

CHARLOTTESVILLE-ALBEMARLE MPO PERFORMANCE-BASED PLANNING PROCESS



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Process for Identification of Needs and Process for Project Prioritization

ACKNOWLEDGMENTS

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ABOUT GAP-TA

Visit vtrans.org/about/GAP-TA for information about the Growth and Accessibility Planning Technical Assistance program. OIPI will provide a blurb describing the GAP-TA program

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GLOSSARY OR LIST OF ACRONYMS

| | |
|-------|--|
| CTB | Commonwealth Transportation Board |
| DRPT | Department of Rail and Public Transportation |
| EEA | Equity Emphasis Area |
| GAP | Growth and Accessibility Program |
| GIS | Geographic Information System |
| L RTP | Long Range Transportation Plan |
| MPO | Metropolitan Planning Organization |
| OIPI | Office of Intermodal Planning and Investment |
| PDC | Planning District Commission |
| TDM | Travel Demand Management |
| VDOT | Virginia Department of Transportation |
| VEDP | Virginia Economic Development Partnership |
| CMAQ | Congestion Mitigation and Air Quality |
| RSTP | Regional Surface Transportation Program |
| PSI | Potential for Safety Improvement |
| EPDO | Equivalent Property Damage Only |

1 - INTRODUCTION

In 2021, the Charlottesville-Albemarle Metropolitan Planning Organization (CAMPO) was awarded a grant through the Virginia Office of Intermodal Planning and Investment (OIP) Growth and Accessibility Planning (GAP) Technical Assistance program to develop a performance-based planning process that identifies transportation needs and prioritizes transportation projects for its Long Range Transportation Plan. Additionally, this process is intended to be managed and maintained over time within the constraints of CAMPO's limited staffing resources. The process resulting from this study is transparent, repeatable, and flexible to accommodate additional measures, new or updated data sources, and alternative analysis parameters, such as needs thresholds and weighting schemes. This data-driven performance-based planning process includes two parts:

1. Process for the Identification of Transportation Needs – This process involves a system evaluation of needs based on performance measures that address goals and objectives in the CAMPO's long range plan including safety, access and equity, mobility and system efficiency, and economic development.
2. Process for the Prioritization of Transportation Projects – This process involves a project-level evaluation of the benefits and costs associated with projects. Project benefits are evaluated based on each project's expected improvements related to safety, accessibility, congestion mitigation, environmental impacts, and economic development. While the prioritization of transportation projects is closely related to the identification of needs and there is a common set of metrics used by both, the analytical processes and combinations of metrics may differ between project prioritization and needs analyses. For example, an important difference is that while needs analysis focuses on existing or forecasted system-level conditions, project prioritization considers a particular project's impacts in its specific location.

This report is divided into four chapters, including this introduction explaining the purpose and organization of the report. Chapter 2 starts by outlining the dimensions of transportation needs indicated in CAMPO's policies and ongoing planning activities. These inform the metrics included in the needs analysis and project prioritization processes. As CAMPO's policies evolve, the performance-based planning process can be updated, extended, or modified accordingly. In addition to presenting the overall process for identifying transportation needs, Chapter 3 discusses the methodologies applied to evaluating needs for each performance measure and the steps for weighting and aggregating across need categories. Chapter 4 presents the process for the prioritization of transportation projects, including the methodologies for evaluating the benefits of all surface transportation improvements, including

highway and roadway, transit, active transportation (i.e., bicycle and pedestrian), and transportation demand management (TDM) projects. Chapter 4 also presents the methodology for normalizing benefit scores across measures, assessing the costs of projects, and developing a single project score that can be used to rank projects across project types. These methodologies were tested on a variety of project types including roadway widenings, bicycle and pedestrian improvements, and transit projects.

2 - CAMPO'S PLANNING PRIORITIES

Through coordination with CAMPO staff and the CAMPO Technical Committee, the technical work group developed metrics that focus on five need categories: Safety, Accessibility and Equity, Mobility and System Efficiency, Environment, and Economic Development. These five need categories align with CAMPO's 2045 Long Range Transportation Plan (LRTP) vision, goals, and objectives while providing sufficient nuance in supportive measures to evaluate a project's competitiveness for a variety of funding opportunities including SMART SCALE, Congestion Mitigation and Air Quality (CMAQ), and the Regional Surface Transportation Program (RSTP).

The five need categories include:

Safety –the aim of the safety category is to identify intersections and segments where safety improvements are needed and prioritize projects that can reduce crashes and/or exposure to risk.

Accessibility and Equity – the aim of the accessibility and equity category is to identify areas where the design and/or performance of the transportation system degrades travelers' ability to reach key destinations, like jobs, especially for disadvantaged users; and prioritize projects that are likely to enhance accessibility through improved connectivity, reduction in delay, more frequent transit services, and/or improved bicycle and pedestrian facilities.

Mobility and System Efficiency – the aim of the mobility and system efficiency category is to identify segments where congestion-related delay degrades travel time and travel time reliability for automobiles and transit vehicles and to prioritize projects that will alleviate delay and/or enhance person throughput throughout the region. This category also includes a measure which considers the on-time performance of the bus system.

Environmental – the aim of the environmental category is to identify resiliency needs, especially where infrastructure is exposed to inland flooding and to prioritize projects that pose no environmental impacts, mitigate impacts, or offer environmental services.

Land Use and Economic Development – the aim of the land use and economic development category is to identify areas where there is access to non-work destinations to stimulate local economic activity or to create transportation choices for disadvantaged people and to prioritize projects that connect to areas of local economic development activity.

The technical team for the study conducted an internal capacity assessment to establish the technologies and staff capabilities available to CAMPO for the implementation and maintenance of this process in diverse planning applications. That assessment is summarized in detail in Appendix A. It informed the development of the needs analysis and project prioritization processes by focusing on measures that are supported by readily available data and

implementable in commonly used software, like Microsoft Excel or ArcMap, with no specialized expertise required. The measures described in the remaining chapters of this report are, therefore, accompanied by step-by-step instructions for their production in the appropriate software.

3 – PROCESS FOR THE IDENTIFICATION OF NEEDS

A critical component of the transportation planning process is the identification of needs for future transportation improvements. Traditional needs assessments have focused on evaluating highway system performance including standard infrastructure condition deficiencies, crash hot spots, and network operational performance. Needs analysis methods have relied on these performance measures due to inadequate data for transit and active transportation modes. This process expands the needs analysis to consider transit and active transportation as part of a holistic multimodal needs assessment.

Figure 1 illustrates the general process for the identification of needs. The first step of this process is establishing the need categories and performance measures that align the scoring factors with the MPO’s goals and objectives. The needs addressed in the process developed for this study are organized into the planning priorities described above. A total of 11 performance measures are defined with each measure assigned to one of the four factors, meaning some factors are defined by combinations of several metrics. For example, safety needs are identified through three metrics: PSI ranking, EPDO crash frequency, and pedestrian safety. The confluence of PSI segments and segments with high crash density and segments with high pedestrian safety priorities will have the highest overall safety need.

The first part of step two is the identification of needs. This step screens the full street network to determine segments that are eligible for scoring. Eligibility is determined by using one of the two threshold options discussed in the following sections within each need category. After eligibility is determined, raw scores are calculated for all performance measures within each need category. The specific steps in calculating metrics are often complex, involving multiple input datasets, spatial analysis, computation, summarization, etc. When describing the metrics used in the needs analysis and project prioritization processes, follow the step-by-step instructions for transparency and replicability. However, most metrics can also be processed using automated procedures developed for this study, usually in custom geoprocessors that can be run in ArcGIS or Microsoft Excel spreadsheet tools. Table 1 illustrates a roles and responsibility matrix that indicates agencies that are responsible for different elements of the process.

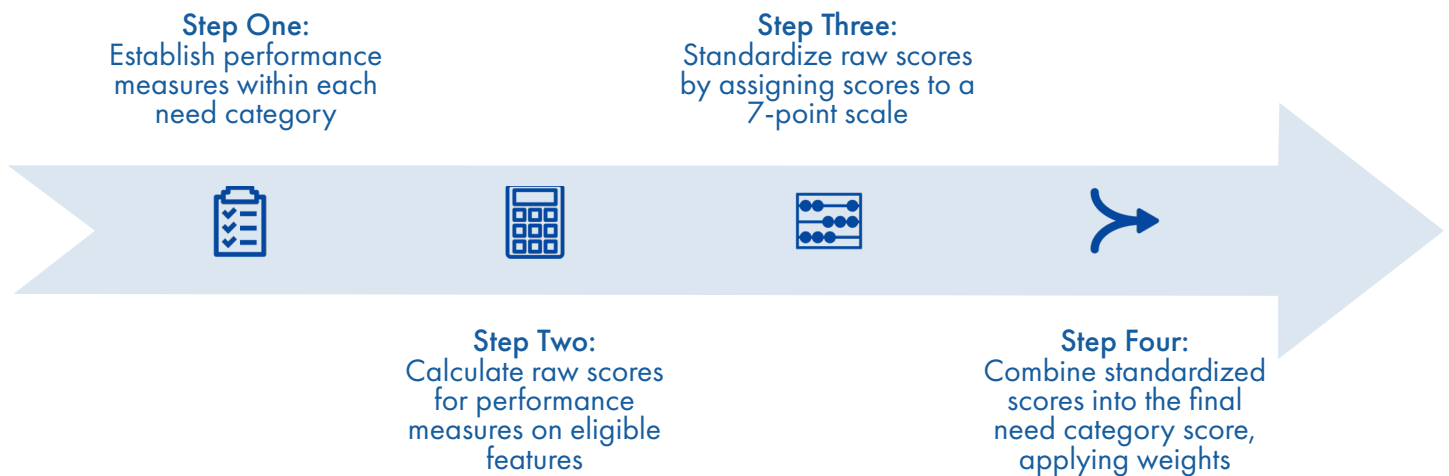


Figure 1 Process for the identification of needs

3 – PROCESS FOR THE IDENTIFICATION OF NEEDS

Table 1 Roles and Responsibility Matrix

| Agency | Role |
|--|---|
| OIP | <ul style="list-style-type: none"> ▪ Provide technical help with data from VTrans Web Map ▪ Update VTrans data as needed |
| VDOT | <ul style="list-style-type: none"> ▪ Provide technical help with VDOT data ▪ Update VDOT data as needed |
| CAMPO | <ul style="list-style-type: none"> ▪ Develop planning goals and objectives for the performance-based planning process ▪ Collect and manage data from other agencies ▪ Run the performance-based planning processes |
| City of Charlottesville and Albemarle County | <ul style="list-style-type: none"> ▪ Coordinate with CAMPO to develop goals and objectives ▪ Update local data as needed |
| Charlottesville Area Transit | <ul style="list-style-type: none"> ▪ Update transit data as needed |

3 – PROCESS FOR THE IDENTIFICATION OF NEEDS

Since each factor is composed of several performance measures, the measures need to be standardized and combined. In Step 3, all measures are expressed on a consistent seven-point scale, with a value of 1 indicating “Very Low” relative need and a value of 7 indicating “Very High” relative need. As shown by Table 2, raw metric values are translated into the seven-point scale based on thresholds that organize similar values into bins reflecting similar levels of need.

Table 2 Need categories and need scores

| Need Category | Need Score |
|---------------|------------|
| Very Low | 1 |
| Low | 2 |
| Medium Low | 3 |
| Medium | 4 |
| Medium High | 5 |
| High | 6 |
| Very High | 7 |

After metrics are standardized, they are combined into a need score for the need category they support (Step 4). In the combination step, all standardized values are summarized into a single score through a weighted-average score. For example, roadway safety needs may be given greater or lower weight than pedestrian safety needs in the safety analysis. This process allows different weights to be assigned to each metric in the scoring process for each factor. The result is that need category scores are combined into an aggregate needs score that reflects total need based on all five need categories. An example of how scores are combined across all needs categories is provided in Table 3.

Since project location is a critical component of environmental impacts, the Environment and Sustainability need category is applied after aggregating need scores. An environmental factor is applied to the overall score as an adjustment to roadway segments that are exposed to projected sea level rise, storm surge, or inland/riverine flooding and whether the segment is within an economically distressed community.

Table 3 Example of aggregate need score based on weighted category need scores

| Need Category | Performance Measure | Weight | Need Score | Weighted Need Score |
|---------------------------------------|--|--------|------------|---------------------|
| Safety (30%) | Roadway Safety | 15% | 4 | 0.6 |
| | Pedestrian Safety | 15% | 6 | 0.9 |
| Accessibility and Equity (30%) | Bicycle Access to Jobs | 8% | 6 | 0.48 |
| | Transit Access to Jobs | 8% | 4 | 0.32 |
| | Automobile Access to Jobs | 6% | 6 | 0.36 |
| | Access to Jobs by Disadvantaged Populations | 8% | 5 | 0.4 |
| Mobility and System Efficiency (20%) | Congestion Mitigation | 5% | 0 | 0 |
| | Travel Time Reliability | 5% | 0 | 0 |
| | Bus Transit On-Time Performance | 10% | 1 | 0.1 |
| Land Use & Economic Development (20%) | Access to Non-Work Destinations | 10% | 5 | 0.5 |
| | Access to Non-Work Destinations by Disadvantaged Populations | 10% | 5 | 0.5 |
| Overall | | 100% | - | 4.16 (Medium) |

3 – PROCESS FOR THE IDENTIFICATION OF NEEDS

Details of each need category and supporting measures are provided in the sections the follow. The measures presented are applicable to all roadway segments. This process does not identify priorities for recreational trails that are not aligned with a public street, although the impacts of these facilities are accounted for in the bicycle access to jobs metric supporting the Accessibility and Equity need category. Similarly, segments where bicycles and pedestrians are not permitted, such as Interstates and other limited access facilities, are excluded from the bicycle access to jobs and pedestrian safety needs measures.

Need Category: Safety

The aim of the safety category is to identify intersections and segments where safety improvements are needed and prioritize projects that can reduce crashes and/or exposure to risk. Safety needs are assessed based on three supporting measures. Two measures: Potential for Safety Improvement (PSI) ranking, and equivalent property damage only (EPDO) crash frequency are blended into a roadway safety score. This is complemented by a pedestrian safety score based on VDOT’s current Pedestrian Safety Action Plan.

Roadway Safety

Roadway safety needs are evaluated based on the combination of two separate performance measures: Potential for Safety Improvement (PSI) ranking and equivalent property damage only (EPDO) crash frequency. The analysis of EPDO crash frequency is limited to segments that are eligible for scoring based on PSI ranking criteria.

PSI is identified by a data-driven safety analysis by VDOT for its Highway Safety Improve Plan (HSIP) that ranks locations by their potential for safety improvement. Locations are ranked within VDOT Construction Districts and statewide. A location’s PSI ranking is an estimate of the extent to which the number of crashes observed at an intersection or along a segment is higher than would be expected based on the facility type, traffic volume, and other factors. The PSI ranking is determined by its excess expected crash frequency, which is the number of observed or “expected” crashes modified by the Empirical Bayes (EB) adjustment method minus the number of typical or “predicted” crashes for the location based on state-specific safety performance functions (SPF). EB accounts for yearly variations and regression to the mean (RTM). SPFs are a mathematical relationship between the frequency of crashes and causal characteristics for a specific highway, including roadway facility type and traffic volume. A positive PSI value indicates a segment or intersection where the number of expected crashes exceeds the number of predicted crashes. Locations with a greater

number of excess expected crashes receive a higher ranking.

The PSI ranking is used to determine segments that are eligible for roadway safety scoring, including the EPDO crash frequency analysis. Segments that do not meet the PSI-based criteria are deemed to have no safety needs, while those that do qualify are differentiated based on their PSI ranking and/or their EPDO crash frequency. The following threshold options were tested to determine scoring eligibility:

1. All PSI Intersections and PSI Segments with three or more crashes in a five-year analysis period.
2. Top ten miles of PSI Segments and top twenty PSI intersections within CAMPO boundaries.

If the first threshold is selected, any feature that has a potential for safety improvement according to VDOT’s PSI analysis is eligible for roadway safety scoring. Alternatively, if the second option is selected, features eligible for scoring are limited to the top ranked segments PSI locations in the study area.

The EPDO crash frequency performance measure identifies locations that have a combined greater severity and frequency of crashes than other locations. It assigns weighting factors to fatal and injury crashes relative to PDO crashes, giving more weight to locations where more severe crashes have occurred. The weighting factors in **Table 4** are used for the identification of roadway safety needs. These values are based on VDOT’s crash costs by severity used for SMART SCALE.

Table 4 Crash value conversion table

| Crash Severity | Rounded Value | Weight |
|-------------------------------|---------------|--------|
| Fatal (F) + Severe Injury (A) | \$2,200,000 | 160 |
| Moderate Injury | \$260,000 | 20 |
| Minor Injury | \$140,000 | 10 |

Source: VDOT EPDO Crash Value Conversion Table (SMART SCALE Technical Guide, 2022)

3 – PROCESS FOR THE IDENTIFICATION OF NEEDS

Calculation Steps

The following steps outline the process for evaluating the level of roadway safety needs by segments:

1. Assign District-level PSI rankings to segments that are eligible for roadway safety scoring.
 - Create route events for PSI segments based on the direction indicated in the PSI segment tabular data. If the direction of the PSI segment applies to both sides of a divided roadway, ensure that route events are created for the opposite route name (WB and SB) in addition the route events created for the prime direction (NB and EB). Use the stated direction only for PSI segments where directionality is limited to eastbound, northbound, southbound, or westbound.
 - Convert PSI Intersections to segments using tabular data to identify the routes that approach PSI intersections. Assign node-based district PSI rankings to segments within a 250 feet influence area around the intersections.
 - Merge segments identified in steps 1a and 1b above into a single collection of segment features with PSI ranking values. If the merged segments needs layer contains both segment-based and intersection-based rankings, retain the higher of the two district PSI rankings.
2. Calculate EPDO crash frequency for segments that are eligible for roadway safety scoring.
 - Assign EPDO weighting factors (Table 3) to all crashes for the most recent five-year analysis period.
 - Assign crash events to segments using a spatial join and sum EPDO-weighted crashes along each segment.

