APPENDIX B
TRANSPORTATION MODELING AND MEASURES OF EFFECTIVENESS METHODOLOGY
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MARYLAND TRANSIT ADMINISTRATION

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TRANSPORTATION MODELING

The Baltimore Metropolitan Council (BMC) has developed an Activity-Based Model called Initiative to Simulate Individual Travel Events (InSITE). This model predicts individuals' choices, daily activity patterns, and travel in the region. These predictions allow the project team to understand individual mode choice, trip travel times, origins, destinations, and more. The project team made modifications to BMC's year 2045 version of the InSITE model to simulate the impacts of seven (7) East-West corridor alternatives on individuals' mode choice and travel behaviors. The model aims to simulate behavior of persons; in this model, the introduction of a new transit line or the change to a transit line's frequency or span can influence a simulated persons' decisions such as where they work.

To modify the model for each alternative, the project team worked with BMC's modelers to build each new corridor alternative transit route(s) into the network. BRT corridor transit alternatives travel times used existing road travel speeds plus improvements based on the type of treatment applied along each segment of the BRT, (e.g., dedicated bus lanes). LRT and HRT corridor transit alternative travel times used industry standards to determine speeds based on the type of treatment (e.g., tunnel or at grade dedicated right-of-way). Previous MDOT MTA rail studies and existing MDOT MTA LRT and Metro Subway speeds also informed travel time for rail modes.

Additionally, if a road segment was proposed to have a travel lane repurposed for exclusive-transit use, this was also modified in the model's road network. Existing transit routes which duplicated a corridor alternative transit route were also reviewed and modified These efforts were meant to realistically simulate what the underlying road and local transit network would look like if a corridor alternative was implemented. All assumptions made during this feasibility study are preliminary in nature and would be further evaluated and adjusted through coordination with stakeholders as the project advances.

While the project team worked to adjust the model to best represent the proposed future conditions of each alternative, there are limitations to the precision of the model and the adjustments that could be made at this stage of study. For example, at this stage of study, the project team must use assumptions about travel speeds because it is not feasible to complete precise engineering within the time allotted for this study. Likewise, the model does not account for transportation network influences on a person's home location choice; in reality, a transportation network may be a significant factor in location choices. Even given the limitations of any modeling effort, it is possible to reliably use results for comparison between multiple alternatives modeled using the same software and assumptions. However, it is not advisable to compare the results of this modeling effort to those of another modeling effort, as different assumptions and modeling methods could have been used.

MEASURES OF EFFECTIVENESS METHODOLOGY

The following sections provide the research question the project team aimed to answer, describes the measure and explains the method for calculating the measure.

Goal 1: Improve the connectivity and operations of the existing transit network

Reliability

How much of the alignment is separated from traffic?
Measure: Percent of the alignment in dedicated or separated guideway

Method: Each alignment was divided into segments by treatment. The length of segments in a tunnel, on an elevated structure, on a transit street, on a track separated from traffic lanes, or in a dedicated bus lane was summed and then divided by the alternative's total length.

Does the Alternative provide a fixed or flexible guideway?
Measure: Which type of guideway does the alternative provide, fixed or flexible.

Method: Each alternative and mode was evaluated to determine if the guideway was fixed or flexible. BRT provide a flexible guideway because a bus can detour or move around obstacles or incidents. Rail modes on the other hand have a fixed guideway from which the transit vehicle cannot move.

System Travel Savings

What are the potential travel time savings compared to existing transit service?
Measure: Average travel time savings for transit riders living in the corridor (minutes per trip)

Method: The TAZs within a ½ mile buffer of each alternative are identified (using stations only). Transit trips whose riders live within the identified TAZs are considered. For each alternative, the average total transit travel time of these trips is compared to that of the baseline 2045 no-build scenario. Additionally, the trips are further analyzed for different population groups to evaluate transit travel time savings for vulnerable populations (low-income and minority).

