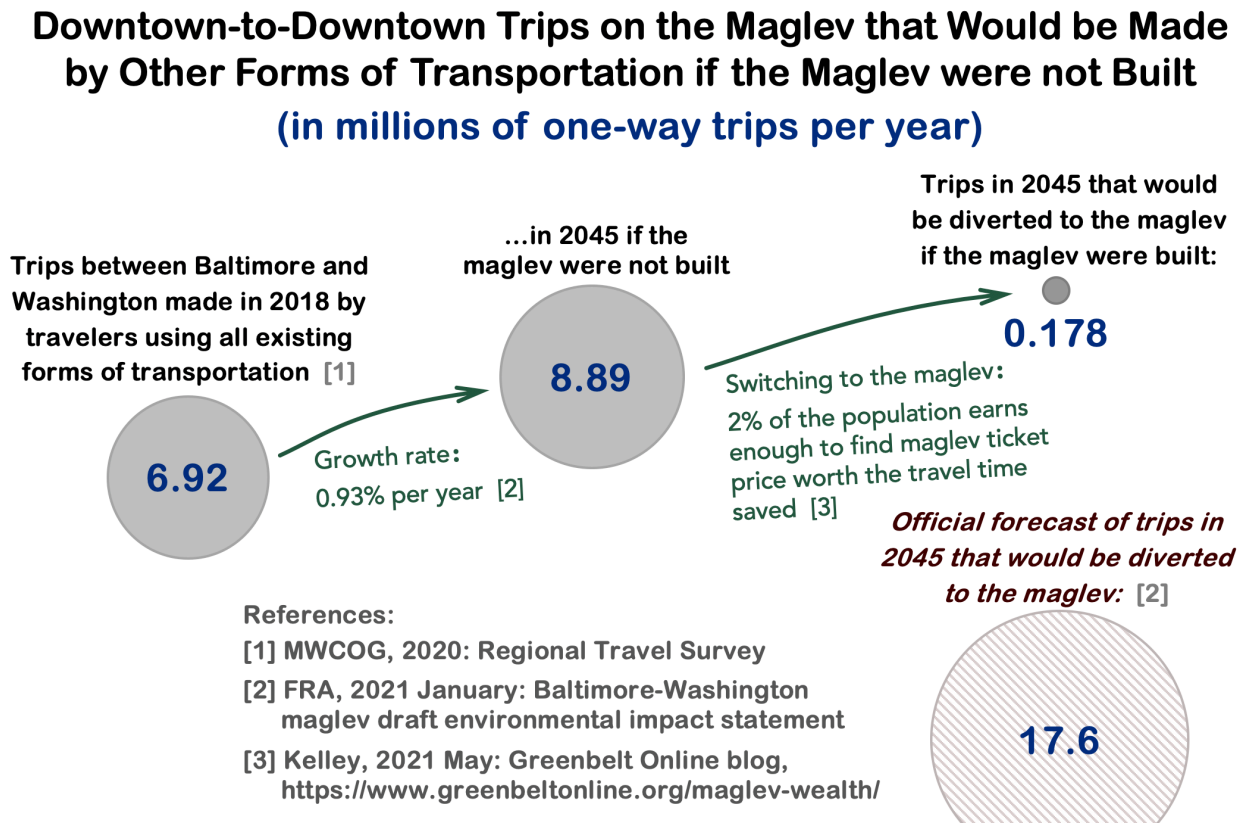

Figure 1. A schematic diagram showing how the present article calculates an unofficial forecast for the number of maglev trips in 2045 that would be made by "diverted" travelers. A diverted traveler is someone who would make the trip by another form of transportation if the maglev were not built. The 17.6-million-trip official forecast is seen to be much larger than the 178,000-trip unofficial forecast. Both forecasts exclude BWI airport passengers.

[11] Official ridership forecast for diverted non-airport travelers calculated as diverted travelers contributing 20.579 million trips (Chapter 4.2, Table 4.2-3, pg. 4.2-7) multiplied by 85.5% of maglev trips would be by people other than BWI airport customers (Appendix D4, Table D4-19, pg. D-35). 17.6 million = 20.579 million · 0.855.