Scoring of Roadway Safety Needs

Roadway safety is assessed as each segment’s average standardized score from the PSI ranking and EPDO crash frequency analyses described above. District PSI ranking standardization thresholds are shown in Table 5. EPDO crash frequency standardization is based on the distribution of raw results over the entire collection of segments scored, as shown in Table 6. This requires sorting segments based on their EPDO crash frequency in descending order, then assigning the need score based on the percentile ranking (in terms of total scored mileage) of each segment. For example, the segments representing the top five percent of scored mileage have “very high” need, while segments representing the bottom fifty percent of scored mileage have “very low” need.

Table 5 Roadway safety need scores applied to District PSI ranks

| Need Category | Need Score | District PSI Rank |
|---------------|------------|-------------------|
| Very High | 7 | Rank <= 20 |
| High | 6 | 40 >= Rank > 20 |
| Medium High | 5 | 60 >= Rank > 40 |
| Medium | 4 | 80 >= Rank > 60 |
| Medium Low | 3 | 100 >= Rank > 80 |
| Low | 2 | 150 >= Rank > 100 |
| Very Low | 1 | Rank > 150 |

Table 6 Roadway safety need scores applied to EPDO

| Need Category | Need Score | Percent of Total Mileage |
|---------------|------------|--------------------------|
| Very High | 7 | 0% to 5% |
| High | 6 | 5.001% to 10% |
| Medium High | 5 | 10.001% to 15% |
| Medium | 4 | 15.001% to 20% |
| Medium Low | 3 | 20.001% to 25% |
| Low | 2 | 25.001% to 50% |
| Very Low | 1 | 50.001% to 100% |

Finally, calculate the overall roadway safety need score by averaging the PSI ranking and the EPDO crash frequency standardized scores. Recall that segments that are not ranked in terms of PSI are assumed not to be roadway safety needs, regardless of underlying EPDO crash frequency. Therefore, they are not part of the target layer that is joined with crashes for calculating EPDO crash frequency. Accordingly, although certain segments may have recorded crashes during a five-year period, the overall score may be zero because they are unranked in terms of district PSI ranking.

Data Requirements

- PSI Locations (source: 2016-2020 Top Potential Safety Improvement Segments and Intersections Web Map)
- 5 year crash data (source: InteractVTrans Map Explorer)
- VDOT Linear Reference System (LRS) Overlap Routes (source: VDOT)

3 – PROCESS FOR THE IDENTIFICATION OF NEEDS

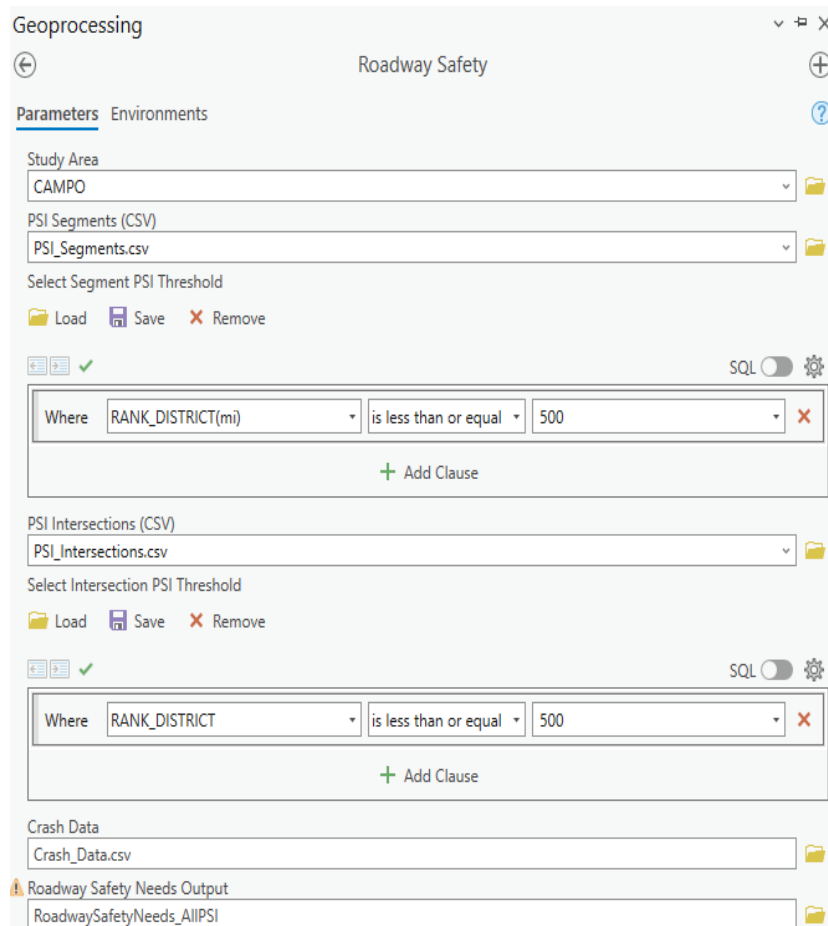


Figure 2 Roadway Safety Geoprocessing Tool

Geoprocessing Tool Overview

Set parameters in the *Roadway Safety* geoprocessing tool exactly as shown in the above figure with input data saved in the following Input geodatabase and csv folder. Save outputs with a descriptive name in the following output geodatabase.

Input Location:

- C:\PerformanceBasedPlanningProcess\Inputs\Inputs.gdb
- C:\PerformanceBasedPlanningProcess\Inputs\csv\Safety

Output Location:

- C:\PerformanceBasedPlanningProcess\Outputs\Outputs.gdb
(Safety Feature Dataset)

The *Roadway Safety* geoprocessing tool requires one input from the 'Inputs' geodatabase, Study Area (CAMPO), and three inputs from the 'Inputs\csv\Safety' directory: PSI Intersections, PSI Segments, and Crash Data which contains five years of crash history for all

crash types. To limit the analysis to PSI locations above a certain ranking, change the 'Select Intersection PSI Threshold' and 'Select Segment PSI Threshold' parameters to the desired values. To include all locations from the PSI analysis, set the threshold to greater than or equal the lowest ranked location in the study area.

3 – PROCESS FOR THE IDENTIFICATION OF NEEDS

Pedestrian Safety

Pedestrian safety needs are evaluated based on VDOT’s Pedestrian Safety Action Plan (PSAP) priority corridors. The PSAP corridors indicate locations where facility design, operations, context, performance, or other issues are likely to lead to pedestrian crashes. Priority corridors are identified through a systematic analysis of statewide data that includes crash history, design speed, number of lanes, traffic volume, demographics and land uses in the vicinity, and other factors. The PSAP process relies on these factors because pedestrian crash events are relatively rare, and the conditions that elevate pedestrian crash risk may be present on numerous facilities even if pedestrian crashes have not been observed in recent years. The PSAP process generates a score for highway segments across the state. The top scoring segments are mapped and made available for download via a web map

Eligibility for pedestrian safety scoring may be determined by one of the following threshold options, based on a segment’s PSAP score relative to other segments in the region:

1. Regional (District) Top 1% Corridors
2. Regional (District) Top 5% Corridor

The above threshold options reflect the available collections of segments generated by the PSAP process (i.e., scores for all segments are not available for download, and other percentile thresholds would require coordination with VDOT to obtain). The top 1% of corridors tend to emphasize major highways, while the top 5% also includes more local roads and may be more appropriate for MPO-scale applications.

Calculation Steps

The following steps outline the process for prioritization within the pedestrian safety need category.

1. Download the most recent PSAP Priority Corridors to identify segments eligible for pedestrian safety scoring, selecting the top 1% or top 5%. The PSAP analysis is conducted approximately every three years.
2. Identify the PSAP Score in the PSAP Priority Corridors. In VDOT’s Pedestrian Safety Action Plan 3.0, segments’ PSAP Scores are in the “MAX_TOT_SCORE” field.

Scoring of Pedestrian Safety Needs

Sort the raw pedestrian safety need score (i.e., PSAP Score) in descending order. Then, using **Table 7**, assign the need score based on the segments’ cumulative length percentage of the combined mileage of all segments that have a need for pedestrian safety.

Table 7 Pedestrian safety need scores

| Need Category | Need Score | Percent of Total Mileage |
|---------------|------------|--------------------------|
| Very High | 7 | 0% to 5% |
| High | 6 | 5.001% to 10% |
| Medium High | 5 | 10.001% to 15% |
| Medium | 4 | 15.001% to 20% |
| Medium Low | 3 | 20.001% to 25% |
| Low | 2 | 25.001% to 50% |
| Very Low | 1 | 50.001% to 100% |

Data Requirements

- PSAP 3.0 Regional Priorities (source: VDOT Pedestrian Safety Action Plan Map Viewer, retrieved from: (source: <https://vdot.maps.arcgis.com/apps/webappviewer/index.html?id=02a155fedefa4e71bdb8c0cf524b636f>)

3 – PROCESS FOR THE IDENTIFICATION OF NEEDS



Figure 3 Pedestrian Safety Geoprocessing Tool

Geoprocessing Tool Overview

Set parameters in the *Pedestrian Safety* geoprocessing tool exactly as shown in the above figure with input data saved in the following Input geodatabase. Save outputs with a descriptive name in the following output geodatabase.

Input Geodatabase:

- C:\PerformanceBasedPlanningProcess\Inputs\Inputs.gdb
(Pedestrian Safety Feature Dataset)

Output Geodatabases:

- C:\PerformanceBasedPlanningProcess\Outputs\Outputs.gdb
(Pedestrian Safety Feature Dataset)

The Pedestrian Safety geoprocessing tool requires two inputs from the 'Inputs' geodatabase: Study Area (CAMPO) and the Input Needs Segments from the Pedestrian Safety Feature Dataset which may be one of the following:

- District_1_Pct_Segments
- District_5_Pct_Segments

3 – PROCESS FOR THE IDENTIFICATION OF NEEDS

Need Category: Accessibility and Equity

The aim of the accessibility and equity category is to identify areas where the design and/or performance of the transportation system degrades travelers' ability to reach key destinations, like jobs, especially for disadvantaged users; and prioritize projects that are likely to enhance accessibility through improved connectivity, reduction in delay, more frequent transit services, and/or improved bicycle and pedestrian facilities. Accessibility and equity needs are assessed based on four supporting measures: bicycle access to jobs, transit access to jobs, automobile access to jobs, and access to jobs by disadvantaged populations. These measures combine to provide a holistic, multimodal assessment of needs that accounts for different needs and abilities among travelers throughout the region.

Many of these supporting measures rely on several key concepts, described in general terms here and applied with specific parameters for each measure. Broadly, accessibility is analyzed on a zone basis and describes the ease with which destinations in other zones can be reached from each origin zone. Accessibility scores can be sensitive to the connectivity provided by the current network, its design and performance, traveler characteristics/preferences, and the number of activities (jobs, e.g.) in destination zones. Maps of accessibility scores show which zones can get to the higher or lower levels of activity in other zones. Since the scores derive from activities in other zones, projects to enhance accessibility may be displaced from the zone where need is indicated, as long as the project enhances the connectivity from the zone having the need to one or more other zones where activities are concentrated.

In this process, the identification of accessibility needs by mode is based on the "potential for accessibility improvement" (PAI), which is estimated as the difference between the "current" accessibility offered and a "reference" condition. The "current" condition refers to the cumulative number of activities (jobs in the case of all metrics generated in this process) accessible from a given location applying parameters, such as level of traffic stress (LTS) or average travel speed, that influence the estimated travel times among zones. The "reference" condition refers to the cumulative number of jobs accessible from the same location but with hypothetical parameters that yield an estimated maximum level of job accessibility. Details regarding the current and reference conditions for each mode are discussed in the subsequent sections on mode-specific accessibility performance measures.

The concepts of "maximum travel time" and "decay function" also determine the cumulative number of jobs that are accessible from a given location. In this analysis, maximum travel time defines the maximum amount of time for traveling from an origin census

block to a destination census block. This maximum travel time parameter may reflect, for example, the idea that walking trips longer than 30 minutes are uncommon. Under this assumption, activities in blocks beyond a 30-minute walk would be ignored in a pedestrian accessibility analysis. Decay functions are commonly used in accessibility analyses to provide more weight to jobs that are closer to origin census blocks than jobs that are located further away. Decay functions are applied in the Access Across America data used in the accessibility metrics described below to reflect the tendency for travelers to choose destinations that are nearby, all else being equal.

The accessibility measures described below also employ the concept of a "catchment area." This refers to the area around a zone that is likely to contribute most substantially to its accessibility score, based on the maximum travel time associated with the mode of travel being analyzed. Catchment areas are included in this analysis primarily because project opportunities to enhance accessibility can be displaced from the zone of need and because the Access Across America data that support the analysis do not include underlying data (such as block-to-block travel time estimates) but only the current and reference accessibility conditions. Thus, the catchment area is used to calculate areawide PAI averages around street segments to rank segments according to the PAI in its surrounding travel shed.

Lastly, functional classification is used to scale the weighted average PAI for each segment by the volume of trips the street is expected to carry. Functional classification refers to the grouping of streets and highways into various classes based on the services they provide. This analysis assumes higher classified streets are more heavily utilized than lower classified streets. Therefore, road segments with a higher functional classification are weighted higher than road segments with a lower function classification as opportunities to provide accessibility enhancements.

3 – PROCESS FOR THE IDENTIFICATION OF NEEDS

Bicycle Access to Jobs

Bicycle access to jobs needs are based on the Access Across America study by the Accessibility Observatory at the University of Minnesota Center for Transportation Studies. This study estimates the number of destinations reachable by bicycle within a given travel time for all census blocks in the United States. In brief, the accessibility calculations performed in the Access Across America study are as follows:

- Calculate travel times by biking from each census block to all other blocks within 20 km using detailed bicycling and walking networks based on OpenStreetMap (OSM) data.
- Calculate cumulative opportunity accessibility to jobs for each block and Level of Traffic Stress score using travel time thresholds of five minutes to one hour. A destination decay function is used to weight the number of jobs reachable such that nearby jobs contribute more to the access score than jobs that are farther away.

Level of Traffic Stress (LTS) is a metric used to evaluate the perception of safety by quantifying the level of discomfort people feel when they bicycle next to traffic. The LTS process assigns numerical values to segments based on OSM tags that indicate the presence or absence of bicycle facilities, number of lanes, and posted roadway posted, and assigns a numerical value of 1 (lowest stress) to 4 (highest stress) to street segments based on these characteristics. For the purposes of applying LTS parameters to the estimation of travel times by biking, LTS values determine segments' traversability. In this case, the tolerance is set to the maximal LTS value. For example, the LTS 3 analysis allows bike trips along facilities classified as LTS 1, 2, or 3, while the LTS 1 analysis only allows bike trips along the LTS 1 facilities. These tolerances reflect the preferences and abilities of different types of users, where LTS 1 is the most inclusive of all users while LTS 4 represents avid cyclists who may tolerate conditions (heavy mixed traffic, e.g.) that are deemed intolerable by other cyclists.

The Access Across America analysis calculates bicycle travel times using an assumed travel speed of 18 kph (approximately 11 mph), while travel times associated with walking portions of trip, including initial access time to reach the nearest network link by foot, barrier-crossing time for segments with a higher stress level than the trip's maximal LRS tolerance, and destination access time, take place at a speed of 5 kph (approximately 3 mph). While bicycle travel time on a network without bicycle infrastructure would be negatively impacted by automobile congestion, this analysis is not sensitive to congestion effects at certain times of the day. The data generated by the study are estimates for each census block of the number of jobs reachable by cycling.

In this analysis, the "current condition" is access to jobs by bicycle along low stress (LTS1) segments and the "reference condition" is access to jobs by bicycling along high stress (LTS4) segments. The reference condition approximates the jobs accessible by cycling assuming all facilities were comfortable for all users rather than only the most avid and experienced cyclists (i.e., how many jobs could be reached by cycling if all facilities were LTS1 facilities?). The deficit that results from subtracting the current condition from the reference condition is the potential accessibility increase (PAI).

The zone (block) data from Access Across America are intersected with 3-mile buffers defining each segment's catchment area. Within each catchment area, the population weighted average PAI is calculated, and the result is multiplied by the segment's functional classification weight. This elevates facilities that are likely to carry relatively high volumes of person trips and that are in areas where bicycle access to jobs could be improved. The segments identified in this process do not necessarily lack suitable facilities for cyclists, so the results should be compared with available inventories of bicycle facilities to determine what projects or investments may be appropriate to enhance bicycle accessibility.

Eligibility for bicycle access to jobs scoring is determined by population weighted PAI for each segment and may be determined by one of the following optional thresholds:

1. All segments where population weighted PAI is greater than zero.
2. All segments where population weighted PAI is greater than the region's median population weighted PAI.

The first option acknowledges all opportunities for potential accessibility enhancements while the second option focuses on the most acute needs. Note that functional classification weightings apply after eligibility is determined.

3 – PROCESS FOR THE IDENTIFICATION OF NEEDS

Calculation Steps

The following steps outline the process for prioritization within the access to jobs by bicycle need category.

1. Obtain the Access Across America datasets given the following parameters:
 - Current Condition: Bicycle LTS 1 (Lowest Stress)
 - Reference Condition: Bicycle LTS 4 (Highest Stress)
 - Maximum Travel Time: 20 minutes
 - Maximum Travel Distance: 3 miles
2. For each census block, calculate PAI as the difference between the reference condition and current condition, or the accessibility deficit between the current condition and the reference condition.

$$\text{Bike PAI} = \text{Reference} - \text{Current}$$

3. Calculate the population weighted PAI for each census block by multiplying PAI by the population of the census block in which the segment is located.

$$\text{Population Weighted PAI} = \text{Population} \times \text{PAI}$$

4. Sum the population weighted PAI and total population in the catchment area around each segment. Next, divide the summed population-weighted PAI by the total population in the catchment area to yield the population-weighted average PAI.

$$\text{Weighted Average PAI} = \frac{\text{Population Weighted PAI}_i}{\text{Catchment Population}_i}$$

5. Calculate the bicycle access to jobs performance measure
 - Assign a functional classification (FC) score to all road segments. Segments where cyclists are not permitted such as Interstates and other limited-access facilities are ignored (receive a score of zero) since they are not relevant to bicycle accessibility.
 - Calculate the raw score for bicycle access to jobs performance measure by multiplying segments' weighted average accessibility improvement by its FC score (see Table 8).

$$\text{Raw Need Score} = \text{Weighted Average PAI} \times \text{FC Score}$$

Table 8 Bicycle access to jobs functional classification score

| Functional Class | FC Score |
|---|----------|
| Other Principal Arterial | 4 |
| Minor Arterial | 3 |
| Major Collector | 2 |
| Minor Collector | 1 |
| Interstates, Other Freeways & Expressways | 0 |

Scoring of Bicycle Access to Jobs Needs

Sort the raw bicycle need score in descending order for all eligible segments. Then, using Table 9 assign the need score based on the segments' cumulative length percentage of the combined mileage of all segments that have a need for bicycle access to jobs.