Transit travel time includes walk/drive time to a station, wait time, and in-vehicle time. Arithmetic mean is used to control the impact of transit ridership. One caveat of this method is the inclusion of transit trips whose travel times are not affected by the alternative; therefore, the reported results are a lower bound or an underestimation of potential average total transit travel times savings.

Source: BMC activity-based model

Travel Time

What is the estimated transit travel time between West Baltimore and Hopkins Bayview?
Measure: Total transit travel time (minutes) between West Baltimore and Hopkins Bayview

Method: A key OD pair was identified, and the average total transit time of the OD pairs is reported for each alternative and the baseline 2045 no-build scenario. Transit travel time includes walk/drive time to a station, wait time and in vehicle time.

Source: BMC activity-based model

Goal 2: Expand the reach and connectivity of the regional transit network

Ridership

How many people will use it?
Measure: Total Daily Ridership (per mile)

Method: Using the outputs from the BMC activity-based model, total boardings were aggregated for the alternative service. Boardings are estimated in the model based on the inputs given for each household and their likely travel decisions. The model is calibrated using 2019 MDOT MTA ridership.

Source: BMC activity-based model

Connections

What connections can be made to existing transit in the region?
Measure: Total number of connections to rail, frequent bus routes, and locally operated transit

Method: Each alternative's stations were buffered. MDOT MTA Light Rail, Metro Subway, MARC stations within the buffer or connected by underground walkway were identified. MDOT MTA Core Bus routes with frequent service within the buffer were identified. Locally operated transit routes within the buffer were also identified. These three types of connections were then summed.

Source: MDOT MTA, Charm City Circulator, and Regional Transit Agency of Central Maryland GTFS feeds; MDOT MTA System Map

Access

How many households will have access?
Measure: Number of households within 1/2 mile of a transit station (per mile)

Method: Each alternative station was buffered ½ mile (as the crow flies) to represent the corridor's walkable access area. The existing households within the station buffers were summed. Additionally, the total number of households within the accessible distance to the alternative service was divided by the total length in miles of the alternative to control for length.

Source: ACS 2015-2019 5 Year Estimates

How many students will have access?
Measure: Count of student population within 1/2 mile of a transit station (per mile)

Method: Each alternative station was buffered ½ mile (as the crow flies) to represent the corridor's walkable access area. The existing student populations within the station buffers were summed. Students were defined as those aged 5-17. Additionally, the total number of students living within the accessible distance to the alternative service was divided by the total length in miles of the alternative to control for length.

Source: ACS 2015-2019 5 Year Estimates

How many jobs will it access?
Measure: Future jobs within ½ mile of stations (per mile)

Method: First, each alternative's service area was defined as the TAZs within a ½ mile buffer of each alternative station. For each TAZ, and for both the baseline 2045 no-build scenario and for the alternative scenario, the total number of jobs accessible within 45 minutes (via transit) was found along with the total number of persons living within the TAZ. Next, the average number of jobs accessible within 45 minutes (via transit) for a person living in the service area was calculated using a weighted average based on the number of residents in each TAZ. Transit travel time includes walk/drive time to a station, wait time and in vehicle time. The 45-minute threshold included all of these factors.

Source: BMC activity-based model

Goal 3: Prioritize the needs of existing transit riders and transit critical populations

Equity

How many low-income people will have access?
Measure: Low-income population within 1/2 mile of a transit station (per mile)

Method: Each alternative station was buffered ½ mile (as the crow flies) to represent the corridor's walkable access area. The existing low-income populations within the station buffers were summed. Additionally, the total number of low-income persons living within the accessible distance to the alternative service was divided by the total length in miles of the alternative to control for length. Low-income designation was defined as less than 150% of the federal poverty level.

Source: ACS 2015-2019 5 Year Estimates

How many racial and ethnic minorities will have access?
Measure: Number of minority communities within 1/2 mile of a transit station (per mile)

Method: Each alternative station was buffered ½ mile (as the crow flies) to represent the corridor's walkable access area. The existing minority populations within the station buffers were summed. Additionally, the total number of minority persons living within the accessible distance to the alternative service was divided by the total length in miles of the alternative to control for length. Minority populations consisted of any person who was not identified as White Non-Hispanic.