[12] MD Aviation Administration December 2020.

riding the maglev to or from BWI are those who live in DC, Arlington, or Alexandra. Most City of Baltimore residents, but not most Baltimore County residents, could save time by riding the maglev to BWI. Approximately 21% of the region's population lives in the four above-mentioned jurisdictions.[13]

Next, apply to the airport trips the same two factors that were applied in the previous section to non-airport trips. The first factor extrapolates the 2019 measured trips to 2045, the year of the official maglev ridership forecast. The second factor is 0.02, the portion of the population that is wealthy enough to find the maglev travel-time savings worth the maglev ticket price.

After combining these factors, the result is an unofficial forecast of 143,000 one-way maglev trips in 2045 by BWI customers traveling to or from the airport on the proposed maglev. Add these 143,000 airport trips to the 178,000 non-airport trips derived in the previous section to arrive at the total number of maglev trips that represent travel diverted from other forms of transportation in 2045. The sum of these two numbers is 321,000 trips, which is far less than the official forecast of 20.6 million trips.

To be clear, the official and unofficial forecasts are both estimates of the number of diverted maglev trips that would be made in 2045. The official forecast is a factor of 64 times greater than the independent, unofficial forecast that the present article derives ($64 \approx 20.6 \div 0.321$).[14]

Commuters

The official ridership forecast is far too high based on the analysis presented so far that uses publicly available reference datasets. Because it is a serious charge to claim that the Federal Railroad Administration has been fooled into republishing a grossly implausible ridership forecast, this section examines yet another reference dataset. This third dataset confirms the pattern seen so far, as explained below.

Data from the Census Bureau show that 13,091 people commuted between Baltimore and Washington in 2015, the most recent year for which these data are available. This number is the sum of the people who live in Baltimore and work in Washington and the people who live in Washington and work in Baltimore. As discussed in Kelley (2021 March 25), these commuters have the District of Columbia, Arlington, or Alexandria at the southern end of their commute and Baltimore County or the City of Baltimore at the northern end of their commute.[15]

The annual number of one-way commuting trips can be estimated by multiplying the number of commuters by two trips per workday and by the average number of workdays in a year.[16]

Multiply this number of trips by the same two factors used in the previous sections of the present article. First, use a 0.93%-per-year increase in travel between the year that the data was collected, 2015, and the maglev forecast year, which is 2045. Second, multiply by 0.02 because only about 2% of the population is wealthy enough that the travel-time saved on the maglev would be worth the maglev ticket price. The result is an unofficial

[13] 21%: see the Census Bureau data described in the Appendix of the present article.

[14] Official forecast of 20.579 million trips by diverted travelers: Chapter 4.2, Table 4.2-3, pg. 4.2-7.

[15] 13,091 commuters: See the American Commuter Survey data in the Appendix of the present article.

[16] How many trips the average commuter would make in a year: Appendix of present article.

forecast that 147,000 one-way maglev trips would be made in 2045 by diverted commuters, commuters who switched from some other form of transportation to ride the maglev.

In contrast, the official forecast is that diverted commuters would make 5.2 million one-way maglev trips per year. The official forecast is 35 times higher than the unofficial forecast ($35 \approx 5.2 \div 0.147$).[17]

To review, the present article has examined three reference datasets. All three of them provide evidence that the official ridership forecast for the proposed maglev is implausibly high. The official forecast in the draft impact statement is more than ten times higher than the reference datasets can support.

Prior Studies Suggest Low Ridership

There is nothing surprising about the present article finding that only a few travelers would prefer the proposed Baltimore-Washington maglev over other forms of transportation.

A high-speed rail line that is shorter than 100 miles cannot compete with car travel according to a National Academies report in 1991 and Federal Railroad Administration reports in 1993 and 2005. This result applies to all types of high-speed rail lines whether or not they use maglev technology. The proposed Baltimore-Washington maglev would be only 36 miles long, which is much shorter than the 100-mile cutoff.[18]

It is surprising that the Federal Railroad Administration chose not to mention the findings of these earlier studies in the January 2021 draft impact statement for the proposed Baltimore-Washington maglev. The regulations that implement the National Environmental Policy Act (NEPA) require that an impact statement evaluate all relevant points of view.[19]

The most natural interpretation of these earlier studies is that a maglev shorter than 100 miles would not be economically viable. For this reason, a short-run maglev line would be an invalid subject for an environmental impact statement. To quote NEPA regulations, the subject of an environmental impact statement must:

> have independent utility or independent significance, i.e., be usable and be a reasonable expenditure even if no additional transportation improvements in the area are made [20]

Based on the analysis in the present article, a maglev between Baltimore and Washington would have so few riders that it would lack the "independent utility" that is required in the above-quoted regulation.