Table 9 Bicycle access to jobs need scores

| Need Category | Need Score | Percent of Total Mileage |
|---------------|------------|--------------------------|
| Very High | 7 | 0% to 5% |
| High | 6 | 5.001% to 10% |
| Medium High | 5 | 10.001% to 15% |
| Medium | 4 | 15.001% to 20% |
| Medium Low | 3 | 20.001% to 25% |
| Low | 2 | 25.001% to 50% |
| Very Low | 1 | 50.001% to 100% |

Data Requirements

- Block-Level Access to Jobs (source: Access Across America analysis by the Accessibility Observatory)
- Functional Classification (source: InteractVTrans Map Explorer)

3 – PROCESS FOR THE IDENTIFICATION OF NEEDS

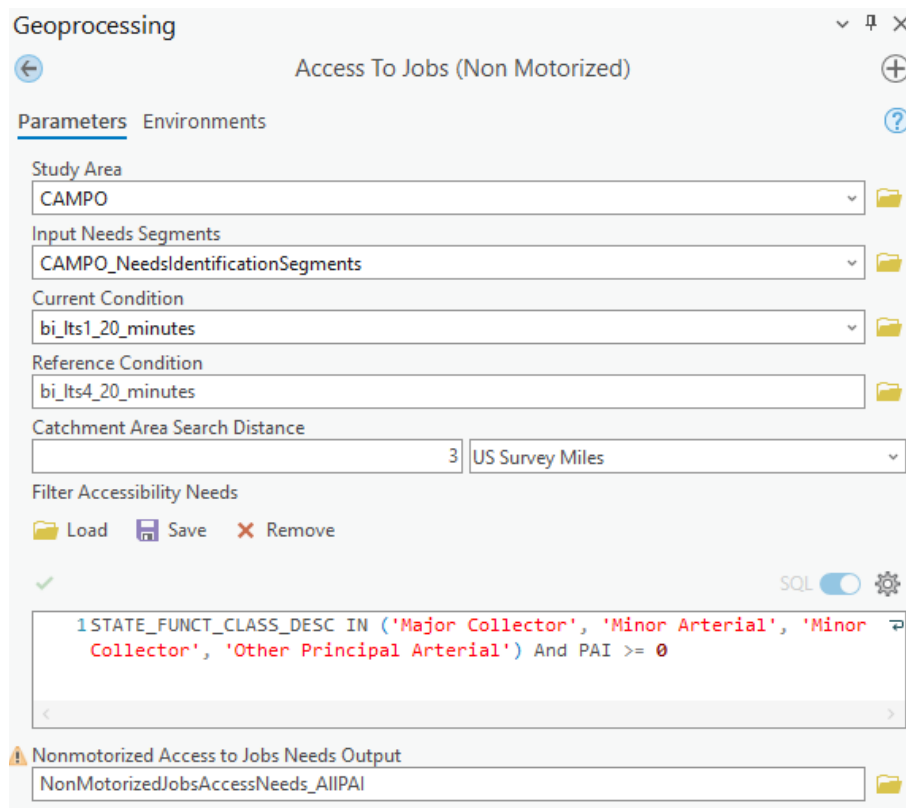


Figure 4 Access to Jobs (Non-Motorized) Geoprocessing Tool

Geoprocessing Tool Overview

Set parameters in the *Access to Jobs (Non-Motorized)* geoprocessing tool exactly as shown in the above figure with input data saved in the following Input geodatabases. Save outputs with a descriptive name in the following output geodatabase.

Input Geodatabases:

- C:\PerformanceBasedPlanningProcess\Inputs\NAE_Tables.gdb
- C:\PerformanceBasedPlanningProcess\Inputs\Inputs.gdb

Output Geodatabases:

- C:\PerformanceBasedPlanningProcess\Outputs\Outputs.gdb (Accessibility Feature Dataset)

The *Access to Jobs (Non-Motorized)* geoprocessing tool requires one input from the 'Inputs' geodatabase: Study Area (CAMPO) The geoprocessing tool also needs the current and reference condition accessibility tables from the 'NAE_Tables' geodatabase.

Edit the 'Filter Accessibility Needs' parameter to filter which segments

are included in the output. The Bicycle Access to Jobs performance measure excludes features with the functional classification attribute 'Interstate' or 'Other Freeways and Expressways' functional classification because bus bus stops do not exist on these facilities. To limit the Bicycle Access to Jobs needs analysis to segments that are greater than the region's average PAI, change the PAI value in the 'Filter Accessibility Needs' parameter.

3 – PROCESS FOR THE IDENTIFICATION OF NEEDS

Transit Access to Jobs

Transit access to jobs needs are based on the Access Across America study by the Accessibility Observatory at the University of Minnesota Center for Transportation Studies. This study estimates the number of destinations reachable by transit and by automobile (see Automobile Access to Jobs) within a given travel time for all census blocks in the United States. In brief, the accessibility calculations performed in the Access Across America study are as follows:

- Calculate travel times by transit from each census block to all other blocks within 60km using transit schedules for the 7:00 – 9:00 AM period and detailed walking networks based on OpenStreetMap (OSM) data.
- Calculate cumulative opportunity accessibility to jobs for each block and departure time using travel time thresholds of five minutes to one hour. A destination decay function is used to weight the number of jobs reachable such that nearby jobs contribute more to the access score than jobs that are farther away

In the Access Across America data, the time cost of travel by transit includes all components of a transit journey, including initial access time, initial wait time, on-vehicle time, transfer access time, transfer wait time, and destination access time. On-vehicle travel time, which is derived from GTFS transit schedules, accounts for variations in service frequency by time of day. Access and egress components of trips (i.e., initial, transfer, and access) are assumed to be made by walking at a speed of 5 kph (3 mph). There is no constraint on the number of transfers required, and it is possible for a block-to-block path to be found that does not use a transit vehicle (i.e., the shortest path from an origin block to a destination block requires walking only).

In the Access Across America data, the time cost of travel by transit includes all components of a transit journey, including initial access time, initial wait time, on-vehicle time, transfer access time, transfer wait time, and destination access time. On-vehicle travel time, which is derived from GTFS transit schedules, accounts for variations in service frequency by time of day. Access and egress components of trips (i.e., initial, transfer, and access) are assumed to be made by walking at a speed of 5 kph (3 mph). There is no constraint on the number of transfers required, and it is possible for a block-to-block path to be found that does not use a transit vehicle (i.e., the shortest path from an origin block to a destination block requires walking only).

In the CAMPO needs analysis, the magnitude of need arising from transit access to jobs performance is determined by the difference in block-level access to jobs between the current condition and the

reference condition. The current condition is access to jobs by transit during the 7:00 – 9:00 AM period and the reference condition is access to jobs by automobile during 8:00 – 9:00 AM period. This elevates areas where jobs access by car is significantly higher than by transit, suggesting an opportunity to enhance transit service to make it more competitive with driving. The deficit that results from subtracting the current condition from the reference condition is the potential accessibility increase (PAI).

The zone (block) data from Access Across America are intersected with 5-mile buffers defining each segment's catchment area. Within each catchment area, the population weighted average PAI is calculated, and the result is multiplied by the segment's functional classification weight. This elevates facilities that are likely to carry relatively high volumes of person trips and that are in areas where transit access to jobs could be improved. The segments identified in this process do not necessarily lack existing transit service, so the results should be compared with current transit routes and schedules to determine what projects or investments may be appropriate to enhance transit accessibility.

Eligibility for transit access to jobs scoring is determined by population weighted PAI for each segment and may be determined by one of the following optional thresholds:

1. All segments where population weighted PAI is greater than zero.
2. All segments where population weighted PAI is greater than the region's median population weighted PAI.

The first option acknowledges all opportunities for potential accessibility enhancements while the second option focuses on the most acute needs. Note that functional classification weightings apply after eligibility is determined.

3 – PROCESS FOR THE IDENTIFICATION OF NEEDS

Calculation Steps

The following steps outline the process for estimating the magnitude of need under the *access to jobs by transit score*:

1. Obtain the Access Across America datasets given the following parameters:
 - Current Condition: Transit
 - Reference Condition: Automobile (8 AM)
 - Maximum Travel Time: 45 minutes
 - Maximum Travel Distance: 5 miles
2. For each census block, calculate PAI as the difference between the reference condition and current condition, or the accessibility deficit between the current condition and the reference condition.

$$\text{Transit PAI} = \text{Reference} - \text{Current}$$

3. Calculate the population weighted PAI for each census block by multiplying PAI by the population of the census block in which the segment is located.

$$\text{Population Weighted PAI} = \text{Population} \times \text{PAI}$$

4. Sum the population weighted PAI and total population in the catchment area around each segment. Next, divide the summed population-weighted PAI by the total population in the catchment area to yield the population-weighted average PAI.

$$\text{Weighted Average PAI} = \frac{\text{Population Weighted PAI}_i}{\text{Catchment Population}_i}$$

5. Calculate the *transit access to jobs* performance measure
 - Assign a functional classification (FC) score to all road segments.
 - Calculate the raw score for *transit access to jobs* performance measure by multiplying segments' weighted average accessibility improvement by its FC score (see Table 10).

$$\text{Raw Need Score} = \text{Weighted Average PAI} \times \text{FC Score}$$

Table 10 Transit access to jobs functional classification score

| Functional Class | FC Score |
|--------------------------|----------|
| Other Principal Arterial | 4 |
| Minor Arterial | 3 |
| Major Collector | 2 |
| Minor Collector | 1 |

Scoring of Transit Access to Jobs Needs

Sort the raw transit need score in descending order. Then, using Table 11, assign the need score based on the segments' cumulative length percentage of the combined mileage of all segments that have a need for *transit access to jobs*.

Table 11 Transit access to jobs need scores

| Need Category | Need Score | Percent of Total Mileage |
|---------------|------------|--------------------------|
| Very High | 7 | 0% to 5% |
| High | 6 | 5.001% to 10% |
| Medium High | 5 | 10.001% to 15% |
| Medium | 4 | 15.001% to 20% |
| Medium Low | 3 | 20.001% to 25% |
| Low | 2 | 25.001% to 50% |
| Very Low | 1 | 50.001% to 100% |

Data Requirements

- Block-Level Access to Jobs (source: Access Across America analysis by the Accessibility Observatory)
- Functional Classification (source: InteractVTrans Map Explorer)

3 – PROCESS FOR THE IDENTIFICATION OF NEEDS

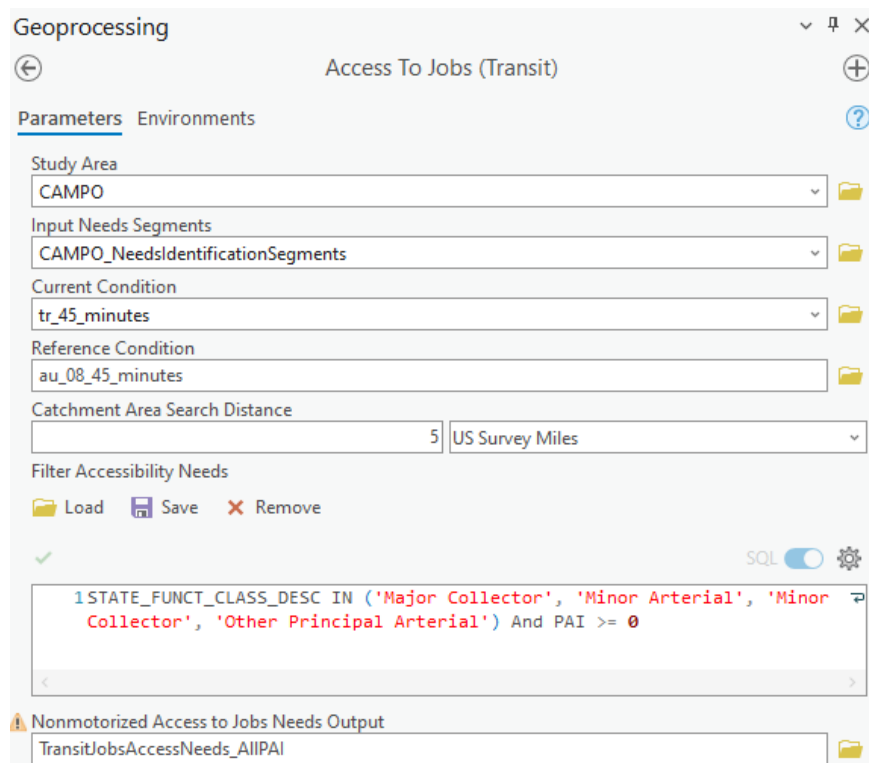


Figure 5 Access to Jobs (Transit) Geoprocessing Tool

Geoprocessing Tool Overview

Set parameters in the *Access to Jobs (Transit)* geoprocessing tool exactly as shown in the above figure with input data saved in the following Input geodatabases. Save outputs with a descriptive name in the following output geodatabase.

Input Geodatabases:

- C:\PerformanceBasedPlanningProcess\Inputs\NAE_Tables.gdb
- C:\PerformanceBasedPlanningProcess\Inputs\Inputs.gdb

Output Geodatabases:

- C:\PerformanceBasedPlanningProcess\Outputs\Outputs.gdb (Accessibility Feature Dataset)

The *Access to Jobs (Transit)* geoprocessing tool requires one input from the 'Inputs' geodatabase: Study Area (CAMPO) The geoprocessing tool also needs the current and reference condition accessibility tables from the 'NAE_Tables' geodatabase.

Edit the 'Filter Accessibility Needs' parameter to filter which segments are included in the output. The Transit Access to Jobs performance

measure excludes features with the functional classification attribute 'Interstate' or 'Other Freeways and Expressways' functional classification because bus bus stops do not exist on these facilities. To limit the Transit Access to Jobs needs analysis to segments that are greater than the region's average PAI, change the PAI value in the 'Filter Accessibility Needs' parameter.

3 – PROCESS FOR THE IDENTIFICATION OF NEEDS

Automobile Access to Jobs

Automobile access to jobs needs are based on the Access Across America study by the Accessibility Observatory at the University of Minnesota Center for Transportation Studies. This study estimates the number of destinations reachable by automobile within a given travel time for all census blocks in the United States. In brief, the accessibility calculations performed in the Access Across America study are as follows:

- Calculate travel times by car from each census block to all other blocks within 120km for each departure time at 1-hour intervals over the 24-hour period. Block-Level Access to Jobs (source: Access Across America)
- Calculate cumulative opportunity accessibility to jobs for each block and departure time using travel time thresholds of five minutes to one hour. A destination decay function is used to weight the number of jobs reachable such that nearby jobs contribute more to the access score than jobs that are farther away.

In the Access Across America data, the time cost of travel by automobile is evaluated by time of day with average link speeds estimated from TomTom, which reports typical speeds based on data collected from GPS devices. Average speed data reflect conditions on Wednesdays (representing a typical weekday) during the June 2017 to June 2019 period.

In the CAMPO needs analysis, the magnitude of need arising from automobile access to jobs performance is determined by the difference in block-level access to jobs between the current condition and the reference condition. The current condition is access to jobs by automobile during the 8:00 – 9:00 AM period and the reference condition is access to jobs by automobile during the 12:00 – 1:00 AM period. This elevates areas where jobs access by car is significantly lower during the morning commute period than it would be under a free flow condition, suggesting an opportunity to enhance highway operations and/or capacity to offer greater access to destinations when highway demand is highest. The deficit that results from subtracting the current condition from the reference condition is the potential accessibility increase (PAI).

The zone (block) data from Access Across America are intersected with 10-mile buffers defining each segment's catchment area. Within each catchment area, the population weighted average PAI is calculated, and the result is multiplied by the segment's functional classification weight. This elevates facilities that are likely to carry relatively high volumes of person trips and that are in areas where automobile access to jobs could be improved. The segments identified in this process do not necessarily experience acute congestion-related delays, so the results should be compared with measures of

delay and reliability to determine what projects or investments may be appropriate to enhance automobile accessibility.

Eligibility for automobile access to jobs scoring is determined by population weighted PAI for each segment and may be determined by one of the following optional thresholds:

1. All segments where PAI deficit is greater than zero
2. All segments where PAI deficit is greater than the region's median PAI deficit

The first option acknowledges all opportunities for potential accessibility enhancements while the second option focuses on the most acute needs. Note that functional classification weightings apply after eligibility is determined.

3 – PROCESS FOR THE IDENTIFICATION OF NEEDS

Calculation Steps

The following steps outline the process for estimating the magnitude of need under the *access to jobs by automobile* score:

1. Obtain the Access Across America datasets given the following parameters:
 - Current Condition: Auto (8 AM - 9AM, Peak Period)
 - Reference Condition: Automobile (12 AM - 1 AM, Off Peak Period)
 - Maximum Travel Time: 45 minutes
Maximum Travel Distance: 10 miles
2. For each census block, calculate PAI as the difference between the reference condition and current condition, or the accessibility deficit between the current condition and the reference condition.

$$\text{Auto PAI} = \text{Reference} - \text{Current}$$

3. Calculate the population weighted PAI for each census block by multiplying PAI by the population of the census block in which the segment is located.

$$\text{Population Weighted PAI} = \text{Population} \times \text{PAI}$$

4. Sum the population in the catchment area around each segment. Next, divide the population weighted PAI by the population in the catchment area to yield the population-weighted average PAI.

$$\text{Weighted Average PAI} = \frac{\text{Population Weighted PAI}_i}{\text{Catchment Population}_i}$$

4. Calculate the *automobile access to jobs* performance measure
 - Assign a functional classification (FC) score to all road segments.
 - Calculate the raw score for automobile access to jobs performance measure by multiplying segments' weighted average accessibility improvement by its FC score (see **Table 12**).

$$\text{Raw Need Score} = \text{Weighted Average PAI} \times \text{FC Score}$$

Table 12 Automobile access to jobs functional classification score standardization

| Functional Class | FC Score |
|---|----------|
| Interstates, Other Freeways & Express, and Other Principal Arterial | 4 |
| Minor Arterial | 3 |
| Major Collector | 2 |
| Minor Collector | 1 |

Scoring of Automobile Access to Jobs Needs

Sort the raw automobile need score in descending order. Then, using **Table 13**, assign the need score based on the segments' cumulative length percentage of the combined mileage of all segments that have a need for *automobile access to jobs*.

