APPENDIX B

TPB Staff Assessment of Cambridge Systematics Report Prepared for The High Road Foundation

National Capital Region
Transportation Planning Board

MEMORANDUM

TO:	Kari Snyder, Michelle Martin, MDOT Staff
FROM:	Dusan Vuksan, COG/TPB Staff
THROUGH:	Nicole McCall, COG/TPB Staff
SUBJECT:	TPB Staff Assessment of Cambridge Systematics Report Prepared for High Road Foundation
DATE:	December 10, 2019
CC:	Heather Murphy, MDOT Staff
	Kanti Srikanth, Mark Moran, Tim Canan, COG/TPB Staff

TPB Staff Assessment of CS Report on I270 Monorail Prepared for High Road Foundation_12112019.docx

The Maryland Department of Transportation (MDOT) has requested National Capital Region Transportation Planning Board (TPB) staff assistance to assess the range of impacts of proposed monorail service in the I-270 Corridor, that could be a component of Maryland's Traffic Relief Plan (TRP). Specifically, in an October 25, 2019 email by MDOT outlining the scope of services, the TPB staff was asked to assess the technical methodology and findings of a monorail ridership analysis conducted by Cambridge Systematics, Inc. (CS) on behalf of the High Road Foundation.[1] Upon careful review of the report, TPB staff have determined that the CS modeling analysis was conducted using state-of-the-practice tools and methods used elsewhere in the region, and that the monorail ridership estimates are reasonable given the assumptions. However, the reasonableness of assumptions may need to be evaluated further given that there are very few existing similar monorail projects operating anywhere in the world at this time. The remainder of this memorandum provides more detailed observations.

BACKGROUND

MDOT is interested in examining potential impacts of monorail service in the I-270 Corridor (sometimes referred to as I-270 Monorail in this memorandum). At this time, there are two ongoing TRP-related, National Environmental Policy Act (NEPA)-related studies that are being undertaken by MDOT in the I-270 Corridor:

- I-495 & I-270 NEPA Managed Lanes Study, covering the Maryland portion of the Capital Beltway and I-270 south of I-370[2]
- I-270: I-370 to I-70 Pre-NEPA Study, covering the I-270 segment between I-370 and I-70

[1] Cambridge Systematics, "Frederick-Shady Grove Ridership and Revenue Study," Final Report, (Bethesda, MD: Cambridge Systematics prepared for High Road Foundation, Inc., March 15, 2019).
[2] Currently, recommended improvements to the Beltway terminate at Branch Avenue (MD 5), i.e., planned improvements would not include the Woodrow Wilson Bridge.

MDOT has decided to assess potential impacts of monorail not within the framework of the previous projects, but as a separate feasibility study.

As CS recently conducted a monorail study in the corridor and documented the findings in a report,[3] MDOT requested that TPB staff review the CS Final Report and provide an independent assessment of the modeling methodology and findings, which is shared in this memorandum. TPB staff's assessment of the CS Final Report includes the following key components:

- Assessment of the High Road Foundation travel demand modeling analysis and findings, conducted by Cambridge Systematics (i.e., Is the analysis acceptable/satisfactory?).
- Identification of any key assumptions with a potential for significant impact on the travel demand model results, which would need to be considered in the design and operating and capital costs, and/or factored into the understanding of the results.
- Discussion of additional analysis that may be needed.

Modeling set-ups and input files were not available for the assessment. Thus, this assessment is based solely on the information documented in the report and other sources listed in footnotes in this memo.

REPORT SUMMARY

This section contains a brief summary of the CS Final Report, which should make this technical memorandum easier to read and follow. However, it is recommended that this technical memorandum be analyzed in conjunction with the relevant section of the CS Final Report. The CS analysis used two tools: 1) the TPB's Ver. 2.3.75 Travel Demand Forecasting Model; 2) the Federal Transit Administration's Simplified Trips-on-Project Software (STOPS). The CS analysis included three years (2017, 2025, and 2045), three service levels ("Higher Service Frequency," "Base Service Frequency," and "Lower Service Frequency"), and two ways to represent the service ("Metro-like" and "LRT-like"), which resulted in a total of 18 modeled scenarios for the travel demand model (see Table 3.2 of the CS Final Report, p. 24) and nine modeled scenarios for the STOPS model.