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[17] Official forecast for diverted commuters calculated as 20.579 million trips by diverted travelers (Chapter 4.2, Table 4.2-3, pg. 4.2-7) multiplied by 25.4% of maglev trips being made by commuters (Appendix D4, Table D4-19, pg. D-35). 5.2 million = 20.579 million · 0.254.

[18] 33–36-mile length stated in maglev DEIS: FRA 2021, Chapter 3, pg. 3-18 and 3-19. National Academies (1991), Figure ES-1, pg. 7. Car's advantages over rail: FRA 1997, pg. 7-4; FRA 2008, pg. 6-7; and FRA 2005, pg. ES-3.

[19] Eccleston 2014, pg. 258–259. NEPA regulation 2005 Section 1502.9(a) states, "the [lead author] agency shall make every effort to disclose and discuss at appropriate points in the draft statement all major points of view on the environmental impacts."

[20] 23 CFR § 771.111, https://www.law.cornell.edu/cfr/text/23/771.111.

Conclusion

The present article has examined the official forecast for the number of trips that would be made on the proposed Baltimore-Washington maglev. The official forecast is stated in the draft environmental impact statement that the Federal Railroad Administration published in January 2021.

The analysis in the present article finds that the official ridership forecast is implausibly high. The official forecast is more than an order of magnitude higher than what reference datasets can support.

The official forecast is 20.6 million one-way maglev trips that would be made each year by travelers diverted from other forms of transportation. In contrast, various reference datasets examined in the present article suggest that a much smaller number of diverted travelers is more likely: 0.32 million one-way maglev trips per year. A diverted traveler is someone who would make the trip by another form of transportation if the maglev were not built. The draft impact statement reports that the great majority of maglev travelers would be diverted from other forms of transportation.

If the official ridership forecast is higher than warranted, then it would prevent the draft impact statement from helping the public and elected officials evaluate the harm and benefits associated with the proposed maglev. The draft impact statement relies on the ridership forecast to derive its estimate for, among other things, the maglev's revenue, the solvency of the maglev operator, the air-pollution reduction, the road-congestion improvement, and the jobs created by maglev operations.

Disclaimer

This analysis was performed by an area resident, acting in his capacity as a individual citizen to examine a non-partisan issue of interest to the public. If errors are suspected, please contact the author at okelley@gmu.edu. Prior phases of this analysis have been published in the Greenbelt Online blog, www.greenbeltonline.org/blog.

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Appendix

This appendix describes the official and unofficial forecasts for various categories of ridership for the proposed Baltimore-Washington maglev. The unit of ridership is a one-way trip on the maglev made by one person, regardless of which maglev stations the passenger uses. The official ridership forecast is extracted from the maglev's draft environmental impact statement (DEIS), as summarized in Table 1 of the present article.

The unofficial forecast is derived in the present article based on the various reference datasets described in this appendix. The unofficial forecast is stated in Table 2 of the present article. Tables 3 through 5 summarize the reference datasets that support the unofficial forecast.

It is unclear whether any of the reference datasets used to create the unofficial ridership forecast are also used in the DEIS to create the official ridership forecast. The DEIS is vague about its input data. The most precise sentence in the DEIS on this topic is the following embarrassingly vague sentence:

> A comprehensive accounting of current intercity trips was developed utilizing MPO surveys and models, transit agency data, airport data, and mobile phone origin / destination data.[21]

The Official and Unofficial Forecasts

The present article discusses exclusively one portion of the maglev's ridership. Specifically, the present article focuses on maglev travelers that are diverted from other forms of transportation. A diverted traveler is someone who would make the trip by the maglev if the maglev were built and who would make the trip by another form of transportation if the maglev were not built. The DEIS contain a forecast for the maglev's diverted ridership in 2045 under the assumption that the downtown Baltimore maglev station would be built at Camden Yards.

The DEIS's official ridership forecast is shown in the rightmost column of Table 1 of the present article. The total number of diverted trips is 20.579 million one-way maglev trips in 2045 as stated in the DEIS, Chapter 4.2, Table 4.2-3 (page 4.2-7). In contrast, the unofficial forecast for the same quantity is only 0.321 million one-

[21] Appendix D2, pg. C-106

way maglev trips in 2045, as stated in Table 2 of the present article. The official forecast is approximately 64 times greater than the unofficial forecast. These forecasts are so wildly different that only one can be anywhere near right.