Table 13 Automobile access to jobs need scores

| Need Category | Need Score | Percent of Total Mileage |
|---------------|------------|--------------------------|
| Very High | 7 | 0% to 5% |
| High | 6 | 5.001% to 10% |
| Medium High | 5 | 10.001% to 15% |
| Medium | 4 | 15.001% to 20% |
| Medium Low | 3 | 20.001% to 25% |
| Low | 2 | 25.001% to 50% |
| Very Low | 1 | 50.001% to 100% |

Data Requirements

- Block-Level Access to Jobs (source: National Accessibility Evaluation, retrieved through VTRC)
- Functional Classification (source: InteractVTrans Map Explorer)

3 – PROCESS FOR THE IDENTIFICATION OF NEEDS

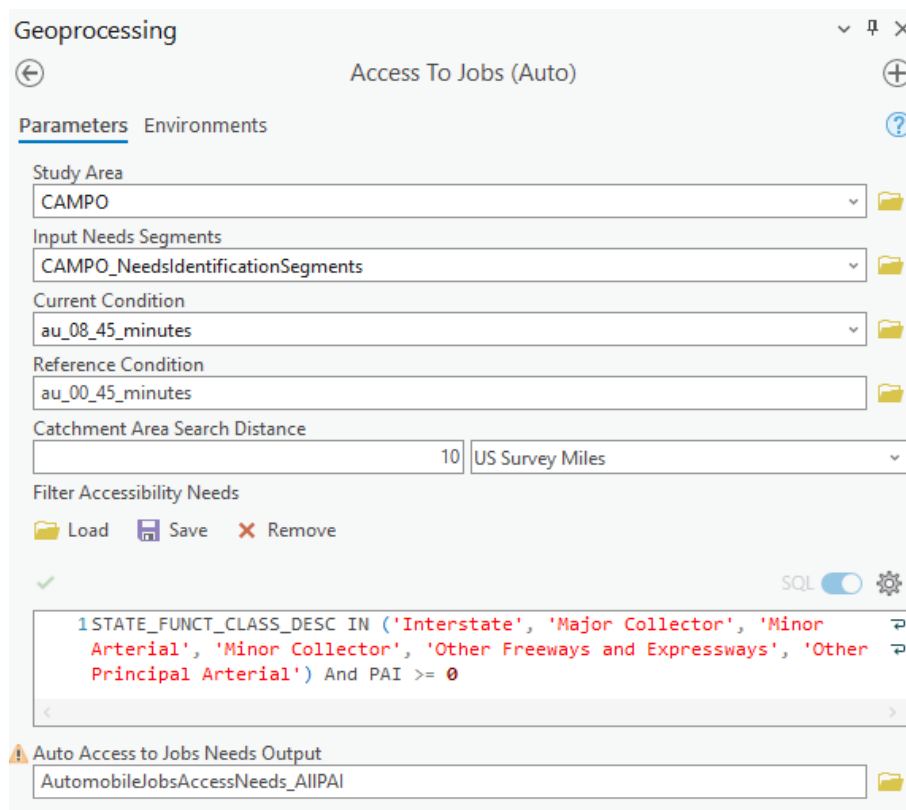


Figure 6 Access to Jobs (Auto) Geoprocessing Tool

Geoprocessing Tool Overview

Set parameters in the *Access to Jobs (Auto)* geoprocessing tool exactly as shown in the above figure with input data saved in the following Input geodatabases. Save outputs with a descriptive name in the following output geodatabase.

Input Geodatabases:

- C:\PerformanceBasedPlanningProcess\Inputs\NAE_Tables.gdb
- C:\PerformanceBasedPlanningProcess\Inputs\Inputs.gdb

Output Geodatabases:

- C:\PerformanceBasedPlanningProcess\Outputs\Outputs.gdb (Accessibility Feature Dataset)

The *Access to Jobs (Transit)* geoprocessing tool requires one input from the 'Inputs' geodatabase: Study Area (CAMPO) The geoprocessing tool also needs the current and reference condition accessibility tables from the 'NAE_Tables' geodatabase.

Edit the 'Filter Accessibility Needs' parameter to filter which segments are included in the output. The *Automobile Access to Jobs*

performance measure includes all functional classification types. To limit the *Automobile Access to Jobs* needs analysis to segments that are greater than the region's average PAI, change the PAI value in the 'Filter Accessibility Needs' parameter.

3 – PROCESS FOR THE IDENTIFICATION OF NEEDS

Access to Jobs by Disadvantaged Populations

Access to jobs by disadvantaged populations needs are based on the analysis of transit access to jobs. However, transit access to jobs results are filtered to segments within areas that are identified as Equity Emphasis Areas (EEA) where transit is available. EEA is an existing dataset provided by OIPI, so no additional calculations are necessary. The full process and data needs are discussed in the Technical Guide for the Identification and Prioritization of the VTrans Mid-Term Needs.

In the CAMPO needs analysis, the magnitude of need arising from access to job for disadvantaged populations is assessed in the same way that transit access to jobs needs are assessed, except that the population weighting is based on populations in EEAs only.

Eligibility for access to jobs for disadvantaged populations scoring is limited to segments within EEAs and determined by population weighted PAI for each segment and may be determined by one of the following optional thresholds:

1. All segments in EEAs where transit is available and where PAI is greater than zero.
2. All segments in EEAs where population weighted PAI is greater than the region’s median population weighted PAI.

Calculation Steps

The following steps outline the process for prioritization within the Access to Jobs by Disadvantaged Populations need category:

3. Obtain the NAE datasets given the following parameters:
 - Current Condition: Transit
 - Reference Condition: Automobile (8 AM)
 - Maximum Travel Time: 45 minutes
 - Maximum Travel Distance: 5 miles
4. For each census block, calculate PAI as the difference between the reference condition and current condition, or the accessibility deficit between the current condition and the reference condition.

$$\text{Transit PAI} = \text{Reference} - \text{Current}$$

5. Calculate the disadvantaged population (DP) weighted PAI for each census block by multiplying PAI by the disadvantaged population of the census block in which the segment is located.

$$\text{DP Weighted PAI} = \text{Population} \times \text{PAI}$$

4. Sum the disadvantaged population in the catchment area

around each segment. Next, divide the population-weighted PAI by the disadvantaged population in the catchment area to yield the population-weighted average PAI.

$$\text{DP Weighted Average PAI} = \frac{\text{DP Weighted PAI}_i}{\text{Catchment DP}_i}$$

5. Calculate the transit access to jobs performance measure
 - Assign a functional classification (FC) score to all road segments.
 - Calculate the raw score for transit access to jobs performance measure by multiplying segments’ weighted average accessibility improvement by its FC score (see **Table 14**).

$$\text{Raw Need Score} = \text{Weighted Average PAI} \times \text{FC Score}$$

Table 14 Access to jobs for disadvantaged populations functional classification score

| Functional Class | FC Score |
|--------------------------|----------|
| Other Principal Arterial | 4 |
| Minor Arterial | 3 |
| Major Collector | 2 |
| Minor Collector | 1 |

Scoring of Access to Jobs by Disadvantaged Populations Needs

Sort the raw automobile need score in descending order. Then, using **Table 15**, assign the need score based on the segments’ cumulative length percentage of the combined mileage of all segments that have a need for Access to Jobs by Disadvantaged Populations.

Table 15 Access to jobs by disadvantaged populations need scores

| Need Category | Need Score | Percent of Total Mileage |
|---------------|------------|--------------------------|
| Very High | 7 | 0% to 5% |
| High | 6 | 5.001% to 10% |
| Medium High | 5 | 10.001% to 15% |
| Medium | 4 | 15.001% to 20% |
| Medium Low | 3 | 20.001% to 25% |
| Low | 2 | 25.001% to 50% |
| Very Low | 1 | 50.001% to 100% |

Data Requirements

- Block-Level Access to Jobs (source: National Accessibility Evaluation, retrieved through VTRC)
- Equity Emphasis Areas (source: InteractVTrans Map Explorer)
- Functional Classification (source: InteractVTrans Map Explorer)

3 – PROCESS FOR THE IDENTIFICATION OF NEEDS

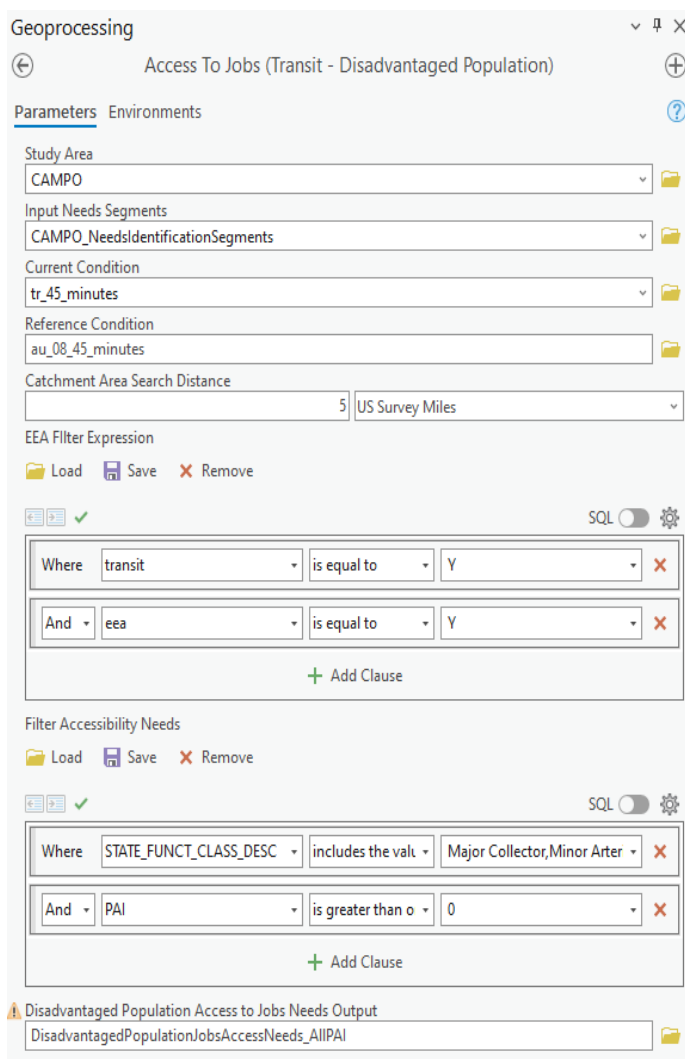


Figure 7 Access to Jobs (Transit - Disadvantaged Population) Geoprocessing Tool

Geoprocessing Tool Overview

Set parameters in the *Access to Jobs (Transit - Disadvantaged Population)* geoprocessing tool exactly as shown in the above figure with input data saved in the following Input geodatabases. Save outputs with a descriptive name in the following output geodatabase.

Input Geodatabases:

- C:\PerformanceBasedPlanningProcess\Inputs\NAE_Tables.gdb
- C:\PerformanceBasedPlanningProcess\Inputs\Inputs.gdb

Output Geodatabases:

- C:\PerformanceBasedPlanningProcess\Outputs\Outputs.gdb (Accessibility Feature Dataset)

The *Access to Jobs (Transit - Disadvantaged Population)* geoprocessing tool requires one input from the 'Inputs' geodatabase: Study Area (CAMPO) The geoprocessing tool also needs the current and reference condition accessibility tables from the 'NAE_Tables' geodatabase.

The *Disadvantaged Population Access to Jobs* performance measure excludes features with the functional classification attribute 'Interstate' or 'Other Freeways and Expressways' functional classification because bus bus stops do not exist on these facilities. Edit the 'Filter Accessibility Needs' parameter to filter which segments are included in the output. To limit the *Access to Jobs by Disadvantaged Populations* needs analysis to segments that are greater than the region's average PAI, change the PAI value in the 'Filter Accessibility Needs' parameter. Additionally, the EEA Filter Expression limits the analysis to segments in Equity Emphasis Areas (EEA = 'Y') where transit is available (transit = 'Y').

3 – PROCESS FOR THE IDENTIFICATION OF NEEDS

Need Category: Mobility and System Efficiency

The aim of the mobility and system efficiency category is to identify segments where congestion-related delay degrades travel time and travel time reliability for automobiles and transit vehicles and to prioritize projects that will alleviate delay and/or enhance person throughput throughout the region. Mobility needs are assessed using two measures: congestion mitigation and travel time reliability. Both measures compare congested travel conditions to free flow conditions, assessing the severity of congestion under typical and extreme conditions, respectively.

Congestion Mitigation

Congestion mitigation needs are identified through Travel Time Index (TTI), which is the ratio of a segment's typical travel time during an observed period (such as the morning or evening peak commuting period) to the time required to travel the same distance in a reference period (under free-flow conditions, e.g.). A TTI value greater than one indicates there is delay during the observation period, and higher numbers indicate increasingly severe delay due to congestion. TTI is usually measured at a segment level. For example, a TTI of 1.3 indicates typical travel times along a particular segment are 30% longer. If it would take 2 minutes to traverse the segment under free-flow conditions, the TTI of 1.3 would imply it typically takes 2 minutes and 40 seconds during congested conditions.

The dataset used for this analysis contains TTI measures by segment that cover a 14-hour period from 6 AM to 8 PM on weekdays and weekends for multiple years (i.e., TTI for weekdays and weekends in 2018, 2019, 2020, and 2021 for each hour from 6 AM to 8 PM). The TTI measures, which are calculated by OIPI using INRIX TMC data from the Regional Integrated Transportation System (RITIS), can be obtained from the InteractVTrans Map Explorer, and reflect the ratio of the 50th percentile travel time to the estimated free flow time.

The identification of qualifying segments requires that a given segment at any time in the previous four years exceeds the congestion mitigation need threshold discussed in the following sections.

The following steps outline the process for identifying congestion mitigation needs. In this process the focus is on weekday and weekend TTI from 6 AM to 8 PM analysis periods.

1. For each segment and each year, calculate the weeklong average TTI for each hour in the analysis period by combining the separate estimates of weekday TTI and weekend TTI as follows:
 - Multiply weekday TTI values by 5/7 (five of seven days)
 - Multiply weekend TTI values by 2/7 (two of seven days)
 - Sum the results of 1a and 1b to obtain weeklong average TTI
2. For each segment, tally the number of hours in the analysis period where the weeklong average TTI in any year is above the eligibility threshold. Select eligible segments where the thresholds are satisfied.

Eligibility for congestion mitigation scoring may be determined by one of the following alternative thresholds:

1. Average weeklong TTI in any year is greater than 1.3 for three or more hours or average weeklong TTI is greater than 1.5 for one or more hours.
2. Average weeklong TTI in any year is greater than 1.5 for three or more hours or average weeklong TTI is greater than 1.7 for one more hours.

3 – PROCESS FOR THE IDENTIFICATION OF NEEDS

Calculation Steps

The following steps outline the process for assessing the magnitude of the congestion mitigation need:

1. Calculate the daily cumulative TTI values from 6 AM to 8 PM. This step accumulates over all qualifying hours in a single year to calculate a "daily cumulative TTI" value.

$$\text{Daily Cumulative TTI} = \frac{5}{7} \left(\sum_{\text{Weekday TTI} > T} \text{Weekday TTI} \right) + \frac{2}{7} \left(\sum_{\text{Weekend TTI} > T} \text{Weekend TTI} \right)$$

Where:

T = TTI threshold (1.3, 1.5, 1.7, e.g.)

2. Adjust for magnitude of congestion by multiplying cumulative congested hours by traffic volume using length weighted Annual Average Daily Traffic (AADT)

$$\text{Normalized TTI_AADT}_i = \frac{\text{TTI_AADT}_i - \text{TTI_AADT}_{\min}}{\text{TTI_AADT}_i - \text{TTI_AADT}_{\max}}$$

Where:

TTI_AADT_i = Cumulative TTI × AADT for segment i

TTI_AADT_{min} = Minimum Cumulative TTI × AADT for all segments

TTI_AADT_{max} = Maximum Cumulative TTI × AADT for all segments

Scoring of Congestion Mitigation Needs

Using **Table 18**, assign need scores based on segments' normalized volume adjusted weekly average TTI.

Table 16 Congestion mitigation need scores

| Need Category | Need Score | Normalized Congestion Need Score |
|---------------|------------|----------------------------------|
| Very High | 7 | 0.95 to 1 |
| High | 6 | 0.9 to 0.95 |
| Medium High | 5 | 0.85 to 0.9 |
| Medium | 4 | 0.8 to 0.85 |
| Medium Low | 3 | 0.75 to 0.8 |
| Low | 2 | 0.5 to 0.75 |
| Very Low | 1 | 0 to 0.5 |

Data Requirements

- Travel Time Index (source: INRIX provided by RITIS via InteractVTrans Map Explorer)
- AADT (source: InteractVTrans Map Explorer)

3 – PROCESS FOR THE IDENTIFICATION OF NEEDS

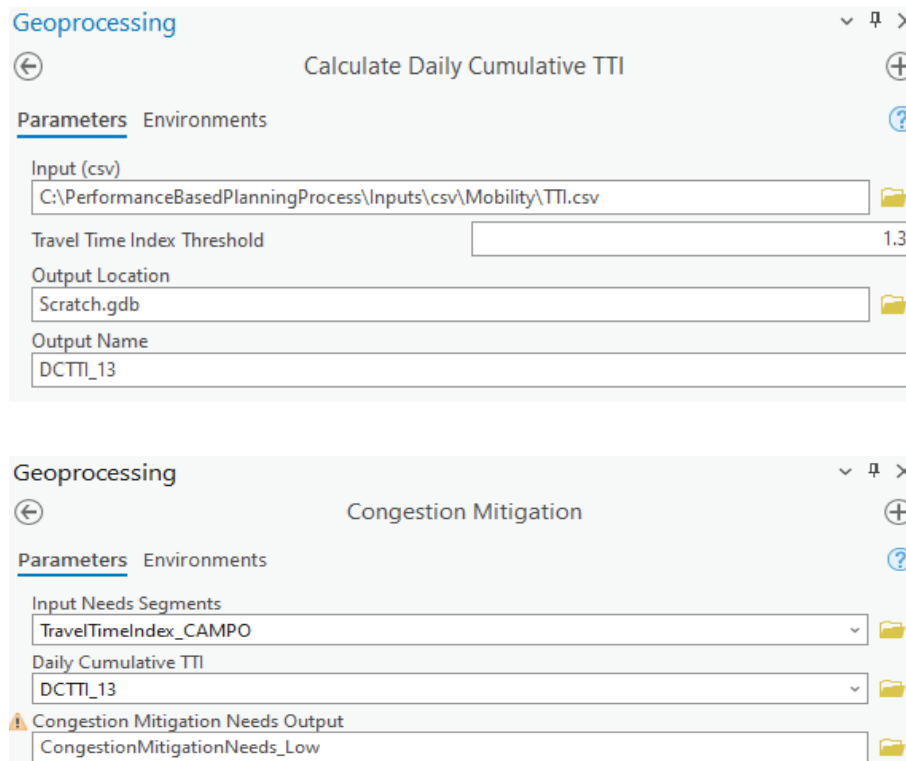


Figure 8 Congestion Mitigation Geoprocessing Tool

Geoprocessing Tool Overview

Set the parameters in the *Calculate Daily Cumulative TTI* and *Congestion Mitigation* geoprocessing tools exactly as shown in the above figures with input data saved in the following Input geodatabases. Then, run the Calculate Daily Cumulative Travel Time Index geoprocessing tool prior to running the Congestion Mitigation geoprocessing tool. Save outputs with a descriptive name in the following output geodatabase.