Chapter 1: Introduction

The introductory chapter describes the service alignment, operating assumptions including service frequency, run time, and fare assumptions, which are all summarized below (pages 6-9 of the CS Final Report):

- The monorail line assumes stations along I-270, located at Shady Grove, Metropolitan Grove, Germantown, COMSAT, Urbana, and Frederick.
- The length of alignment is approximately 27 miles.
- The assumed end-to-end travel time is 31 minutes, relying on deployment of the BYD Skyrail vehicles that can develop revenue service top design speeds of 70 miles per hour, according to the CS report. It is important to note that maximum revenue service speed for Metrorail is

[3] Ibid, 1.

59 miles per hour,[4] so the assumed top speed of the monorail is 19 percent faster than Metrorail. It is also worth mentioning that the monorail is assumed to have 30-second dwell times at each station (p. 8), whereas Metrorail dwell times typically average 30 to 60 seconds.[5] Finally, although the top speeds are forecasted to be 70 miles per hour, the assumed end-to-end travel time of 31 minutes on a 27-mile long alignment indicates that an average speed of approximately 50 miles per hour was assumed in the modeling analysis, which accounts for dwell time and time needed to accelerate to and decelerate from the 70 miles per hour cruise speed.

- Service frequencies in each scenario are noted in Table 1.1 below.

Table 1.1 Hours of Operation and Frequency of Service

Day of Week and Time of Day	High Service Frequency (minutes)	Base Service Frequency (minutes)	Low Service Frequency (minutes)
Weekday			
AM Peak (5:00 AM - 9:30 AM)	3	6	6
Mid Day (9:30 AM - 3:00 PM)	10	12	15
PM Peak (3:00 PM - 7:00 PM)	3	6	6
Evening (7:00 PM - 10:00 PM)	10	12	15
Late Night (10:00 PM - 12:30 AM)	15	15	15

Source: Adapted from The High Road Foundation, Inc. Service begins with Metrorail service; ends 30 minutes after Metrorail close.

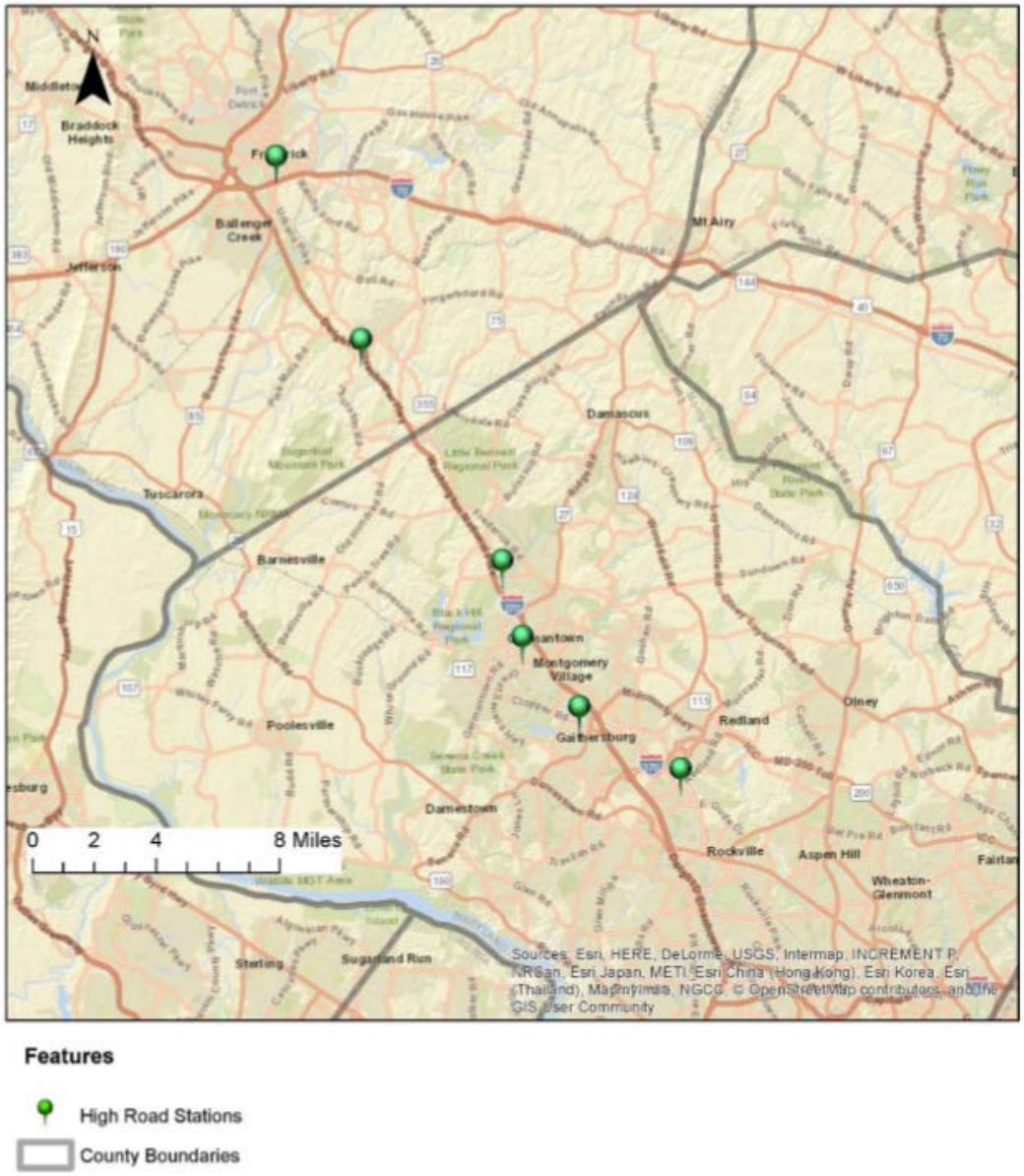
Source: CS Final Report, Table 1.1, page 8