One way that the DEIS categorizes diverted travelers is that they are either airline customers at Baltimore/Washington International (BWI) Airport or they are travelers with some other, non-airport travel goal. The DEIS identifies commuters as a subcategory of non-airport diverted travelers.

The DEIS does not explicitly state the ridership (trips per year) for these specific categories of diverted travelers. But the ridership can be easily calculated from the percentages that are explicitly stated in the DEIS's Appendix D4, Table D4-19 (page D-35). These percentages are used to populate rows 1, 2, and 4 of Table 1 of the present article.

An Unofficial Forecast of Non-airport Diverted Travelers

The unofficial forecast for non-airport diverted travelers is 178,000 one-way maglev trips in 2045, as stated in the rightmost column of Table 2. To derive this number, start with data from the Regional Travel Survey that was published in 2020 based on data collected in 2017 and 2018. This survey was developed by the National Capital Region Transportation Planning Board (NCRTPB) which is an organization within the regional planning body called the Metropolitan Washington Council of Governments, MWCOG. (See also Jon 2021).

Table 3 of the present article gives the relevant data from the Regional Travel Survey. The total number of one-way trips between the cities is 18,956 during a typical weekday. As a simplifying assumption, the present article assumes that the average traffic on a Saturday or Sunday is equal to the average traffic on a weekday, Monday through Friday. For this reason, the daily trip count can be multiplied by the number of days in a year (365.25 days) to obtain an estimate of the annual trip count in 2018 (6.924 million trips). This is the number of trips in 2018 without the maglev, obviously, because the proposed maglev didn't exist in 2018.

This simplifying assumption about weekend-vs.-weekday traffic volume is acceptable for approximate calculations. For tourist, recreation, and leisure-activity destinations, weekend traffic may be greater than weekday traffic. Conversely, an office-dense location may have much less weekend traffic than weekday traffic. Hankey et al. (2014, Table 2) found that average traffic volume on weekends vs. weekdays varies typically by approximately ±20% depending on the primary use of that location.

The decision in the present article on which jurisdictions to extract from the Regional Travel Survey is based on the article "The maglev would serve a small geographic area" by Kelley (2021 March 25). At the northern end of the trip, Baltimore County and the City of Baltimore are included in this ridership area. In order to work with whole jurisdictions, Anne Arundel County is not included in the maglev ridership area. Most residents of Anne Arundel County would find it faster to drive directly to destinations in the Washington area rather then detour northward to reach the maglev station at BWI or in downtown Baltimore.

Presumably, BWI airport passengers would be a small portion of the trips included in the Regional Travel Survey's total for the number of trips with one end in District of Columbia, Alexandra, or Arlington and the other end in Anne Arundel County. It is impossible to know

based on the Regional Travel Survey what exact portion of such trips is made by BWI airport passengers. For this reason, the Regional Travel Survey is not well suited for analyzing airport customers. Airport customers are treated in the next section of the Appendix using a different reference dataset.

The simplest formula to extrapolate 2018 non-airport travel data to 2045 is to use a fixed annual increase in traffic:

$$f_{\text{growth}} = \{ 1 + (a \div 100\%) \}^{d}$$

where d is the number of years, a is the percent increase in traffic in a single year, and f_{growth} is the fractional increase in traffic over the stated period of years. Initially, consider travel growth during a 27-year period (2018 to 2045) and at an annual growth rate of 0.93%, the rate specified in the maglev DEIS. Under these conditions, traffic volume would grow by a factor of 1.284 between 2018 and 2045. Applying this growth factor, one obtains 6.924 million one-way trips in 2045 made by all forms of transportation, under the assumption that the maglev were not built. This is the bottom number in Table 3 of the present article.[22]

The last step is to convert the number of trips between Baltimore and Washington in 2045 by non-maglev forms of transportation into the forecasted portion of these trips that would be diverted to the maglev were the maglev built. Two percent of these trips would be diverted to the maglev according to the work of Kelley (2021 May 2) in the article titled "Maglev riders would come from the wealthiest 2% of the Baltimore-Washington population." The result is an unofficial forecast for the number of non-airport diverted trips on the maglev in 2045: 178,000 one-way maglev trips, as stated in Table 2 of the present article.