Input Geodatabases:

- C:\PerformanceBasedPlanningProcess\Inputs\csv\Mobility
- C:\PerformanceBasedPlanningProcess\Inputs\Inputs.gdb (Mobility Feature Dataset)

Output Geodatabases:

- C:\PerformanceBasedPlanningProcess\Outputs\Outputs.gdb (Mobility Feature Dataset)

In the *Calculate Daily Cumulative TTI* geoprocessing tool, set the Travel Time Index Threshold equal to the desired value. This parameter limits the analysis to segments with TTI greater than the value set for the threshold.

3 – PROCESS FOR THE IDENTIFICATION OF NEEDS

Travel Time Reliability

Travel time reliability needs are identified through Planning Time Index (PTI), which is the ratio of a segment's 95th percentile travel time compared to the time needed to travel the same distance in a reference period (free-flow traffic, e.g.). PTI refers to the total planned duration of travel (expected delay plus unexpected delay) that is required for an on-time arrival for 95% of trips on a given segment. For example, a PTI of 1.5 at a given time indicates that a trip that normally takes 10 minutes in uncongested conditions should be planned to take 15 minutes to ensure that 95% of trips arrive on time. PTI is a measure of travel time reliability because it measures the extent of unexpected delay against free flow traffic and measures the consistency or dependability in travel times across different times of day.

The dataset used for this analysis contains PTI measures that cover a 14-hour period from 6 AM to 8 PM on weekdays and weekends for multiple years (i.e., PTI for weekdays and weekends in 2018, 2019, 2020, and 2021 for each hour from 6 AM to 8 PM). The PTI measures, which are calculated by OIPI using INRIX TMC data from the Regional Integrated Transportation System (RITIS), can be obtained from the InteractVTrans Map Explorer and reflect the ratio of the 95th percentile travel time to the estimated free flow time.

The identification of qualifying segments requires that a given segment at any time in the previous four years exceeds the congestion mitigation need threshold discussed in the following sections. The following steps outline the process for identifying travel time reliability needs. In this process the focus is on weekday and weekend PTI from 6 AM to 8 PM analysis periods.

1. For each segment and each year, calculate the PTI for each hour in the analysis period by combining the separate estimates of weekday PTI and weekend PTI as follows:
 - Multiply weekday PTI values by 5/7 (five of seven days)
 - Multiply weekend PTI values by 2/7 (two of seven days)
 - Sum the results of 1a and 1b to obtain weeklong average PTI
2. For each segment, tally the number of hours in the analysis period where the weeklong average PTI in any year is above the eligibility threshold. Select eligible segments where the thresholds are satisfied.

Eligibility for travel time reliability scoring may be determined by one of the following alternative thresholds::

1. Average weekday and weekend PTI is greater than 1.3 for three hours or greater than 1.5 for one hour.
2. Average weekday and weekend PTI is greater than 1.5 for three hours or greater than 1.7 for one hour.

3 – PROCESS FOR THE IDENTIFICATION OF NEEDS

Calculation Steps

The following steps outline the process for assessing the magnitude of the congestion mitigation need:

1. Calculate the daily cumulative PTI values from 6 AM to 8 PM. This step accumulates over all qualifying hours in a single year to calculate a "daily cumulative PTI" value.

$$\text{Daily Cumulative PTI} = \frac{5}{7} \left(\sum_{\text{Weekday PTI} > T} \text{Weekday PTI} \right) + \frac{2}{7} \left(\sum_{\text{Weekend PTI} > T} \text{Weekend PTI} \right)$$

Where:

T = TTI threshold (1.3, 1.5, 1.7, e.g.)

2. Adjust for magnitude of congestion by multiplying cumulative congested hours by traffic volume using length weighted Annual Average Daily Traffic (AADT)
3. Repeat steps 1 and 2 for all years available in the PTI dataset to calculate AADT-weighted daily cumulative PTI for each year. Retain the maximum result across all years for each segment.
4. Normalize the AADT adjusted PTI for all years available in the dataset using the following equation. Normalization results in values ranging from 0.0 to 1.0, with the segment that has the lowest volume adjusted PTI receiving a score of 0.0 and the segment that has the highest volume adjusted PTI receiving a score of 1.0.

$$\text{Normalized TTI_AADT}_i = \frac{\text{PTI_AADT}_i - \text{PTI_AADT}_{\min}}{\text{PTI_AADT}_i - \text{PTI_AADT}_{\max}}$$

Where:

PTI_AADTi = Cumulative PTI × AADT for segment i

PTI_AADT_{min} = Minimum Cumulative PTI × AADT for all segments

PTI_AADT_{max} = Maximum Cumulative PTI × AADT for all segments

Scoring of Travel Time Reliability Needs

Using Table 17, assign need scores based on segments' normalized volume adjusted weekly average PTI.

Table 17 Travel time reliability need scores

| Need Category | Need Score | Normalized Congestion Need Score |
|---------------|------------|----------------------------------|
| Very High | 7 | 0.95 to 1 |
| High | 6 | 0.9 to 0.95 |
| Medium High | 5 | 0.85 to 0.9 |
| Medium | 4 | 0.8 to 0.85 |
| Medium Low | 3 | 0.75 to 0.8 |
| Low | 2 | 0.5 to 0.75 |
| Very Low | 1 | 0 to 0.5 |

Data Requirements

- Planning Time Index (source: INRIX provided by RITIS via InteractVTrans Map Explorer)
- AADT (source: InteractVTrans Map Explorer)

3 – PROCESS FOR THE IDENTIFICATION OF NEEDS

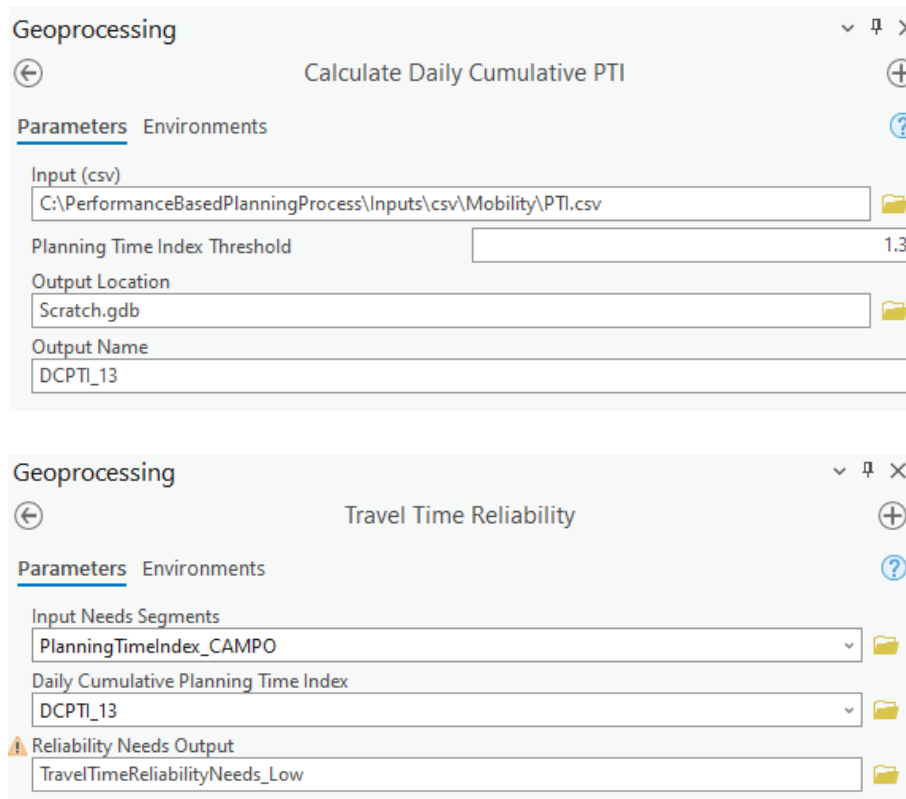


Figure 9 Travel Time Reliability Geoprocessing Tool

Geoprocessing Tool Overview

Set the parameters in the *Calculate Daily Cumulative PTI* and *Travel Time Reliability* geoprocessing tools exactly as shown in the above figures with input data saved in the following Input geodatabases. Then, run the *Calculate Daily Cumulative Travel Time Index* geoprocessing tool prior to running the *Congestion Mitigation* geoprocessing tool. Save outputs with a descriptive name in the following output geodatabase.

Input Geodatabases:

- C:\PerformanceBasedPlanningProcess\Inputs\csv\Mobility
- C:\PerformanceBasedPlanningProcess\Inputs\Inputs.gdb
(Mobility Feature Dataset)

Output Geodatabases:

- C:\PerformanceBasedPlanningProcess\Outputs\Outputs.gdb
(Mobility Feature Dataset)

In the *Calculate Daily Cumulative PTI* geoprocessing tool, set the Travel Time Index Threshold equal to the desired value. This parameter limits the analysis to segments with PTI greater than the value set for the threshold.

3 – PROCESS FOR THE IDENTIFICATION OF NEEDS

Bus Transit On-Time Performance

While there are multiple factors that influence people’s decisions to use public transportation, one of the most important decision-making factors in low-frequency bus systems such as Charlottesville Area Transit (CAT) is passenger waiting time, which is influenced by the reliability of the transit service and adherence to published schedules. When buses regularly depart from stops at the scheduled time, passengers can time their arrival at the stop to minimize wait time. However, if the bus is not usually on time, passengers can face unpredictable wait times. Accordingly, one of the most common measures of the effectiveness of the bus transportation system is on-time performance (OTP).

For the purpose of this analysis, OTP measures how well transit vehicles adhere to the published schedule within an acceptable level of deviation measured in time and serves as an indicator of the attractiveness of bus transit as a travel option. OTP is expressed as a percentage and is calculated by the count of bus timepoint departures that are on time divided by the count of total departures multiplied by 100. Buses are considered “on-time” if they are no more than 30 seconds early and no more than 5 minutes late to the major stops on the route schedule.

Since OTP data is only collected at stops where departure times are scheduled (i.e., timepoints), this analysis does not include intermediate stops with scheduled departure times. Since stop locations may include bus stops for more than one route, the term “timepoint” refers to bus stops associated with a specific route (i.e., there may be multiple timepoint features at a single stop location). Additionally, this analysis does not consider reliability in terms of service consistency or the change in reliability over time. For example, a bus that is consistently six minutes late is not on time but is reliable. Furthermore, the analysis of OTP does not provide reasons for poor performance including predictable events such as traffic congestion, passenger loads, and delays due to at-grade railroad crossings or unexpected events like crashes, disabled buses, temporary detours, weather, and issues related to labor.

The following threshold options were tested to determine scoring eligibility:

1. Stops where OTP is less than the systemwide weekly average OTP from the previous year.
2. Stops where OTP is less than 85% or an alternative target value in accordance with CAMPO’s transit performance goals.

Calculate OTP for all timepoints in the analysis period for weekdays and weekends separately.

1. Calculate OTP in two steps:
 - Find the percentage of on-time departures by dividing the sum of on-time departures by the sum of total departures, then multiply by 100.
 - Subtract the result from 100 to obtain the share of departures that are not on time.
2. Multiply timepoints’ weekday OTP values by 5/7 (five of seven days)
3. Multiply timepoints’ weekend OTP values by 2/7 (two of seven days)
4. Sum the results of step 2 and step 3 to obtain weeklong average OTP by timepoint

OTP is used in the identification of needs to determine if stops are eligible for bus transit on-time performance scoring. The first threshold option determines eligibility if OTP at a timepoint is worse than the systemwide weekly average OTP from the previous year or analysis period. Alternatively, if the second threshold option is selected, timepoints are eligible for scoring if OTP is less than a target value set by CAMPO (e.g., 85%). The second threshold option does not require computation of an average weeklong average OTP.

3 – PROCESS FOR THE IDENTIFICATION OF NEEDS

Calculation Steps

The following steps outline the process for assessing the magnitude of the *congestion mitigation* need:

1. Calculate the daily cumulative OTP values from 6 AM to 8 PM. This step accumulates over all qualifying hours in a single year to calculate a “weeklong OTP” value.

$$\text{Weeklong OTP} = \frac{5}{7} \left(\sum_{\text{Weekday OTP} > T} \text{Weekday OTP} \right) + \frac{2}{7} \left(\sum_{\text{Weekend OTP} > T} \text{Weekend OTP} \right)$$

Where:

Weeklong OTP = Average OTP for each stop by route

T = OTP threshold (83%, 85%, 90%, e.g.)

2. Adjust Weeklong OTP by subtracting the on-time rate from 100%. This will ensure that the timepoints with greater needs receive a higher value. For example, a timepoint with an OTP of 80% will become 20%, while a timepoint with an OTP of 60% will become 40%.
3. Account for the magnitude of needs by multiplying the adjusted weeklong OTP by the number of daily boardings and alightings at each timepoint (boardings and alightings are treated as a proxy for ridership in this analysis).

$$\text{OTP}_{\text{Ridership}_i} = \text{Ridership}_i \times \text{Adjusted Weeklong OTP}_i$$

Where,

OTP_{Ridership}_i = Ridership Adjusted OTP at timepoint i

Ridership_i = Daily Ridership at timepoint i

Weeklong OTP_i = Adjusted Weeklong OTP at timepoint i

4. Normalize ridership adjusted OTP.

$$\text{Normalized OTP}_{\text{Ridership}_i} = \frac{\text{OTP}_{\text{Ridership}_i} - \text{OTP}_{\text{Ridership}_{\min}}}{\text{OTP}_{\text{Ridership}_i} - \text{OTP}_{\text{Ridership}_{\max}}}$$

Where:

OTP_{Ridership}_{min} = Minimum ridership adjusted OTP across all timepoints

OTP_{Ridership}_{max} = Maximum ridership adjusted OTP across all timepoints

Scoring of Bus On Time Performance Needs

Using **Table 18**, assign need scores based on segments’ normalized volume adjusted weekly average OTP.

Table 18 Bus Transit On-Time Performance need scores

| Need Category | Need Score | Normalized Reliability Need Score |
|---------------|------------|-----------------------------------|
| Very High | 7 | 0.95 to 1 |
| High | 6 | 0.9 to 0.95 |
| Medium High | 5 | 0.85 to 0.9 |
| Medium | 4 | 0.8 to 0.85 |
| Medium Low | 3 | 0.75 to 0.8 |
| Low | 2 | 0.5 to 0.75 |
| Very Low | 1 | 0 to 0.5 |

Data Requirements

- Charlottesville Area Transit On-Time Performance (source: CAT)
- Charlottesville Area Transit Daily Ridership (source: CAT)

3 – PROCESS FOR THE IDENTIFICATION OF NEEDS

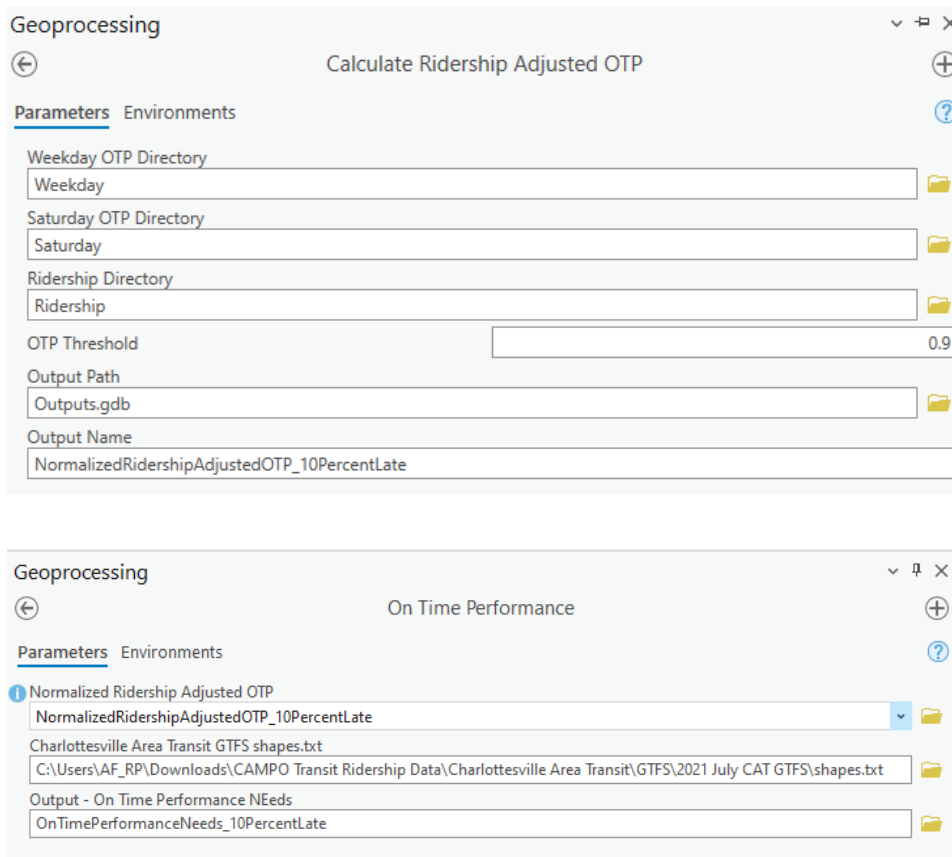


Figure 10 Bus On-Time Performance Geoprocessing Tool

Geoprocessing Tool Overview

Set the parameters in the *Calculate Ridership Adjusted OTP* and *On Time Performance* geoprocessing tools exactly as shown in the above figures with input data saved in the following Input geodatabases. Then, run the *Calculate Daily Cumulative Travel Time Index* geoprocessing tool prior to running the *Congestion Mitigation* geoprocessing tool. Save outputs with a descriptive name in the following output geodatabase.