Source: ACS 2015-2019 5 Year Estimates

How many households with no car will have access?
Measure: Number of zero car households within 1/2 mile of a transit station (per mile)

Method: Each alternative station was buffered ½ mile (as the crow flies) to represent the corridor's walkable access area. The existing zero-car households within the station buffers were summed. Additionally, the total number of zero-car households within the accessible distance to the alternative service was divided by the total length in miles of the alternative to control for length.

Source: ACS 2015-2019 5 Year Estimates

How many Limited English Proficiency (LEP) people will have access?
Measure: Count of LEP population within 1/2 mile of a transit station (per mile)

Method: Each alternative station was buffered ½ mile (as the crow flies) to represent the corridor's walkable access area. The existing LEP populations within the station buffers were summed. Additionally, the total number of LEP persons living within the accessible distance to the alternative service was divided by the total length in miles of the alternative to control for length.

Source: ACS 2015-2019 5 Year Estimates

How many older adults will have access?
Measure: Number of adults aged 65 and older within 1/2 mile of a transit station (per mile)

Method: Each alternative station was buffered ½ mile (as the crow flies) to represent the corridor's walkable access area. The existing senior populations (adults 65 years or older) within the station buffers were summed. Additionally, the total number of seniors living within the accessible distance to the alternative service was divided by the total length in miles of the alternative to control for length.

Source: ACS 2015-2019 5 Year Estimates

How many people with disabilities will have access?
Measure: Count of disabled population within 1/2 mile of a transit station (per mile)

Method: Each alternative station was buffered ½ mile (as the crow flies) to represent the corridor's walkable access area. The existing disabled populations within the station buffers were summed. Additionally, the total number of people with a disability living within the accessible distance to the alternative service was divided by the total length in miles of the alternative to control for length.

Source: ACS 2015-2019 5 Year Estimates

Goal 4: Maximize the economic and environmental benefit of a major transit investment

Sustainability

How many driving trips would be shifted to transit trips?
Measure: Net trips shifted to transit

Method: The TAZs within a ½ mile buffer of each alternative are identified. The total number of transit trips for those living within the identified TAZs for each alternative is compared to that of the baseline 2045 no-build scenario. The difference, which is the net number of trips who shifted to transit, is reported for each alternative.

Source: Output of the BMC activity-based model

Capital Cost

How much will it cost to design and construct?
Measure: Capital costs (total)

Method: Planning-level cost estimates were developed for the seven alternatives evaluated. Given the limited level of detail available associated with a feasibility study and the uncertainty of the final transitway configuration, estimates were established on a per-mile basis and include large contingencies. Due to higher than typical inflation and quickly escalating construction costs experienced in the transit industry in 2020 and 2021, an additional contingency factor was added to the estimates. The capital cost estimates produced by this feasibility study should not be characterized as a bottoms-up engineering estimate and should not be utilized for programming purposes. These estimates are intended to provide order of magnitude comparisons between the alternatives.

Capital costs estimates are based on generalized typical sections and per-mile cost estimates derived from local projects including the Red Line and BRT projects in the State of Maryland. Each alternative was divided into segments by the treatment (e.g., Median BRT; Surface LRT) and the per-mile costs were applied. Table 1 lists the typical sections and cost sources for each. Generalized transit station costs were added according to assumptions of mode and elevation (e.g., surface; tunnel).

Sources:

Table 1: Typical Section Cost Sources

Typical Section	Cost Source
Curb BRT	MDOT SHA Cost Manual / historical planning level costs from other projects in Baltimore City

Median BRT	MDOT SHA Cost Manual
Elevated LRT	MDOT MTA Baltimore Red Line Monthly Cost Reports (inflated to 2021 dollars)
Elevated HRT	Eno Transit Cost Database, 2021
Mixed Traffic	MDOT SHA Cost Manual
Surface LRT	MDOT MTA Baltimore Red Line Monthly Cost Reports (inflated to 2021 dollars)
Surface HRT	Eno Transit Cost Database, 2021
Transit Street	MDOT SHA Cost Manual
Tunnel LRT	MDOT MTA Baltimore Red Line Monthly Cost Reports (inflated to 2021 dollars)
Tunnel HRT	Eno Transit Cost Database, 2021

