Virginia Transit Equity and Modernization

Baseline Conditions and Needs Assessment Technical Memorandum

Final Report

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Virginia Transit at a Glance

Purpose/Place in Study

This technical memorandum summarizes the baseline conditions and opportunities for considering equity in transit planning and modernizing the Commonwealth of Virginia's transit practices. To achieve this task, the study team developed approaches for six technical areas in which the Commonwealth should focus its efforts and resources:

- Transit Accessibility
- Adequacy of Infrastructure
- Emerging Technologies
- Electrification
- Transit Safety
- System Engagement and Governance

This technical memorandum defines these technical areas, outlines the methodology and data used to assess baseline conditions, identifies next steps for further analysis, summarizes preliminary results and findings, and identifies opportunities for the Commonwealth to make transit more equitable using the findings from that analysis.

This Baseline Conditions and Opportunities Assessment follows the first technical memorandum, which provided an overview of data collected from local, state, federal, and open sources to inform the Transit Equity and Modernization Study. The opportunities identified in this technical memorandum will be used to develop an action plan and ultimately the final report to the Virginia legislature.

While this technical memorandum identifies opportunities across six different topic areas, the analyses of each area are tied to common sources of data, as described in the first technical memorandum, and a survey to all transit agencies in the Commonwealth. Results from the analyses conducted under each topic area are provided within contextual frameworks that allow for consideration of transit agency service characteristics and service area demographics; these frameworks are described below as transit service transects and Vulnerable Population Index (VPI).

Six Technical Areas

The analyses in this technical memorandum were conducted across six technical areas, which address the needs and opportunities of transit equity and modernization across linked, but separate, topics. These technical areas are:

- **Transit Accessibility:** Assesses the linkage between transit supply and need, opportunities to provide transit to underserved populations, the reach of transit travel shedstravel sheds to jobs and community resources, and trends in equitable service planning and zero-fare services.
- **Adequacy of Infrastructure:** Identifies gaps in critical transit infrastructure reporting, opportunities for improved passenger amenities and bus stop infrastructure, and conditions of fleet and facilities (in terms of State of Good Repair, as well as Americans with Disabilities Act [ADA] access).
- **Emerging Technologies:** Assesses the feasibility of implementing emerging technologies within the context of the Virginia fleet and the associated costs, benefits, and timeline for implementation.
- **Electrification:** Evaluates the current state of electric transit vehicles and fuel demands of Virginia's bus fleets and identifies opportunities and barriers to transitioning to zero-emissions buses.
- **Transit Safety:** Determines the perceptions of safety and security experienced by transit agencies, their employees, and passengers within the context of policy and regulation of safety and security and associated performance metrics to identify opportunities to improve training, oversight, guidance, and emergency preparation.
- **System Engagement and Governance:** Defines transit agency practices for engaging with communities, particularly transit-disadvantaged communities, and representing the public in transit governance; identifies areas where practices and guidance can be improved to meet state and federal requirements and lessons learned from peer agencies.

Transit Agency Survey

To capture both qualitative and quantitative inputs directly from local agencies, the study team conducted a survey from July 29 to September 1, 2021. The release of the survey was paired with a webinar for local transit agencies to inform them about the study and how agencies could participate. The survey itself had full participation from all local agencies in the Commonwealth and Virginia Railway Express (VRE). Survey questions covered all six technical areas and sought to measure interest in various topics, identify concerns and opportunities, and gauge progress on the local level toward equity and modernization goals.

Transit Service Transects

Transit service transects serve as an observational tool to identify and communicate transit service within jurisdictional boundaries such as counties or cities. Transects are defined primarily by the diversity of the types of transit service available, and the definitions are supplemented with community features such as population and employment density. The four transect categories include demand responsive, fixed route, enhanced fixed route, and areas where transit service currently is not offered. Shown in **Figure 1**, this organizational strategy captures a range of transit options available across the Commonwealth, spanning from demand-responsive services, to fixed-route buses, to rail systems. Transect definitions are flexible from capturing an array of jurisdictions and allows for service providers to plan for strategic and context-sensitive growth and improvements.

For transit service analysis, transects are an effective tool to organize data, perform analysis, and communicate findings to support the modernization of Virginia transit. To compare productively across baseline conditions, transects strategically organize geographies by transit service types, establishing a consistent structure for holistic and appropriate recommendations across Virginia. In some technical areas, alternate categorizations are employed to provide comparisons more closely linked to agency size or federal reporting requirements in addition to or in lieu of the transects.