Input Geodatabases:

- C:\PerformanceBasedPlanningProcess\Inputs\csv\Mobility
- C:\PerformanceBasedPlanningProcess\Inputs\Inputs.gdb (Mobility Feature Dataset)

Output Geodatabases:

- C:\PerformanceBasedPlanningProcess\Outputs\Outputs.gdb (Mobility Feature Dataset)

In the *Calculate Ridership Adjusted OTP* geoprocessing tool, set the *On Time Performance Threshold* equal to the desired value. This parameter limits the analysis to timepoints with on-time arrivals less than the value set for the threshold.

3 – PROCESS FOR THE IDENTIFICATION OF NEEDS

Need Category: Land Use and Economic Development

The aim of the land use and economic development category is to identify areas where there is access to non-work destinations to stimulate local economic activity or to create transportation choices for disadvantaged people and to prioritize projects that connect to areas of local economic development activity. Land use needs are assessed using two measures: walk access to *non-work destinations* and *walk access to non-work destinations by disadvantaged populations*. Both measures rely on WalkScore and BikeScore indices, focusing on the general population and disadvantaged populations, respectively.

Walk Access to Non-Work Destinations

The need for walk access to non-work destinations is determined by a segment's maximum of WalkScore and BikeScore and its future population and employment level (i.e., activity level). WalkScore3 measures walkability through measures of access to non-work destinations (cultural, restaurants, groceries, parks, errands) and roadway connectivity such as intersection density and average block length. In this needs assessment process, the maximum WalkScore or BikeScore is weighted by future activity level from the regional travel demand model. This performance measure shows locations that are in close proximity to non-work destinations, population and employment. Through the WalkScore component, the performance measure indicates where there is high network connectivity. However, these locations may have barriers to walking not accounted for in the WalkScore methodology including lack of sidewalks or crosswalks along existing facilities. Therefore, the walk access to non-work destinations performance measure indicates where investments in pedestrian improvements would likely yield the greatest benefits.

Segment eligibility for walk access to non-work destinations scoring may be determined by one of the following optional thresholds:

1. All segments in the City of Charlottesville and in Albemarle County Development Areas
2. All segments in "somewhat walkable" census tracts (i.e., WalkScores greater than 49)

If the first threshold option is selected, all segments in the City of Charlottesville or in one of Albemarle County's five Development Areas are eligible for *walk access to non-work destinations* scoring. Development areas, which are defined by the County's Comprehensive Plan, are intended "to focus development into the urban areas to create quality living areas, avoid sprawl, improve

access to services, and protect the natural and agricultural resources and uses of the rural areas." Development areas include Crozet, Pantops, the US-29 corridor from Hydraulic Road to north of the airport, the Southern and Western neighborhoods adjacent to Charlottesville, and the Village of Rivanna. The effect of selecting this threshold option is that needs will be considered for all areas regardless of the current WalkScore.

Alternatively, if the second threshold option is selected, segments are eligible for *walk access to non-work destinations* scoring if they are in "somewhat walkable" census tracts which is defined by WalkScores that are greater than 49. The result of selecting this threshold option is that needs will be considered for all areas regardless of its designation as a Development Area (for Albemarle County only). However, given that WalkScores are higher in more urban areas due to better network connectivity and shorter distances to amenities, the more realistic outcome is that needs will be identified in areas within Development Areas where there is the greatest potential for improving access to non-work destinations.

3 – PROCESS FOR THE IDENTIFICATION OF NEEDS

Calculation Steps

The following steps outline the process for assessing the magnitude of the *walk access to non-work destinations* need:

1. Calculate segments’ average WalkScore by performing a spatial join of segments that intersect the WalkScore feature layer.
2. Calculate segments’ average activity level by performing a spatial join of segments that intersect the regional travel demand model’s Traffic Analysis Zones (TAZ) layer that contains total population and all employment. Summarize the average activity level for segments that span two or more TAZs.
3. Calculate segments’ activity weighted WalkScore by multiplying average WalkScore by average future activity level.

$$\text{Weighted Walk Score} = \text{Walk Score} \times (\text{Average Population} + \text{Average Jobs})$$

4. Normalize the weighted WalkScore using the following equation:

$$\text{Normalized Walk Score} = \frac{\text{Weighted Walk Score}_i - \text{Weighted Walk Score}_{\min}}{\text{Weighted Walk Score}_i - \text{Weighted Walk Score}_{\max}}$$

Where:

Weighted WalkScore_i = WalkScore × Activity level for Segment i

Weighted WalkScore_{min} = Minimum WalkScore × Activity level

Weighted WalkScore_{max} = Maximum WalkScore × Activity level

Scoring of Walk Access to Non-Work Destinations Needs

Sort the normalized average WalkScore weighted by average activity level. Then, using **Table 19**, assign the need score based on the segments’ cumulative length percentage of the combined mileage of all segments that have a need for *walk access to non-work destinations*.

Table 19 Walk access to non-work destinations need scores applied to segments by population weighted WalkScore

| Need Category | Need Score | Percent of Total Mileage |
|---------------|------------|--------------------------|
| Very High | 7 | 0% to 5% |
| High | 6 | 5.001% to 10% |
| Medium High | 5 | 10.001% to 15% |
| Medium | 4 | 15.001% to 20% |
| Medium Low | 3 | 20.001% to 25% |
| Low | 2 | 25.001% to 50% |
| Very Low | 1 | 50.001% to 100% |

Data Requirements

- WalkScore and BikeScore (source: InteractVTrans Map Explorer)
- Future population and employment (source: Charlottesville-Albemarle Regional Model)

3 – PROCESS FOR THE IDENTIFICATION OF NEEDS

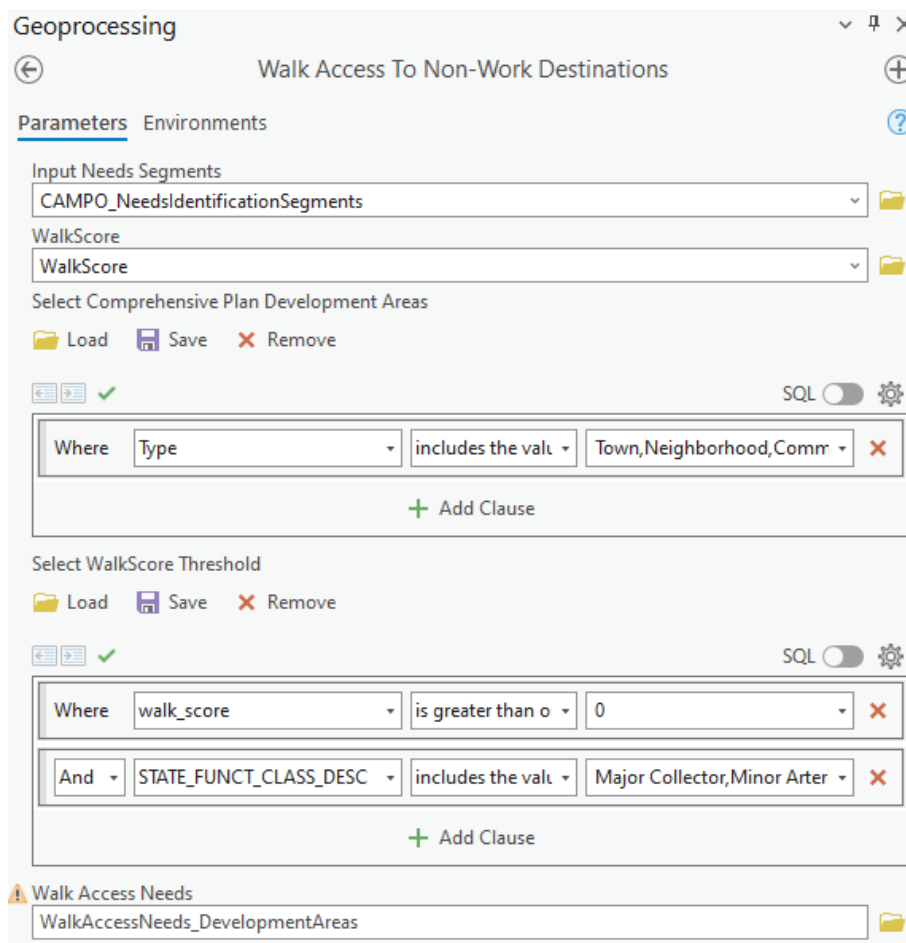


Figure 11 Walk Access to Non-Work Destinations Geoprocessing Tool

Geoprocessing Tool Overview

Set the parameters in the *Walk Access to Non-Work Destinations* geoprocessing tools exactly as shown in the above figures with input data saved in the following Input geodatabases. Save outputs with a descriptive name in the following output geodatabase.

Input Geodatabases:

- C:\PerformanceBasedPlanningProcess\Inputs\csv\Mobility
- C:\PerformanceBasedPlanningProcess\Inputs\Inputs.gdb (Land Use Feature Dataset)

Output Geodatabases:

- C:\PerformanceBasedPlanningProcess\Outputs\Outputs.gdb (Land Use Feature Dataset)

The Walk Access to Non-Work Destinations performance measure excludes features with the functional classification attribute 'Interstate'

or 'Other Freeways and Expressways' functional classification because pedestrians are not permitted on these facilities.

Edit the 'Select Comprehensive Plan Development Areas' parameter to filter segments by name or by type. Edit the 'Select WalkScore Threshold' parameter walk_score variable to limit the analysis to segments where the WalkScore is greater than or equal to 50 (i.e., 'Somewhat Walkable' according to WalkScore analysis).

3 – PROCESS FOR THE IDENTIFICATION OF NEEDS

Walk Access to Non-Work Destinations by Disadvantaged Populations

The need for walk access to non-work destinations by disadvantaged populations is similar to the performance measure described in the previous section but the combined WalkScore and BikeScore is weighted by disadvantaged population from Equity Emphasis Areas in the InteractVTrans Map Explorer instead of future activity level. Like walk access to non-work destinations, this performance measure shows locations that are in close proximity to non-work destinations and disadvantaged populations and where there is high network connectivity. However, these locations may still have barriers to walking not accounted for in the WalkScore methodology including lack of sidewalks or crosswalks along existing facilities. Therefore, the walk access to non-work destinations by disadvantaged populations performance measure indicates where investments in pedestrian improvements would likely yield the greatest benefits for disadvantaged residents.

Segment eligibility for walk access to non-work destinations for disadvantaged populations scoring may be determined by one of the following optional thresholds:

1. All segments in EEAs where transit is available
2. All segments in EEAs where transit is available and that are also in “somewhat walkable” census tracts (i.e., WalkScores of 50 or higher)

The implication of selecting all segments in transit EEAs for walk access to non-work destinations scoring is that the current WalkScore does not affect which segments are scored for walk access to jobs by disadvantaged populations. Conversely, the effect of choosing the threshold option that limits scoring to segments in “somewhat walkable” locations is that “car-dependent” EEAs which have a combined WalkScore and BikeScore of less than 50 will not be considered for scoring.

Calculation Steps

The following steps outline the process for assessing the magnitude of the walk access to non-work destinations need:

1. Calculate segments’ average WalkScore by performing a spatial join of segments that intersect the WalkScore feature layer.
2. Calculate segments’ disadvantaged population by performing a spatial join of segments that intersect the Equity Emphasis Areas (EEA) Census tract layer. Sum the low-income population, age 75-plus population, disabled population, limited English proficiency population, minority population, and Hispanic

population for each segment.

3. Calculate segments’ weighted WalkScore by multiplying average WalkScore by average disadvantaged populations in intersecting zones.

$$\text{Weighted Walk Score} = \text{Walk Score} \times \text{Segment Disadvantaged Population}$$

4. Normalize the weighted WalkScore using the following equation:

$$\text{Normalized Walk Score} = \frac{\text{Weighted Walk Score}_i - \text{Weighted Walk Score}_{\min}}{\text{Weighted Walk Score}_i - \text{Weighted Walk Score}_{\max}}$$

Where:

$\text{Weighted WalkScore}_i = \text{WalkScore} \times \text{disadvantaged population of Segment } i$

$\text{Weighted WalkScore}_{\min} = \text{Minimum WalkScore} \times \text{disadvantaged population of all segments}$

$\text{Weighted WalkScore}_{\max} = \text{Maximum WalkScore} \times \text{disadvantaged population of all segments}$

Scoring of Walk Access to Non-Work Destinations for Disadvantaged Populations Needs

Sort the normalized average WalkScore weighted by disadvantaged population. Then, using **Table 20**, assign the need score based on the segments’ cumulative length percentage of the combined mileage of all segments that have a need for walk access to non-work destinations.

Table 20 Walk access to non-work destinations for disadvantaged populations need scores

| Need Category | Need Score | Percent of Total Mileage |
|---------------|------------|--------------------------|
| Very High | 7 | 0% to 5% |
| High | 6 | 5.001% to 10% |
| Medium High | 5 | 10.001% to 15% |
| Medium | 4 | 15.001% to 20% |
| Medium Low | 3 | 20.001% to 25% |
| Low | 2 | 25.001% to 50% |
| Very Low | 1 | 50.001% to 100% |

Data Requirements

- WalkScore and BikeScore (source: InteractVTrans)
- Equity Emphasis Areas (source: InteractVTrans Map Explorer)

3 – PROCESS FOR THE IDENTIFICATION OF NEEDS

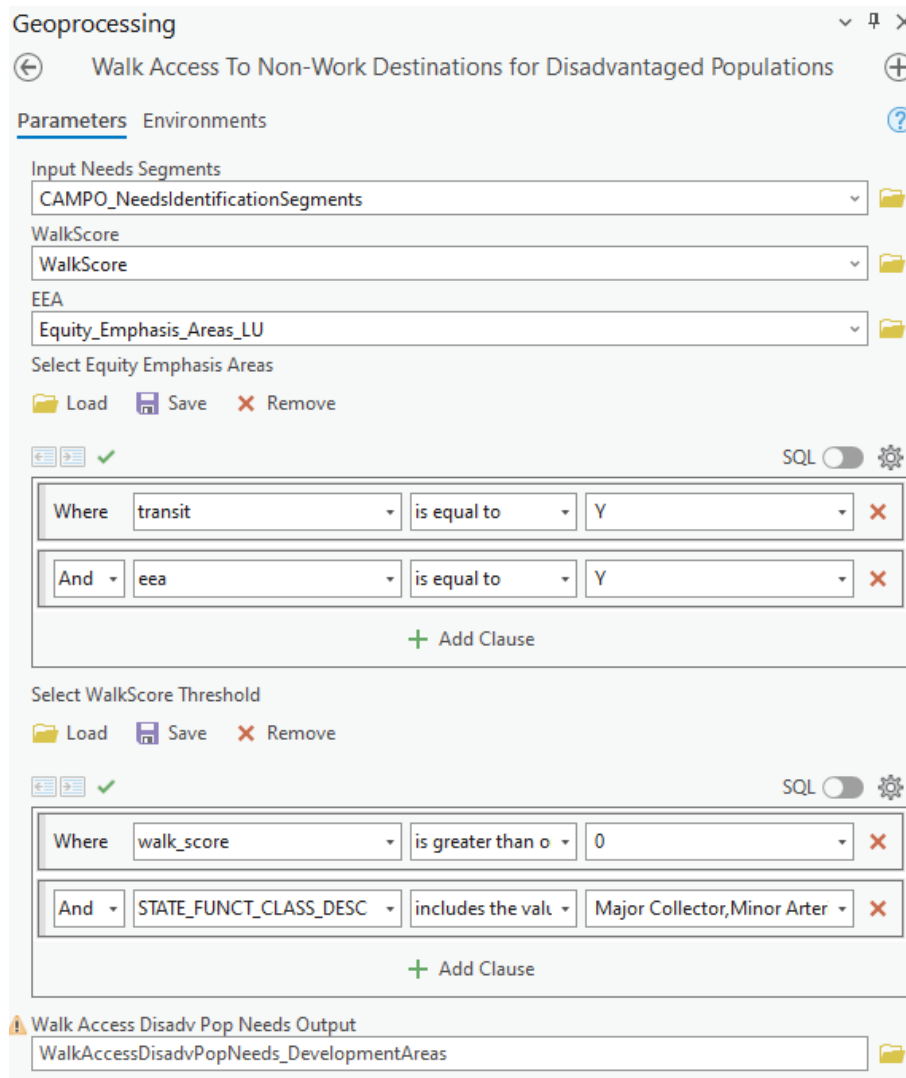


Figure 12 Walk Access to Non-Work Destinations for Disadvantaged Populations Geoprocessing Tool

Geoprocessing Tool Overview

Set the parameters in the *Walk Access to Non-Work Destinations* geoprocessing tools exactly as shown in the above figures with input data saved in the following Input geodatabases. Save outputs with a descriptive name in the following output geodatabase.

Input Geodatabases:

- C:\PerformanceBasedPlanningProcess\Inputs\csv\Mobility
- C:\PerformanceBasedPlanningProcess\Inputs\Inputs.gdb (Land Use Feature Dataset)

Output Geodatabases:

- C:\PerformanceBasedPlanningProcess\Outputs\Outputs.gdb (Land Use Feature Dataset)

The Walk Access to Non-Work Destinations for Disadvantaged Populations performance measure excludes features with the functional classification attribute 'Interstate' or 'Other Freeways and Expressways' functional classification because pedestrians are not permitted on these facilities.

Edit the 'Select Comprehensive Plan Development Areas' parameter to filter segments by area name or by type (e.g., 'Community', 'Town', 'Village', or 'Neighborhood'). Edit the 'Select WalkScore Threshold' parameter walk_score variable to limit the analysis to segments where the WalkScore is greater than or equal to 50 (i.e., 'Somewhat Walkable' according to WalkScore analysis).