An Unofficial Forecast of Airport Diverted Travelers

The number of passengers arriving and departing Baltimore/Washington International (BWI) Airport is reported each year. The organization that runs the airport is called the Maryland Aviation Administration. According to the Administration, the number of passengers was 26.933 million in 2019. Each one of these airplane trips necessitates one passenger-trip to or from the airport.

The question is what fraction of these 26.933 million trips to or from BWI would be made within the maglev ridership area so that the maglev would be an option for these travelers, were the maglev built. A reasonable first guess would be that the fraction of trips within the maglev ridership area would be similar to the fraction of the region's population that lives within the maglev ridership area.

This fraction of the region's population can be calculated from the Census Bureau population data that is provided in Table 4 of the present article. The percent of the region's population that lives in the jurisdictions where the maglev could save them time on a trip to BWI airport is 20.93% based on the data shown in Table 4. Traveling south on the maglev, it would be only City of Baltimore residents traveling to BWI. In contrast, most Baltimore County residents would find it just as fast to drive directly to BWI and skip the unnecessary expense of the maglev according to Kelley (2021 May 2). At the southern end of the maglev line, the residents of the District of Columbia, Arlington, and Alexandria would save

[22] "The overall level of growth in intercity trips within the project area was estimated at .93% compounded average annual growth between a base year of 2017 and a horizon year of 2045": Appendix D2, pg. C-106.

time riding the maglev north to BWI, again according to Kelley (2021 May 2).

Multiplying the 2019 number of BWI trips by 0.2093 gives 5.637 million BWI trips in 2019 that would be in the maglev's ridership area. Multiplying this number by 1.272 projects this number 26 years into the future to 2045, using the formula for f_{growth} that was introduced in the previous section of the Appendix. Multiplying this number by 0.02 converts the total number of trips assuming the maglev isn't built into the number of trips that would be diverted if the maglev were built. The 0.02 factor comes from Kelley (2021 May 2) as discussed in the previous section of the Appendix. The result is an unofficial forecast of 143,000 one-way maglev trips in 2045 made by BWI-airport customers traveling to or from the airport. This number is stated in Table 2 of the present article.

An Unofficial Forecast of Diverted Commuters

The American Commuter Survey (ACS) of the Census Bureau provides a travel matrix of commuters. In other words, the ACS provides a list of the number of people living in a particular county or city and commuting to work in various other counties or cities. The most recent year for which these data are available is 2015. Table 5 of the present article shows the relevant ACS data for estimating diverted commuter traffic on the proposed Baltimore-Washington maglev.

By summing the data in Table 5 of the present article, one can calculate the number of commuters in 2015 who traveled between Baltimore and Washington summing over all existing forms of transportation. The southern end of the commute is in the District of Columbia, Arlington County, or the City of Alexandria. The northern end of the commute is in Baltimore County or the City of Baltimore. These jurisdictions were chosen based on Kelley (2021 March 25).

To convert from number of commuters to number of annual trips made by commuters, one first needs to estimate the number of days in a year that the average commuter travels to the office. There are 261 workweek days in a year, i.e., Monday through Friday each week of the year (261 days ≈ 365.25 days · 5 ÷ 7). From these 261 days, subtract 10 federal holiday and subtract 3 weeks of paid vacation (15 workdays). The result is 236 workdays per year.[23]

Because a fraction of the Washington region's workforce will telework from home on a typical workday rather than going to the office, the number of travel-to-the-office days is less than the number of workdays for the average worker. The Metropolitan Washington Council of Governments reported in 2019 that teleworking reduced the number of daily commutes to the office by 9.7% relative to the number that would have occurred without teleworking.[24]

Multiply the 236 workdays by 0.903 because 9.7% of workdays are telework days in the Washington region (0.903 = {100% -9.7%} ÷ 100%). The result is 213 days per year in which the average worker in the Washington region travels to the office (213 days = 236 days · 0.903). Assuming two trips during each of these days

[23] 15–19 days of paid vacation per year is the most likely range for full-time non-government workers who have been at their current job at least 5 years:

or Statistics 2020, Table 37; 10 federal holidays per year: Office of Personnel Management, https://www.opm.gov/policy-data-oversight/pay-leave/federal-holidays/#url=2020

[24] 9.7%: MWCOG 2019, pg. ii and 8.

means that, in a year, each commuter in the Washington region makes on average 426 one-way trips to the office.