- Fares are assumed to be comparable to Metrorail.

The report notes that "the monorail will provide direct connections with transit services into the District of Columbia and other regional destinations" (page 6). Although the service provides direct connections, these would not be one-seat rides, i.e., there would be a forced transfer at Metropolitan Grove MARC Station or Shady Grove Metrorail Station. The locations of the proposed I-270 Monorail stations are shown in Figure 1.1.

[4] Washington Metropolitan Area Transit Authority, "System Safety Program Plan" (January 2014).
[5] LTK Engineering Services, "Metrorail Capacity White Paper" (Washington, D.C.: Washington Metropolitan Area Transit Authority, November 11, 2015), 32, https://planitmetro.com/wp-content/uploads/2016/12/C3788_WMATA-Core-Capacity_20151130.pdf.

Figure 1.1 Proposed Project Station Locations



Source: The High Road Foundation, Inc.

Source: CS Final Report, Figure 1.1, page 7

Chapter 2: Ridership Forecasting Methodology

Ridership forecasting methodology is discussed in Chapter 2 of the report, including the following:

- CS used both TPB Version 2.3.75 Travel Demand Model and Federal Transit Administration's Simplified Trips-on-Project Software (STOPS) to estimate monorail demand/ridership (page 10).
- Analyzed alternatives included 2017 No-Build, 2017 Build, 2025 Build, and 2045 Build (page 11).

Chapter 3: Ridership Forecasting Using the COG/TPB Model

CS discussed the modeling inputs and methodology related to the application of the TPB Model in Chapter 3 of the report, with some of the main points summarized below:

- Transportation networks for each alternative were based on the constrained element of the Visualize 2045 Long-Range Transportation Plan, which includes Traffic Relief Plan elements on I-270 and I-495, and future BRT routes in the corridor (page 12).
- Demographic data inputs were based on Round 9.1 Cooperative Forecasts (page 16).
- Base-year model validation against observed ridership data was found to be acceptable with respect to the combined MARC Brunswick Line (commuter rail) and Shady Grove Metrorail station boardings (pages 21 and 22).
- CS discussed the uncertainty regarding estimating transit ridership for a new mode, and different ways to represent monorail in the model – with Metro-Like "unincluded attributes" for an upper bound estimate and light rail (LRT) attractiveness (LRT-Like) for a lower bound estimate (page 23). Travel time was not varied in these scenarios. Thus, the variation between these two scenarios comes from the way that Metrorail and LRT are treated in transit path-building and mode choice.
- Average weekday and annual ridership estimates, along with associated system revenues, are reported in Sections 3.3 and 3.4. Notably, daily (average weekday) ridership ranges from 27,300 riders in Lower Service Frequency LRT-Like scenario in 2017 to 55,100 riders in the Higher Service Frequency Metro-Like scenario in 2045 (Table 3.2 on page 24).
- CS conducted additional sensitivity testing with respect to fares and noted that a 20 percent increase in fare resulted in a 5 percent decrease in ridership. The magnitude of these two changes comports with expectations, since the demand for transit service has typically been found to be price inelastic.