3 – PROCESS FOR THE IDENTIFICATION OF NEEDS

Need Category: Environment and Resiliency

The aim of the environmental category is to identify resiliency needs, especially where infrastructure is exposed to inland flooding and to prioritize projects that pose no environmental impacts, mitigate impacts, or offer environmental services.

Exposure to Projected Sea Level Rise, Storm Surge, or Historical Inland/Riverine Flooding

Environmental and Resiliency needs are accounted for as an adjustment to combined needs scores for segments that are exposed to sea level rise, storm surge, or historical flooding and are within an Economically Distressed Community. This metric adjusts the aggregate scores of all roadway segments with a need based on Flooding Risk Assessment and the Distressed Communities Index (DCI).

OIPI’s Flooding Risk Assessment is a system level analysis of the system’s assets’ (i.e., roads and bridges) vulnerability to climate change, including sea level rise, storm surge, and inland flooding. The components of vulnerability as defined by the Federal Highway Administration (FHWA) include exposure, sensitivity, and adaptive capacity. For the purposes of CAMPO’s environmental needs analysis, only system exposure to inland flooding is considered. The following definitions, which are taken from the VTrans Vulnerability

Assessment Tech Memo, reflect the components of vulnerability as defined by FHWA.

- Exposure determines whether the asset is experiencing the direct effects of climate change
- Sensitivity determines how well the system fares when exposed to climatic events
- Adaptive Capacity determines the system’s ability to adjust with future climate impacts

The Distressed Communities Index (DCI), which derives data from the American Community Survey (ACS), sorts zip codes into quintiles of economic well-being: prosperous, comfortable, mid-tier, at risk, and distressed. The seven components of DCI is the share of residents who are 25 or older who do not have a high school diploma or equivalent, housing vacancy rate, unemployment rate for working-age adults (25-54), the share of the population living under the poverty line, median household income as a percent of metro area/state median household income, the percent change in employment from 2016 to 2020, and the percent change in the number of business establishments from 2016 to 2020. **Table 21** lists zip codes in the Charlottesville-Albemarle MPO area by DCI.

Table 21 Distressed Communities Index for Zip Codes in the Charlottesville-Albemarle Area

| Zip Code | Post Office | Distressed Communities Index | Population (2021) |
|--------------------|-----------------|------------------------------|-------------------|
| 22901 | Charlottesville | 35.6 (Comfortable) | 36,964 |
| 22902 | Charlottesville | 38.5 (Comfortable) | 24,018 |
| 22903 | Charlottesville | 62.9 (At Risk) | 44,101 |
| 22904 ₄ | Charlottesville | n/a | 3,119 |
| 22911 | Charlottesville | 7.4 (Prosperous) | 18,627 |
| 22923 | Barboursville | 9.4 (Prosperous) | 6,004 |
| 22932 | Crozet | 15.3 (Prosperous) | 10,102 |
| 22936 | Earlysville | 15.4 (Prosperous) | 5,186 |
| 22947 | Keswick | 47.4 (Mid-Tier) | 5,150 |
| 22959 | North Garden | 60.7 (At Risk) | 1,932 |
| 22968 | Ruckersville | 21.9 (Comfortable) | 11,239 |
| 22974 | 22974 | 34.5 (Comfortable) | 5,441 |

3 – PROCESS FOR THE IDENTIFICATION OF NEEDS

Calculation Steps

Since project location is a critical component of environmental impacts, the Environment and Sustainability need category is applied after aggregating need scores across the other metrics described in previous sections. The adjustment factors apply to aggregate scores for road segments that are exposed to projected sea level rise, storm surge, or inland/riverine flooding and to segments in economically distressed communities.

- 5% adjustment for segments exposed to historical flooding in a 100-year flood zone
- Adjustments for economically distressed communities
 - 5.0% adjustment applied to aggregate score of road segments in a zip code that has a DCI index of 80 to 100 (i.e., distressed)
 - 3.5% adjustment applied to aggregate score of road segment in a zip code that has a DCI rating of 60 to 80 (i.e., at risk)
 - Additional 2.0% if a roadway segment falls within a zip code that has a DCI rating of 40 to 60 (i.e., mid-tier)

Data Requirements

- VTrans Flood Risk Assessment (source: InteractVTrans Map Explorer)
- Distressed Communities Index (source: Economic Innovation Group)⁵

4 – PROCESS FOR THE PRIORITIZATION OF PROJECTS

This chapter describes the overall process, performance measures, and methodologies for evaluating and prioritizing surface transportation projects, including highway and roadway, active transportation (i.e., bicycle and pedestrian), transit, and travel demand management (TDM) improvements. While the project prioritization is separate from the process for identifying needs, the process includes the same goal categories.

In general, the project prioritization performance measures evaluate changes due to project implementation, or between the base year with existing conditions and the horizon year with future conditions. Project types that are not eligible for scoring under this process are standalone studies and the maintenance of existing facilities including bridge rehabilitation, pavement repair/replacement, guardrail repair/replacement, and other activities eligible for State of Good Repair funding.

- The Crash Frequency (S1) and Crash Rate (S2) performance measures within the Safety prioritization category indicate projects where there is the highest expected reduction in the annual number of crashes after the implementation a safety treatment, improvement, or countermeasure. Projects that are expected to reduce higher numbers of crashes receive higher scores.
- The Access to Jobs (A1) and Access to Jobs for Disadvantaged Populations (A2) performance measures in the Accessibility and Equity prioritization category indicate projects where there is the most potential for improving access to employment opportunities. Projects that have the greatest potential for accessibility improvement (i.e., constructing new bike and pedestrian facilities, increasing transit frequency, reducing vehicular delay) and are located near where people live will be assigned the highest scores. The Access to Multimodal Choices (A3) performance measure assigns points to projects for increasing multimodal transportation choices such as constructing new bicycle and pedestrian facilities, increasing transit frequency, or providing additional park and ride spaces. Projects that are likely to have the greatest impacts on improving access to multimodal choices and improving air quality will receive higher scores.
- The Demand (M1) performance measures in the Mobility and System Efficiency prioritization category identify projects in areas with the highest potential volume of users who are likely to benefit from the project. Likewise, the Congestion (M2) performance measure identifies projects located in areas with the most congestion. Projects in in areas with more traffic and congestion receive higher scores.
- The Access to Non-Work Destinations (L1) and Access to Non-Destinations for Disadvantaged Populations (L2) performance

measures in the Land use and Economic Development prioritization categories identify high ‘walkability’ areas through the MPO and within equity emphasis areas. Projects that score highly in this measure are most likely to integrate into the existing bicycle and pedestrian network. The Proximity to Activity Centers (L3) and Job Growth (L4) performance measures identify projects which are closest to concentrations of regional economic activity. These projects are likely to have the greatest impact on economic development.

- The Sensitive Features (E1) performance measure within the Environmental Impacts prioritization category identify projects that the fewest environmental impacts. This measure in an inverse measure which means that projects with the fewest impacts will receive the highest score.

4 – PROCESS FOR THE PRIORITIZATION OF PROJECTS

Prioritization Category: Safety

The Safety prioritization category is evaluated based on the performance measure weights shown **Table 22**.

Table 22 Safety Performance Measure Weights

| Performance Measure | Weight |
|----------------------|--------|
| Crash Frequency (S1) | 50% |
| Crash Rate (S2) | 50% |
| Total | 100% |

These performance measures are appropriate for measuring the safety benefits of highway and roadway improvements at intersections, interchanges, bridges, freeway segments, and non-freeway segments, as well as bicycle and pedestrian related improvements such as new sidewalks, bicycle lanes, shared use paths, and crossing improvements.

Estimation of changes in crash frequency and rate relies on the use of Crash Modification Factors (CMF). The CMF is a multiplicative factor used to compute the expected reduction in the number of crashes after implementing a safety improvement, treatment, or countermeasure at a specific site. While the Crash Modification Factors Clearinghouse contains thousands of CMFs covering hundreds of treatment options for a variety of crash types, crash severities, and site locations, this process uses a simplified list of fatal and injury CMFs used for SMART SCALE. For example, the conversion of stop/yield control to a signal is expected to reduce the number of fatal and injury crashes by 35% because of a planning level CMF of 0.65 ($1 - 0.65 = 0.35 \times 100 = 35\%$)

Project types where CMFs are not available, including standalone transit and travel demand management (TDM) projects do not qualify for Safety scoring. **Table 23** lists the relationship between project type and the crash data needed for the safety analysis of highway and roadway projects and bicycle and pedestrian projects.

Table 23 Safety Project Prioritization Data by Project Type

| Project Type | Crash Type | Crash Severity |
|-----------------------|------------------------|------------------|
| Highway and Roadway | Motor vehicle | Fatal and Injury |
| Active Transportation | Bicycle and pedestrian | Fatal and Injury |

Crash Frequency (S1)

This measure calculates the reduction in Equivalent Property Damage Only (EPDO) crash frequency. The expected change in crashes is calculated using simplified planning level crash modification factors (CMF) associated with the project improvement. The outcome of this measure is the annual change in the number of fatal and injury crashes due to project implementation.

Calculation Steps

1. Add the project limits layer to an ArcMap document and create 250 foot buffers around each project.
2. Add crash data to the map document, then calculate EPDO weights for each row in a new field using the crash severity conversion values in **Table 3**.
3. Use the 'Spatial Join' tool to join points in the crash layer that intersect the project limits buffer layer. Calculate the sum of crashes by EPDO that intersect the project limits buffer.
4. Calculate the average annual EPDO by dividing the sum of crashes in the project area weighted by EPDO by the number of years included in the analysis.
5. Calculate the Percent Expected Crash Reduction (PECR) using the appropriate CMF for the project improvements with the following equation:

$$PECR = 1 - CMF$$
6. Calculate the expected annual reduction in crashes by multiplying the annual average EPDO of fatal and injury crashes by PECR.

Data Requirements

- Project limits
- 5 year crash data (source: InteractVTrans Map Explorer)
- SMART SCALE Planning Level CMFs (source: https://smartscale.org/documents/cmf-list-smart-scale-rd4_fy2022.pdf)

4 – PROCESS FOR THE PRIORITIZATION OF PROJECTS

Crash Rate (S2)

This measure calculates the annual reduction in EPDO of fatal and injury crashes (EPDOF+I) per Hundred Million Vehicle Miles Traveled (HMVMT) on a roadway segment or Million Entering Vehicles (MEV) for an intersection. Crash rate allows for better comparison between projects on routes with different traffic volumes. The outcome of this measure is the change in the annual rate of fatal and injury crashes weighted by severity (EPDOF+I) per HMVMT (segments) or MVE (intersections) due to project implementation.

Calculation Steps

1. Add the project limits layer to an ArcMap document and create 250 foot buffers around each project.
2. Add the AADT layer.
3. Use Select by Location to select segments in the AADT layer that intersect the project limits. Manually deselect segments in the buffer that are on roads not part of the project. For intersection improvements, include all segment approaches and exclude parallel segments. For highway and road projects that are not at an intersection, include the segments where the project is physically located and exclude side streets and parallel segments
4. Calculate the length of segments that intersect the project limits buffer layer using the 'Calculate Geometry' tool. Ensure that all other segments have a zero or null value
5. Use the 'Spatial Join' tool to join segments in the AADT layer that intersect the project limits buffer layer.
6. For segments (i.e., non-intersection projects), calculate the annual traffic volume in HMVMT. For projects that cross multiple segments, HMVMT is the cumulative annual VMT for all segments, calculated for each segment using its AADT and length. For intersections, calculate the annual traffic volume in Million Entering Vehicles (MEV)

$$HMVMT = \frac{\sum AADT_i \times Segment\ Length_i \times 365}{1,000,000}$$

$$MEV = \frac{\sum AADT_i \times 365}{1,000,000}$$

7. Calculate reduction in annual EPDO of fatal and injury crashes due to project implementation (measure S1)

$$Segment\ Crash\ Rate = \frac{EPDO_{K+1}}{HMVMT}$$

$$Intersection\ Crash\ Rate = \frac{EPDO_{K+1}}{MEV}$$

8. Convert reduction in annual EPDO of fatal and injury crashes into the reduced crash rate using the following formulas

Data Requirements

- Project Limits
- 5 year crash data (source: InteractVTrans Map Explorer)
- Planning Level Crash Modification Factors (CMF) (source: SMART SCALE Planning Level Crash Modification Factors)
- Average Annual Daily Traffic (source: InteractVTrans Map Explorer)

4 – PROCESS FOR THE PRIORITIZATION OF PROJECTS

Prioritization Category: Accessibility and Equity

The Accessibility and Equity prioritization category is evaluated based on the performance measure weights shown **Table 24**.

Table 24 Accessibility and Equity Performance Measure Weights

| Performance Measure | Weight |
|---|--------|
| Access to Jobs (A1) | 40% |
| Access to Jobs for Disadvantaged Populations (A2) | 40% |
| Access to Multimodal Choices (A3) | 20% |
| Total | 100% |

Access to Jobs (A1)

The Access to Jobs measure calculates a project’s potential for improving access to job opportunities for all populations. Scores are determined by the project’s weighted average Potential for Accessibility Improvement (PAI) within a buffer distance of the project limits. The buffer distance for evaluating the Census blocks impacted by project implementation is determined by project mode (auto, transit, non-motorized).

PAI is estimated as the difference between the “current” accessibility offered and a “reference” condition. The “current” condition refers to the cumulative number of activities (jobs in the case of all metrics generated in this process) accessible from a given location applying parameters, such as level of traffic stress (LTS) or average travel speed, that influence the estimated travel times among zones. The “reference” condition refers to the cumulative number of jobs accessible from the same location but with hypothetical parameters that yield an estimated maximum level of job accessibility. Refer to the chapter on the Process for the Identification of Needs for more information about terms referred to in the project prioritization process.

Calculation Steps

1. Add the project limits layer to an ArcMap document and create buffers to select Census blocks within a specified distance of the project (catchment area).
2. Add the Census blocks layer and block-level accessibility and population attribute data to an ArcMap document. See **Table 25** to determine data tables needed for each project type. Create buffers based on project type using the catchment area.

Table 25 Accessibility and Equity Performance Measure Parameters

| Project Type | Current Condition | Reference Condition | Maximum Travel Time (minutes) | Catchment Area (miles) |
|------------------------|--------------------------|-------------------------|-------------------------------|------------------------|
| Bicycle and Pedestrian | Bike LTS 1 (High Stress) | Bike LTS 4 (Low Stress) | 20 | 3 |
| Transit | Transit | Auto 8 AM (Off Peak) | 45 | 5 |
| Highway and Roadway | Auto 8 AM (Peak) | Auto 12 AM (Off Peak) | 45 | 10 |

3. In the Census blocks layer, create four new fields (data type Long) named ‘reference’, ‘current’, ‘PAI’, and ‘population’. Join the block-level accessibility and population attribute data to the Census block layer then calculate the ‘current’, ‘reference’, and ‘population’ fields from the joined data.
4. For each Census block, calculate ‘PAI’ as the difference between the reference condition and current condition, or the accessibility deficit between the current condition and the reference condition.

$$PAI = Reference - Current$$

5. Add the Functional Classification layer and then use the ‘Spatial Join’ tool to join the Census blocks that have their center within the catchment area. Sum the population of blocks within the catchment area.
6. Calculate the weighted average PAI for each functional classification segment by multiplying PAI by the total population of the census block in which the segment is located then divide by the total population of the catchment area.

$$Population\ Weighted\ PAI = Population \times PAI$$

$$Weighted\ Average\ PAI = \frac{Population\ Weighted\ PAI_i}{Catchment\ Population_i}$$

4 – PROCESS FOR THE PRIORITIZATION OF PROJECTS

7. Calculate the raw access score. First, assign a functional classification (FC) score to all road segments. Next, calculate the raw score for transit access to jobs performance measure by multiplying segments' weighted average accessibility improvement by its FC score. In Chapter 3 on the Process for the Identification of Needs, see **Table 9** for Functional Classification Value for Transit and Active Transportation Projects and **Table 11** for Highway and Roadway Projects.

$$\text{Raw Score} = \text{Weighted Average PAI} \times \text{FC Score}$$

8. Calculate the project accessibility score with the following steps:
 - Intersect the Project Limits layer with the Census Block layer that contains population and Potential for Accessibility Improvement
 - Spatial Join the intersected Project Limits layer with the Census Census Block layer that contains population and sum the population in the catchment area
 - Calculate the raw score for the project's intersects with the Census Block layer using the raw need score equation from the Access to Jobs needs identification category
 - Calculate the length-weighted average for the project

Data Requirements

- Project Limits
- Census blocks
- NAE Current Condition and NAE Reference Condition
- Census block population
- Functional Classification (source: InteracVTrans Map Explorer)

4 – PROCESS FOR THE PRIORITIZATION OF PROJECTS

Access to Jobs for Disadvantaged Populations (A2)

The Access to Jobs measure calculates a project’s potential for improving access to job opportunities for disadvantaged populations. Scores are determined by the project’s weighted average Potential for Accessibility Improvement (PAI) in Equity Emphasis Areas (EEA) within a buffer distance of the project limits. The buffer distance for evaluating the Census blocks impacted by project implementation is determined by project mode (auto, transit, non-motorized).

PAI is estimated as the difference between the “current” accessibility offered and a “reference” condition. The “current” condition refers to the cumulative number of activities (jobs in the case of all metrics generated in this process) accessible from a given location applying parameters, such as level of traffic stress (LTS) or average travel speed, that influence the estimated travel times among zones. The “reference” condition refers to the cumulative number of jobs accessible from the same location but with hypothetical parameters that yield an estimated maximum level of job accessibility. Refer to the chapter on the Process for the Identification of Needs for more information about terms referred to in the project prioritization process.

Calculation Steps

1. Add the project limits layer to an ArcMap document and create buffers to select Census blocks within a specified distance of the project (catchment area).
2. Add the Census blocks layer and block-level accessibility and population attribute data to an ArcMap document. See **Table 25** to determine data tables needed for each project type. Create buffers based on project type using the maximum travel distance thresholds.
3. In the Census blocks layer, create four new fields (data type Long) named ‘reference’, ‘current’, ‘PAI’, and ‘population’. Join the block-level accessibility and population attribute data to the Census block layer then calculate the ‘current’, ‘reference’, and ‘population’ fields from the joined data.
4. For each Census block, calculate ‘PAI’ as the difference between the reference condition and current condition, or the accessibility deficit between the current condition and the reference condition.

$$PAI = Reference - Current$$

5. Add the Functional Classification layer and then use the ‘Spatial Join’ tool to join the Census blocks that have their center within the catchment area. Sum the population of blocks within the

catchment area.