Multiply the number of commuters by 426 one-way trips per year, and the result is 5.577 million one-way trips between Baltimore and Washington in 2015 by all forms of available transportation, obviously excluding the maglev because the maglev didn't exist in 2015. Multiply by the previously defined factor f_{growth} to extrapolate from 2015 to 2045. Multiply by 0.02 to convert from all modes of non-maglev transportation to the number of such trips that would be diverted to maglev were the maglev built. The result is an unofficial forecast of 147,000 one-way maglev trips made by diverted commuters in 2045. This number is stated in Table 2 of the present article.

Table 1. The official ridership forecast for the proposed Baltimore-Washington maglev as published in the January 2021 draft environmental impact statement.

	One-way maglev diverted trips in 2045	
Category of maglev traveler	Percent of diverted trips	Number of diverted trips
1. Maglev, diverted non-airport	85.5% [b]	17.595 million
2. Maglev, diverted airport customers	14.5% [b]	2.984 million
3. Maglev, diverted (non-airport + airport) [a]	100%	20.579 million
4. Maglev, diverted commuter (a subcategory of diverted non-airport customers)	25.4% [b]	5.227 million
5. Maglev, total ridership (diverted + induced) [a]	---	24.939 million

[a] Diverted and total ridership are stated explicitly in the draft impact statement: Chapter 4.2, Table 4.2-3, pg. 4.2-7. The quoted numbers are for the year 2045 if the downtown Baltimore maglev station was located at Camden Yards.

[b] Percent commuters and percent airport: Appendix D4, Table D4-19, pg. D-35. The number of one-way trips for these rows are calculated using the number of trips in row 3 (20.579 million trips) multiplied by these percentages.

Table 2. The unofficial ridership forecast for the proposed Baltimore-Washington maglev as derived in the present article.

	All modes of transportation, assuming the maglev is not built		Trips diverted to the maglev
Category of traveler	One-way trips before diversion [baseline year]	One-way trips in 2045, before diversion [d]	One-way diverted trips in 2045 [e]
1. Non-airport	6.924 million [2018] [a]	8.890 million	0.178 million
2. Airport customers	5.637 million [2019] [b]	7.170 million	0.143 million
3. Total diverted trips including non-airport and airport	---	---	0.321 million
4. Commuter (a subcategory of non-airport customers)	5.577 million [2015] [c]	7.362 million	0.147 million

[a] MWCOG Regional Travel Survey (RTS) published in 2020 using data collected in 2018. For details see Table 3 of the present article.

[b] The Maryland Aviation Administration reports 26.933 million passengers passed through Baltimore/Washington International (BWI) airport in 2019. According to the US Census data shown in Table 4 of the present article, 20.93% of the region's residents live in the District of Columbia, Arlington, Alexandra, or City of Baltimore. 5.640 = 0.2093 x 26.933.

[c] American Commuter Survey data from the Census Bureau as display in Table 5 of the present article.

[d] The scale factor f_{growth} to account for an 0.93%-per-year growth in travel in the region. The factor f_{growth} equals 1.284, 1.272, or 1.320 for a start year of 2018, 2019, or 2015 and an end year of 2045. See the equation that defines f_{growth} in the Appendix of the present article.

[e] This column is calculated by multiplying the 2045 trips before diversion by 0.02 because the present article follows the 2% proposed in Kelley (2021 May 2), "Maglev riders would come from the wealthiest 2% of the Baltimore-Washington population."

Table 3. Trips between Baltimore and Washington on a typical weekday as estimated by the Metropolitan Washington Council of Governments' Regional Travel Survey published in 2020 [a]

	Northern terminus of trip		
Direction of travel	City of Baltimore	Baltimore County	Total [b]
Northbound [c]	6,033 ± 973	3,232 ± 681	9,265 ± 1,188
Southbound [d]	6,898 ± 1,067	2,793 ± 675	9,691 ± 1,263
Total number of trips during typical weekday in 2018:			18,956 ± 1,733
Total number of trips per year in 2018 [e]:			6.924 ± 0.633 million

[a] The southern terminus of each trip is in the District of Columbia; Arlington County, Virginia; or the City of Alexandria, Virginia.

[b] The standard deviation of a sum is calculated here as the square root of the squares of the standard deviations of the individual terms of the sum: $\sigma_{x+y}^2 = (\sigma_x^2 + \sigma_y^2)^{1/2}$.