Chapter 4: Ridership Forecasting Using STOPS

The report documents the ridership forecasting analysis using STOPS in Chapter 4. STOPS, or Simplified Trips-on-Project Software, is a simplified modeling tool developed by the Federal Transit Administration (FTA) for development of forecasts associated with New Starts and Small Starts project applicants for FTA's discretionary funding program known as Capital Investment Grants (CIG). A brief summary of key takeaways from this section is provided bellow:

- Transit networks were developed based on General Transit Feed Specification (GTFS) data (page 34).
- Demographic data inputs were based on Round 9.1 Cooperative Forecasts (page 33).
- Regional auto travel times, which is a key STOPS input, are based on the Version 2.3.75 Model travel times (current TPB model).
- Other STOPS inputs and parameters, including project visibility factor and station group calibration, are discussed as well.
- Base-year model validation against observed ridership data was found to be acceptable in the corridor (pages 36 and 37).
- Average weekday ridership estimated using STOPS is reported in Section 4.4. Notably, daily (average weekday) ridership ranges from **27,700** riders in Lower Service Frequency scenario in 2017 to **47,600** riders in the Higher Service Frequency scenario in 2045 (Tables 4.3, 4.4 and 4.5 on pages 38 and 39), which is comparable to the estimates obtained from the regional travel demand model.

Chapter 5: Findings

The main CS ridership analysis findings are documented in Chapter 5, and they are summarized below (pages 40-41):

- Higher service frequency Metro-Like scenarios generate the highest ridership forecasts.
- The Metro-Like scenarios generate higher forecasts than similar LRT-Like scenarios.
- Ridership is estimated to increase by 40 percent between the base year (2017) and horizon year (2045) due to the increases in population and employment, and changes in transportation networks.
- Shady Grove and Frederick stations are predicted to have the highest ridership.
- The forecasts in the report were generated using third-party information and high-level assumptions, with possibilities for refinement in future studies.

REPORT ASSESSMENT

Modeling Methodology

Providing a feasibility assessment for a "new mode" in any region can be challenging. But evaluating a long-haul, commuter mode that is both new to this region and found very infrequently in the United States adds another layer of uncertainty. TPB staff's assessment of the report is based on evaluating the ridership estimates based on what is typically prepared for a "feasibility study," and not for a full NEPA project. Overall, CS employed a reasonable approach to produce a range of forecasts for I-270 Monorail using, as noted earlier, two different distinct tools:

- Regional Travel Demand Model (TPB Version 2.3.75 Model)
- FTA's STOPS model.

The regional modeling approach was in line with other similar projects, relying on the most recent planning assumptions and modeling tools, which include the transportation networks based on the constrained element of Visualize 2045, Round 9.1 Cooperative Forecasts, and Version 2.3.75 Travel Demand Model. Based on the CS report, it does not appear that there were any changes made to any of the baseline network or land use input assumptions in the No-Build and Build alternatives.

Furthermore, CS modeled a range of scenarios for 2017, 2025 and 2045 analysis years, including different assumptions related to frequency and mode attractiveness. In total, 18 scenarios were modeled using TPB's travel demand model and nine scenarios were modeled using FTA's STOPS model. Additional sensitivity tests were also conducted (e.g., with respect to fares).

TPB staff find the modeling methodology acceptable for a feasibility study. Given the assumed monorail speeds and the monorail service frequencies that were comparable to Metrorail's, TPB staff also find the reported range of ridership values are reasonable (27,000 to 55,000 average weekday riders, depending on the modeling tool, analysis year and service frequency).