6. Calculate the eligible disadvantaged population (EDP) weighted average PAI for each functional classification segment by multiplying PAI by the EDP of the census block in which the segment is located then divide by the EDP of the catchment area

$$Population\ Weighted\ PAI = Population \times PAI$$

$$Weighted\ Average\ PAI = \frac{Population\ Weighted\ PAI_i}{Catchment\ Population_i}$$

7. Calculate the raw access score. First, assign a functional classification (FC) score to all road segments. Next, calculate the raw score for transit access to jobs performance measure by multiplying segments’ weighted average accessibility improvement by its FC score. In Chapter 3 on the Process for the Identification of Needs, see **Table 9** for Functional Classification Value for Transit and Active Transportation Projects and **Table 11** for Highway and Roadway Projects.

$$Raw\ Need\ Score = Weighted\ Average\ PAI \times FC\ Score$$

8. Calculate the project accessibility score with the following steps:
 - Intersect the Project Limits layer with the Census Block layer that contains population and Potential for Accessibility Improvement
 - Spatial Join the intersected Project Limits layer with the Census Census Block layer that contains population and sum the population in the catchment area
 - Calculate the raw score for the project’s intersects with the Census Block layer using the raw need score equation from the Access to Jobs needs identification category
 - Calculate the length-weighted average for the project

Data Requirements

- Project Limits
- Census blocks
- NAE Current Condition and NAE Reference Condition
- Census block population
- Functional Classification (source: InteractVTrans Map Explorer)
- Equity Emphasis Areas (source: InteractVTrans Map Explorer)

4 – PROCESS FOR THE PRIORITIZATION OF PROJECTS

Access to Multimodal Choices (A3)

This measure considers the degree to which a project can increase access to non-single occupant vehicle (SOV) travel options. The objective is to assign more points to projects that that promote multimodal transportation, enhance connections between modes or create new connections to travel destinations. The outcome of this measure is points assigned to projects for providing elements that increase access to multimodal transportation.

Calculation Steps

1. Assign total points to TDM projects that include the following active transportation and transit elements (maximum of five points):
 - Transit system improvements on a route with at least 1 transit vehicle per hour = 5 points
 - Improvements to an existing or proposed park-and-ride lot = 4 points
 - Construction, enhancement, or replacement of substandard bicycle facilities = 1.5 points
 - Construction, enhancement, or replacement of substandard pedestrian facilities = 1.5 points

Data Requirements

- Project Improvements

4 – PROCESS FOR THE PRIORITIZATION OF PROJECTS

Prioritization Category: Mobility and System Efficiency

The performance measures in the Mobility and System Efficiency prioritization category are evaluated based on the performance measure weights in **Table 26**.

Table 26 Mobility and System Efficiency Performance Measure Weights

| Performance Measure | Weight |
|---------------------|--------|
| Demand (M1) | 50% |
| Congestion (M2) | 50% |
| Total | 100% |

Demand (M1)

This measure calculates the demand for the project based on existing traffic volumes around the project limits for highway and roadway projects. The demand measure uses Annual Average Daily Traffic (AADT) to identify the potential volume of users who are likely to benefit from the project.

Calculation Steps

1. Add the project limits and AADT layers to an ArcMap document and create quarter mile buffers around each project.
2. Use Select by Location to select segments in the AADT layer that intersect the project limits buffer. Manually deselect segments in the buffer that are on roads not part of the project. For intersection improvements, include all segment approaches and exclude parallel segments. For highway and road projects that are not at an intersection, include the segments where the project is physically located and exclude side streets and parallel segments.
3. If necessary, create a 'Mileage' field (data type Double), then calculate the length of the AADT segments that intersect the project limits buffer, then use the 'Calculate Geometry' tool to calculate the length of each segment.
4. Use the 'Spatial Join' tool to calculate the length sum of all AADT segments that intersect the project limits buffer.
5. Add a field named 'VMT' (data type Long) to the attribute table in which to calculate Vehicle Miles Traveled for each selected segment. Multiply the AADT field by 'Mileage' using the field calculator to calculate Vehicle Miles Traveled.
6. Calculate the weighted-average AADT for the project by dividing the total VMT of all segments by the total length of all segments:

$$AADT = \frac{\sum VMT_n}{\sum Length_n}$$

Data Requirements

- Project limits
- Average Annual Daily Traffic

4 – PROCESS FOR THE PRIORITIZATION OF PROJECTS

Congestion (M2)

This measure estimates the level of traffic congestion around the project limits. Congestion is measured by the average Travel Time Index (TTI) of segments within a quarter mile of the project. TTI is the ratio of a segment's typical travel time during an observed period (such as the morning or evening peak commuting period) to the time required to travel the same distance in a reference period (under free-flow conditions, e.g.). For example, a value of 1.3 indicates a 20-minute trip during free-flow conditions requires 26 minutes to complete during the peak period.

Calculation Steps

1. Add the project limits and TTI layers to an ArcMap document and create quarter mile buffers around each project.
2. Identify the segment TTI as the maximum hourly travel time index across all hours in the most recent year for each segment.
3. Use Select by Location to select segments in the TTI layer that intersect the project limits buffer. Manually deselect segments in the buffer that are on roads not part of the project. For intersection improvements, include all segment approaches and exclude parallel segments. For highway and road projects that are not at an intersection, include the segments where the project is physically located and exclude side streets and parallel segments.
4. If necessary, create a 'Mileage' field (data type Double), then calculate the length of the TTI segments that intersect the project limits buffer, then use the 'Calculate Geometry' tool to calculate the length of each segment.
5. Use the 'Spatial Join' tool to calculate the length sum of all TTI segments that intersect the project limits buffer.
6. Add a field named 'WeightedTTI' (data type Double) to the attribute table in which to calculate weighted Travel Time Index for each selected segment. Multiply the TTI field by 'Mileage' using the field calculator to calculate weighted Travel Time Index.
7. Calculate the length weighted-average TTI for the project by dividing the cumulative TTI of all segments by the total length of all segments:

Data Requirements

- Project limits
- Travel Time Index (source: InteractVTrans Map Explorer)

4 – PROCESS FOR THE PRIORITIZATION OF PROJECTS

Prioritization Category: Land Use and Economic Development

The performance measures in the Land Use and Economic Development prioritization category are evaluated based on the performance measure weights in **Table 27**.

Table 27 Land Use and Economic Development Performance Measure Weights

| Performance Measure | Weight |
|--|--------|
| Access to Non-Work Destinations (L1) | 35% |
| Access to Non-Work Destinations for Disadvantaged Populations (L2) | 35% |
| Proximity to Activity Centers (L3) | 10% |
| Job Growth (L4) | 20% |
| Total | 100% |

Access to Non-Work Destination (L1)

This measure combines Walk Score and Bike Score metrics with job growth to evaluate the ease of accessing non-work destinations on foot or bike at a given location. The outcome of this performance measure is the ability to access non-work destinations by bike or on foot and the potential of the project to improve network connectivity for travel by bike or pedestrian modes.

Factors that are considered in the Walk Score include population density, block length, intersection density, and proximity to amenities. Bike Score considers existing bike facilities, hills, road connectivity, and the share of bike commuters. The Access to Non-Work destinations measure is applied to active transportation, transit, and TDM projects only.

Calculation Steps

1. Add the Walk Score, Bike Score, and the project limits layers to an ArcMap document.
2. Use the 'Buffer' tool to create a quarter mile buffer around the project limits.
3. Intersect the project limits buffer with the Walk Score and Bike Score layers.
4. Recalculate the length of each segment resulting from the intersection.

5. Calculate what proportion of each Walk Score and Bike Score zone belongs to each segment.
 - For point or polygons projects (such as park-and-ride lots), assign the Walk Score and the Bike Score assign the point or polygon centroid is located.
 - For a transit project, if stops have been designated, assign the average of each of the stop's Walk Scores and Bike Scores to the project. If stops have not been designated yet, average Walk Scores and Bike Scores at regular intervals along the affected transit route.
6. Calculate the length weighted average Walk Score and Bike Score for each project.
7. Average the Walk Score and Bike Score together to create a single score for the project.

Data Requirements

- Project limits
- WalkScore (source: InteractVTrans Map Explorer)
- BikeScore (source: InteractVTrans Map Explorer)

4 – PROCESS FOR THE PRIORITIZATION OF PROJECTS

Access to Non-Work Destination for Disadvantaged Populations (L2)

This measure combines Walk Score and Bike Score metrics with job growth to evaluate the ease of accessing non-work destinations on foot or bike at a given location. The outcome of this performance measure is the ability to access non-work destinations by bike or on foot and the potential of the project to improve network connectivity for travel by bike or pedestrian modes for disadvantaged populations.

Factors that are considered in the Walk Score include population density, block length, intersection density, and proximity to amenities. Bike Score considers existing bike facilities, hills, road connectivity, and the share of bike commuters. The Access to Non-Work destinations measure is applied to active transportation, transit, and TDM projects only.

Calculation Steps

1. Add the Walk Score, Bike Score, and the project limits layers to an ArcMap document.
2. Use the 'Buffer' tool to create a quarter mile buffer around the project limits.
3. Intersect the project limits buffers within Equity Emphasis Areas with the Walk Score and Bike Score layers.
4. Recalculate the length of each segment resulting from the intersection.
5. Calculate what proportion of each Walk Score and Bike Score zone belongs to each segment.
 - For point or polygons projects (such as park-and-ride lots), assign the Walk Score and the Bike Score assign the point or polygon centroid is located.
 - For a transit project, if stops have been designated, assign the average of each of the stop's Walk Scores and Bike Scores to the project. If stops have not been designated yet, average Walk Scores and Bike Scores at regular intervals along the affected transit route.
6. Calculate the length weighted average Walk Score and Bike Score for each project.
7. Average the Walk Score and Bike Score together to create a single score for the project.

Data Requirements

- Project limits
- WalkScore (source: InteractVTrans Map Explorer)
- BikeScore (source: InteractVTrans Map Explorer)
- Equity Emphasis Areas (source: InteractVTrans Map Explorer)

4 – PROCESS FOR THE PRIORITIZATION OF PROJECTS

Proximity to Activity Centers (L3)

Activity centers are defined by OIPI as “areas of regional importance that have a high density of economic and social activity”. This measure calculates the number of activity centers within a specified distance of the project based on functional classification or project type.

Calculation Steps

1. Add the project limits layer to an ArcMap document.
2. In a new ‘buffer’ field (data type Double), calculate buffer distance by functional classification with the values in the buffer size column in **Table 28**. For point or polygons projects (such as park-and-ride lots), assign the Walk Score and the Bike Score assign the point or polygon centroid is located.
3. Run the ‘Buffer’ tool, setting the buffer distance to values in the ‘Buffer’ field.

Table 28 Functional Classification Buffer Size

| Project Type | Functional Class | Buffer Size (Miles) |
|--|---|---------------------|
| Highway and Roadway Projects | Interstate Principal Arterial | 10 |
| | Minor Arterial | 7.5 |
| | Major Collector Minor Collector Local | 5 |
| Active Transportation, Transit, and TDM Projects | n/a | 1 |

Data Requirements

- Project limits
- VTrans Activity Centers (source: InteractVTrans Map Explorer)
- Functional Classification (source: InteractVTrans Map Explorer)

4 – PROCESS FOR THE PRIORITIZATION OF PROJECTS

Job Growth (L4)

This measure calculates the change in jobs in the vicinity of a project between a base year and a horizon year (e.g., from 2021 to 2045) using data found in the regional travel demand model. The change in jobs is evaluated using Traffic Analysis Zones (TAZ) within a specified distance of the project based on functional classification. The outcome of this measure is expected total number of new jobs that will be served by the project.

Calculation Steps

1. Add the project limits layer to an ArcMap document.
2. In a new 'Buffer' field (data type Long), calculate buffer distance by functional classification with the values in the buffer size column in **Table 28**.
3. Run the 'Buffer' tool, setting the buffer distance to the values in the 'Buffer' field.
4. Use the 'Spatial Join' tool to join TAZs that have their center in each project limits buffer. In the tool dialogue box, sum the 2021 jobs and 2045 jobs.
5. In a new 'growth' field (data type Long), calculate the total job growth for the project area by subtracting the total 2021 jobs from the total 2045 jobs.

Data Requirements

- Project limits
- Base Year (2021) and Horizon year (2045) total employment (source: VDOT Transportation and Modeling and Accessibility Program)
- Functional Classification (source: InteractVTrans Map Explorer)

4 – PROCESS FOR THE PRIORITIZATION OF PROJECTS

Prioritization Category: Environmental Impact

The performance measures in the Environmental Impact prioritization category are evaluated based on the performance measure weights in **Table 29**.

Table 29 Environmental Impact Performance Measure Weights

| Performance Measure | Weight |
|-------------------------|--------|
| Sensitive Features (E1) | 100% |
| Total | 100% |

Sensitive Features (E1)

Some infrastructure projects have impacts on the natural environment, including watersheds, wetlands, and animal habits. Additionally, building areas that regularly flood can reduce the functionality of the infrastructure during severe storms. Furthermore, lands sets aside for public use, agricultural, or historic value may be impaired by nearby development. The sensitive features performance measure calculates the percentage of acres of environmentally sensitive areas, including wetlands, flood hazard zones, and conservation lands within a quarter mile of the project limits. This measure is an inverse measure which means that the project with the fewest impacts (i.e., lowest percentage of impacted land within project buffer) will receive the highest score.

Calculation Steps

1. Add the environmentally sensitive area layers and the project limits layer to an ArcMap document. Add a field named "tier" to the project limits attribute table. Project tier is determined by the type of environmental document required: a Categorical Exclusion (Tier 1), an Environmental Assessment (Tier 2), or an Environmental Impact Statement (Tier 3).
2. Use the 'Dissolve' tool to dissolve environmentally sensitive areas into one feature (DCR conservation lands, 'AE' Flood Hazard Zone, DCR Conservation Lands, Wetlands).
3. Use the 'Buffer' tool to create a quarter mile buffer around the project limits.
4. Run the 'Intersect' tool on the buffered project limits layer and the dissolved environmentally sensitive areas layer to determine the areas of overlap between the two layers.
5. Calculate the total areas of the quarter mile buffer layer around the project and the intersect layer with environmentally sensitive and conservation areas by adding a field named "SqMi" to the

attribute tables of both layers. Then use 'Calculate Geometry' to calculate square mileage for all features of both layers

6. Adjust the intersect layer based on the following adjustment factors and the formula:
 - Tier 1 (Categorical Exclusion) - 10%
 - Tier 2 (Environmental Assessment) - 30%
 - Tier 3 (Environmental Impact Statement - 50%

$$\text{Impact Area} = \text{Overlap Area (mi}^2\text{)} \times \text{Adjustment Factor}$$

7. Sum the weighted intersection areas and divide the impact area by the project buffer to get the impacted percentage of land within the project limits.

Data Requirements

- Project limits
- Conservation Lands (source: Department of Conservation and Recreation. Retrieve from: <https://www.dcr.virginia.gov/natural-heritage/cldownload>)
- Wetlands (source: Virginia Fish and Wildlife Service. Retrieve from: <https://fwsprimary.wim.usgs.gov/wetlands/apps/wetlands-mapper/>)
- Flood Hazard Zones (source: Federal Emergency Management Agency. Retrieve from: <https://msc.fema.gov/portal/advanceSearch>). To download Flood Hazard Zones:
 1. Enter product IDs and download flood hazard zones for Albemarle County and the City of Charlottesville ('NFHL_51003C').
 2. Export 'AE' flood zones to a new shapefile or polygon feature class in a file geodatabase. Zone 'AE' designates areas subject to inundation by the 100-year flood (i.e., a flood that statistically has a 1% chance of occurring in any given year).

4 – PROCESS FOR THE PRIORITIZATION OF PROJECTS

Project Scoring

1. Calculate the raw value for all performance measures within the five prioritization category for each project.
2. Normalize raw scores by performance measure (PM) to compare scores across multiple projects. The normalization procedure results in an unweighted project benefit score of 0 to 100. Use the following equation:

$$\text{Normalized Score} = \frac{\text{Raw Score}_i - \text{RawScore}_{\min}}{\text{Raw Score}_{\max} - \text{RawScore}_{\min}}$$

Where,

RawScore_i = Raw score for project i in each performance measure

RawScore_{\min} = Minimum raw score for each performance measure

RawScore_{\max} = Maximum raw score for each performance measure

3. Multiply the normalized performance measure score by their respective measure weights.
4. Sum the weighted normalize performance measure scores within each performance measure to produce the scoring value for each prioritization category.
5. Multiply the total prioritization category score by its respective weight to produce the weighted prioritization category scoring value. Choose one scenario weighting scheme from **Table 30** to determine the appropriate weights for each prioritization

category. The Safety prioritization category weight is equivalent in the 'accessibility' and 'mobility' scenarios in recognition of the importance of safety throughout all scenarios

- The 'Accessibility' scenario prioritizes projects that increase access to jobs, non-work destinations, and multimodal choices for bicycling, walking, and transit.
 - The 'Balanced' scenario prioritized each prioritization equally with an increased emphasis on limiting environmental impacts
 - The 'mobility' scenario prioritizes highway and roadway projects that reduce vehicular delay.
6. Sum the weighted prioritization category scoring value to produce the project benefit score.
 7. If cost information is available for every project, divide each project's benefit score by its total project cost (per \$10 million) to produce the project score. If cost is not available, record the project's benefit score as its project score.
 8. Rank projects by project score in descending order (the project receiving the highest score will be ranked first).

Table 30 Project Prioritization Category Weights

| Prioritization Category | Prioritization Scenarios | | |
|-----------------------------------|--------------------------|---------|----------|
| | Accessibility | Balance | Mobility |
| Safety | 25% | 20% | 25% |
| Accessibility and Equity | 30% | 20% | 20% |
| Mobility and System Efficiency | 10% | 20% | 30% |
| Land Use and Economic Development | 25% | 20% | 10% |
| Environmental Impact | 10% | 20% | 10% |
| Total | 100% | 100% | 100% |