[c] Northbound trips have their northern terminus as the trip destination. The relevant RTS trip data for the core region (DC, Arlington, Alexandria) with trip terminus in Baltimore City or Baltimore County are found in the file called T09_D_STATE_COUNTY_FIPS_a and in the rows begin with "Activity Center."

[d] Southbound trips have their northern terminus as the trip origin. The relevant RTS trip data for the core region (DC, Arlington, Alexandria) with trip origin in Baltimore City or Baltimore County are found in the file called T05_O_STATE_COUNTY_FIPS_a and in rows that begin with "Activity Center."

[e] Assuming that the number of trips on a Saturday or Sunday is equal to those on a typical weekday (Monday through Friday), then an estimate of the annual number of trips can be generated by multiplying the value for a typical day by 365.25 d y^{-1}.

Table 4. The population of counties and cities in the planning areas of the Metropolitan Washington Council of Governments (MWCOG) and the Baltimore Metropolitan Council (BMC).

Location	Population [a]
Washington-area jurisdictions served by the proposed maglev [b]	1,102,019
District of Columbia	705,749
Arlington County, VA	236,842
City of Alexandria, VA	159,428
Baltimore-area jurisdictions served by the proposed maglev [b]	1,420,860
City of Baltimore, MD	593,490
Baltimore County, MD	827,370
Jurisdictions not served by the proposed maglev	5,579,749
Fairfax County, VA	1,147,532
Prince William County, VA	470,335
Loudon County, VA	413,538
Frederick County, MD	259,547
Montgomery County, MD	1,050,688
Prince George's County, MD	909,327
Carroll County, MD	168,447
Howard County, MD	325,690
Ann Arundel County, MD	579,234
Hartford County, MD	255,411
Population served by the proposed maglev for travel between Baltimore and Washington	2,522,879
Population served by the proposed maglev for travel to Baltimore/Washington International (BWI) airport [b]	1,695,509 [c]
Total population in the Baltimore-Washington region	8,102,628

[a] As of 2019 according to the US Census. Data in *.csv format: https://www2.census.gov/programs-surveys/popest/datasets/2010-2019/counties/totals/co-est2019-alldata.csv. Description: https://www.census.gov/data/datasets/time-series/demo/popest/2010s-counties-total.html.

[b] A jurisdiction is served by the maglev if the majority of its residents would save time riding the maglev rather than making the trip by car. See Kelley (2021 March 25) for details. The present article includes Baltimore County in the area served by the maglev for travel between Baltimore and Washington largely because many Baltimore County residents would save time if they used the maglev station at BWI. However, when the destination is BWI, then only the downtown Baltimore maglev station can serve as a starting point, which is too far out of their way for most Baltimore County residents to find useful.

[c] This population is 20.93% of the Baltimore-Washington region's population.

Table 5. Number of people commuting between Baltimore and Washington as estimated by the Census Bureau's American Commuter Survey (ACS) in 2015 [a]

	Job location					
	Baltimore		Washington			
Location of home	Baltimore City	Baltimore County	District of Columbia	Arlington	Alexandria	Total
Baltimore City			4,765	392	182	5,339
Baltimore County			5,120	369	247	5,736
District of Columbia	1,234	403				
Arlington	115	16				
Alexandria	231	17				
Total	1,580	436			Number of commuters:	13,091
					Number of one-way trips per year [b]:	5.577 million

[a] Data from the US Census Bureau, 2015: Table 4, Residence MCD/County to Workplace MCD/County Commuting Flows for the United States and Puerto Rico Sorted by Workplace Geography: 5-Year ACS, 2011-2015. An Excel spreadsheet for the entire country with over 594,000 rows. On the web page titled "2011–2015 5-year ACS commuting flows," https://www.census.gov/data/tables/2015/demo/metro-micro/commuting-flows-2015.html.

[b] The total number of trips is the number of commuters times 426 one-way trips per year. The number of one-way trips per year is 2 one-way trips per day of traveling to the office: $426 = 2 \cdot 0.903 \cdot 236$. The factor of 0.903 comes from the fact that Washington-region workers spend, on average, 9.7% of their days teleworking rather than traveling to their office. The 236 figure is the number of weekday in the year minus 10 federal holidays and minus 3 weeks of paid vacation (15 days): 236 = 365.25 (5/7) - (10 + 15) = 261 -25.