Study Assumptions with Significant Impact on Ridership

The average weekday monorail ridership estimates prepared by CS, ranging between 27,000 and 55,000, are of the same order of magnitude as the entire three-line MARC system ridership in 2016, which amounted to approximately 34,000 riders on an average weekday.[6] Given the vast coverage of the MARC system that connects Washington, Baltimore, Frederick and West Virginia, it is important to identify why a single monorail line with only six stations is predicted to have similar or greater ridership than an entire commuter rail system.

Monorail Service Speeds

TPB staff note that the assumed monorail speeds are the primary driver of reported I-270 Monorail ridership estimates. Average monorail speeds are assumed to be approximately 50 miles per hour including dwell times, with 70 miles per hour top speeds, resulting in travel times of 31 minutes between Frederick and Shady Grove. Therefore, I-270 Monorail is assumed to have faster speeds than any other transit service in the metropolitan Washington region, resulting in competitive travel times, especially in 2045, when vehicle-hours of delay are expected to increase in the TPB Planning Region by 46% relative to today.[7] As a point of comparison, travel times on MARC between Frederick and Metropolitan Grove are approximately 50 minutes today.[8] It would take only 26 minutes to complete the same trip on I-270 Monorail (page 9).

Based on the proposed station-to-station segment distances and simplified calculations derived from acceleration and deceleration rates of other monorail systems in the U.S., TPB staff have found that top operational speeds of 70 miles per hour and corresponding average speeds of 50 miles per hour

---

[6] https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/regulations-and-guidance/safety/60631/maryland-transit-administration-mta-introduction.pdf

[7] National Capital Region Transportation Planning Board, "Visualize 2045 , A Long-Range Transportation Plan for the National Capital Region" (Washington, D.C.: October 17, 2019), https://www.mwcog.org/assets/1/6/Final_Visualize_2045_-_Chapter_5.pdf

[8] https://www.mta.maryland.gov/schedule/timetable/marc-brunswick

are theoretically achievable for this service.[9] At the same time, based on limited research, TPB staff have not found other currently operational BYD Skyrail systems that reach top speeds of 70 miles per hour. However, existing BYD Skyrail and other monorail lines typically differ in character from the proposed I-270 Monorail in that they generally feature shorter link lengths with more stations, thus making it more challenging to develop and maintain high operational speeds. For example, Shenzhen Monorail in China currently includes seven stations across 2.7 miles, with top operational speeds listed at 50 miles per hour.[10] I-270 Monorail, in contrast, is proposed to feature six stations over 27 miles with its shortest segment (about 3 miles) likely longer than the entire length of the Shenzhen line.

Finally, building a system that can maintain such high speeds may have an impact on capital and design costs.

Service Frequencies

Service frequencies comparable to Metrorail also play a significant role in ridership estimates, as other non-Metrorail transit services in the corridor generally operate at lower frequencies (e.g., MARC). Six-minute peak period frequencies modeled in Base Service scenario are comparable to some of the Metrorail routes, including the nearby Red Line. Frequent off-peak service (12 minutes in mid-day and 15 minutes at night in the Base Service scenario), also comparable to Red Line, makes I-270 Monorail a desirable system not only in the peak period but also throughout the day. High service frequencies would certainly need to be considered in capital and operating cost calculations.

Park-and-Ride Lot Access

While walking to monorail would be an option for a limited number of riders, the system users would likely resemble the current commuter rail market, which relies heavily on park-and-ride lot access to the transit system. Although some stations are clearly located near existing park-and-ride lots (e.g., Shady Grove and Frederick), it is unclear from the report whether each monorail station was assumed to have a park-and-ride lot located nearby. Given the projected monorail ridership levels, new and expanded park-and-ride lots and/or extensive network of feeder bus service along the corridor would be necessary to support these ridership levels. Park-and-ride lot expansion/construction or addition of feeder bus service would increase capital and operating costs.

Unobserved Attributes

When developing a logit mode choice model, such as the one that is used in the Version 2.3.75 Model, some travel characteristics are represented **explicitly** (such as travel time and cost) and others (such as comfort, reliability, and convenience) are represented **implicitly** within the mode choice model. The implicitly included travel characteristics are known as “unincluded attributes” or “unobserved attributes.” As discussed in the report, system attractiveness related to “unincluded attributes” has an impact on ridership, with “Metro-Like” attractiveness resulting in higher ridership estimates than “LRT-Like” attractiveness (pages 23 and 24). It is reasonable that CS developed a range of forecasts within the existing framework of TPB’s travel demand model. “Metro-Like”

---

[9] Of course, the actual alignment of the tracks, can also influence speeds: Too much curvature will result in lower speeds. But this type of assessment requires an engineering analysis, which is beyond the scope of the TPB staff review.