Roadway improvements costs associated with widening, resurfacing, striping, signing, marking, signals, sidewalks, medians, etc. were included in the per-mile cost estimates utilizing the MDOT SHA 2020 Cost Estimate Manual unit costs and methodology and cost information from other transit projects in Baltimore City. Non-construction costs that could not be itemized such as design, facilities support services, administrative/overhead, were estimated as percentages of total construction, utilizing local projects as references.

Common Construction Items

The following general assumptions were applied to cost estimates for all alternatives:

- Typical sections that include bicycle and pedestrian accommodations
- Traffic signals would be upgraded through surface typical sections.
- Existing roadway travel lanes would be resurfaced, unless assumed as reconstructed as part of the improvement
- Station costs for LRT, BRT, and HRT stations (surface, tunnel, elevated) were derived from Baltimore Red Line and MD 355 BRT cost estimates.

Non-Construction Costs

The cost estimates include the following non-construction items:

- Contingency: These estimates are based on per-mile cost assumptions and do not rely on any engineering design, mapping, or field review. High contingencies were utilized to reflect the level of detail associated with this phase of the project. Furthermore, an additional contingency factor was utilized to account for a high inflation index in late 2021 and higher than expected construction bids in the industry.
- Administrative/overhead costs: 15.3% for major projects per MDOT SHA Manual
- Preliminary engineering, final design, and other professional services: derived from the Baltimore Red Line cost estimate and replicated for all alternatives as a percentage of total construction cost.
- LRT and BRT lump sum costs for facilities are included and derived from the Baltimore Red Line and regional bus and BRT projects.
- Vehicles costs are based on the number of vehicles required for the proposed service plan. Market price for zero emissions transit vehicles is assumed.

How much will it cost to operate and maintain?

Measure: Annual operating & maintenance costs

Method: For BRT costs, operations and maintenance costs were based on estimated revenue hours for the BRT alternative multiplied by MDOT MTA's fiscal year 2022 hourly cost: $69.34. This was added to the total mileage cost which was calculated as the revenue miles for the BRT alternative multiplied by MDOT MTA's fiscal year 2022 per mile cost: $4.21. Vehicle costs were included in capital cost calculations.

For LRT costs, MDOT MTA Light Rail actual operating and maintenance costs were attributed to either revenue hours, revenue miles, peak vehicles, or track miles as appropriate for each cost line item. The total costs were divided by the actual revenue hours, revenue miles, peak vehicles, and track miles to obtain unit costs, which were inflated to 2021 dollars. These unit costs were multiplied by the LRT alternative's revenue hours, revenue miles, peak vehicles, and track miles and then summed. An annual estimate of the cost to operate and maintain an underground station was taken from the Baltimore Red Line studies, inflated to 2021 dollars, multiplied by the number of stations in tunnel segments, and added to the total cost. For HRT costs, the same methodology was applied but using actual MDOT MTA Metro Subway costs and service data.

Sources: National Transit Database 2019, Baltimore Red Line DEIS Operating & Maintenance Cost Technical Report

Implementation- Time

How long will it take to plan, design, and construct?

Measure: Total estimated years

Method: Implementation was divided into NEPA approval, final design, and construction phases. The NEPA process is estimated to take 2-3 years regardless of mode. Final design is estimated to take 2 years for BRT and 3 years for rail. Construction is estimated to take 2-3 years for BRT, 3-4 years for LRT, and 5-6 years for HRT. The estimates for all phases were summed, then one year was subtracted for alternatives in the Baltimore Red Line corridor.

Implementation - Tunneling Complexity

What is the tunneling complexity for the alternative?

Measure: High, Medium risk or not applicable (N/A)

Method: Each alternative was reviewed for length of tunneling required to construct. Tunnel construction could result in a higher risk to the project by increasing the implementation time and cost of the project.