[10] https://sg.byd.com/wp-content/uploads/2017/11/SkyRail%20Brochure.pdf

attractiveness was used to assume that the monorail would have unincluded attributes like Metrorail (e.g., reliability and convenience). By contrast, "LRT-like" attractiveness was used to assume that the monorail would have unincluded attributes like LRT, such as reduced perceptions of ride quality, comfort, and reliability. Therefore, the "Metro-Like" scenarios provide an upper bound for monorail ridership estimates, and "LRT-Like" scenarios provide a lower bound. It is the understanding of TPB staff that no changes were made to the model itself.

Additional Analysis

TPB staff believes that additional analysis, provided below, could be useful in assessing the impacts of monorail service in the corridor. Given that CS conducted a ridership analysis intended to provide an order-of-magnitude assessment on a limited budget,[11] it would have been challenging for CS or any other agency to conduct further analysis described in this section of the memorandum without additional funding. In fact, development of enhanced models comparable to MDOT's project development activities related to the Purple Line[12] may be required to successfully accomplish some of the recommended tasks, especially those pertaining to trip distribution validation.

New Transit Trips / Riders

It would be beneficial to conduct both No-Build and Build model runs for 2025 and 2045, as the report does not indicate that 2025 No-Build and 2045 No-Build runs were undertaken. That way, in addition to providing ridership estimates for I-270 Monorail, the number of new transit riders or trips could be estimated for all three analysis years (this number could be estimated for 2017, as both 2017 No-Build and Build scenarios were modeled). While the report includes some brief discussion of monorail impacts on certain MARC stations, it could be beneficial to evaluate ridership impacts of the new monorail line on the entire MARC Brunswick line.

Trip Distribution Validation

In addition to validating transit ridership to individual lines or station/line groupings, it could be advisable to validate the trip distribution in the corridor. In other words, how well does the model represent person-trip movement for the specific origins and destinations that would be served by the I-270 Monorail? What are the travel markets in the corridor?

Impact on Vehicle Hours of Delay (Congestion)

Although new transit services are often introduced to provide additional travel options for residents, it would still be beneficial to examine whether the new monorail service has any impact on vehicle-hours of delay (VHD) for the roadways in the corridor.

Additional STOPS Model Calibration

Even though they are technically not required, development of local inputs that rely on more recent local on-board surveys as opposed to national defaults would be beneficial in STOPS model calibration and subsequent estimates. TPB staff are aware that this would require additional funding

---

[11] https://www.washingtonpost.com/local/trafficandcommuting/a-montgomery-developer-has-a-plan-to-ease-traffic-on-i-270-build-a-monorail/2019/05/18/fc89372a-7724-11e9-b3f5-5673edf2d127_story.html

[12] MTA Maryland, "Purple Line Travel Forecasts Results Technical Report," (Baltimore, MD: August 2013).

for data collection. Similarly, if it was not already performed, further calibration of zone-to-zone auto travel times (or "skims") from the regional travel demand model would improve the STOPS model accuracy.

OVERALL FINDINGS

Upon detailed review of the report, TPB staff have determined that the CS modeling analysis was conducted using state-of-the-practice tools and methods used elsewhere in the region, and that the monorail ridership estimates are reasonable given the model input assumptions. However, the reasonableness of assumptions may need to be evaluated further given that there are very few existing similar monorail projects operating anywhere in the world at this time. It is also important to note that these findings are based on transportation networks that already include a number of projects in the corridor, including managed lanes on I-270 and Corridor Cities Transitway BRT.

This COG/TPB assessment is based on the "feasibility study" methods and criteria, which are typically associated with minimal revisions to model inputs and forecasting tools. I-270 Monorail ridership forecasts are primarily driven by fast monorail speeds, service frequencies, and system attractiveness. Therefore, if the assumed end-to-end transit times and service frequencies could not be realized, monorail ridership estimates would decline.