Figure 1: Transit Service Transects by Block Group

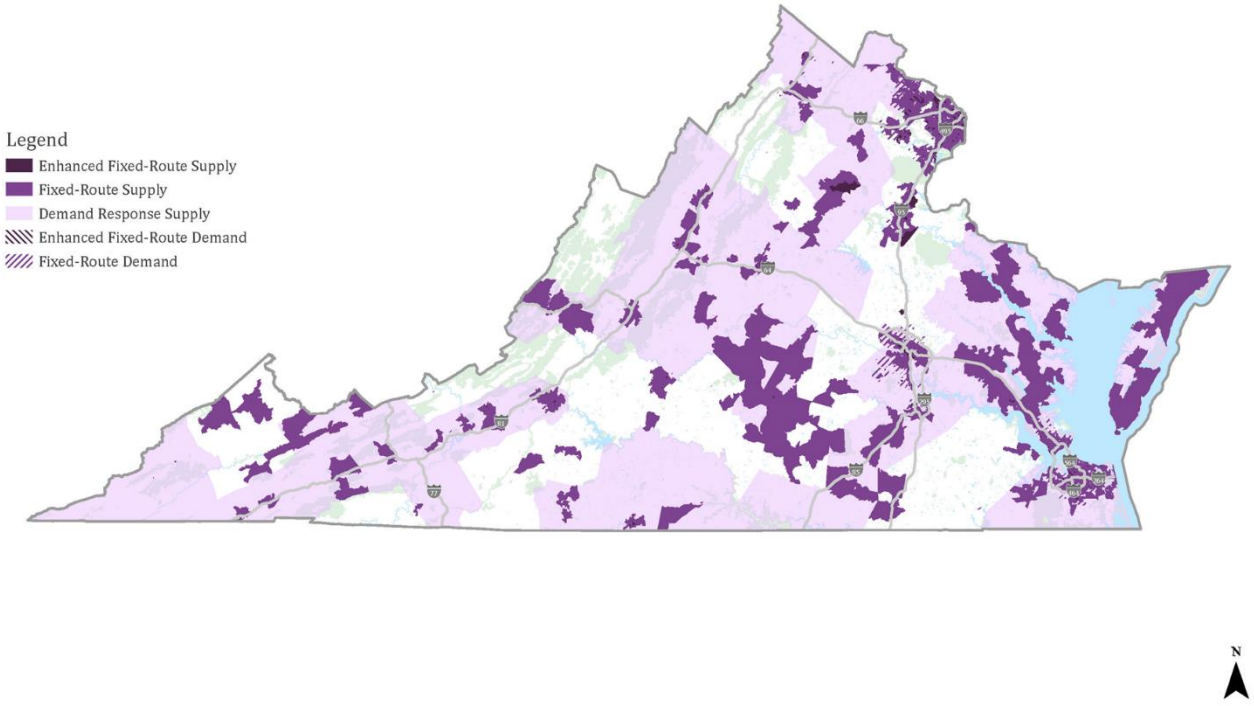


Table 1 also categorizes each agency by transect for grouping of analysis. There are 40 transit agencies in the Commonwealth considered for evaluation in the study (not including the Washington Metropolitan Area Transit Authority [WMATA]). Out of the 40 agencies, Virginia Breeze Bus Lines is unique in that it provides state-funded intercity bus service and does not report assets or infrastructure to the Federal Transit Administration (FTA). Data related to Virginia Breeze Bus Lines is limited and therefore is not included in the quantitative analysis within this technical memorandum.

Table 1: Virginia Transit Agencies by Transect and Service

Agency	Transect	Service
Lake Country Area Agency on Aging	Demand Response	Demand Response
Mountain Empire Older Citizens	Demand Response	Demand Response
Alexandria Transit Company (DASH)	Enhanced Fixed Route	Fixed-Route Bus, Demand Response – Taxi, (interface with rail)
Arlington County Transit	Enhanced Fixed Route	Fixed-Route Bus, Demand Response, Demand Response – Taxi, (interface with rail)
City of Fairfax (CUE)/Fairfax City University Energy Saver	Enhanced Fixed Route	Fixed-Route Bus, (interface with rail)

Agency	Transect	Service
Fairfax County (Fairfax Connector)	Enhanced Fixed Route	Fixed-Route Bus, (interface with rail)
Fredericksburg Regional Transit (FRED)	Enhanced Fixed Route	Fixed-Route Bus, (interface with rail)
Greater Richmond Transit Company (GRTC)	Enhanced Fixed Route	Fixed-Route Bus, Bus Rapid Transit, Demand Response, Vanpool
Hampton Roads Transit	Enhanced Fixed Route	Fixed-Route Bus, Light Rail, Ferryboat, Demand Response, Demand Response – Taxi, Vanpool
Potomac and Rappahannock Transportation Commission (PRTC, Omniride)	Enhanced Fixed Route	Fixed-Route Bus, Commuter Bus, Vanpool, (interface with rail)
Virginia Railway Express	Enhanced Fixed Route	Rail-Only Provider
Altavista Community Transit System	Fixed Route	Fixed-Route Bus, Flag Stops
Bay Transit	Fixed Route	Fixed-Route Bus, Demand Response
Blacksburg Transit	Fixed Route	Fixed-Route Bus, Demand Response
Blackstone Area Bus System	Fixed Route	Fixed-Route Bus, Flag Stops
Bristol Virginia Transit	Fixed Route	Fixed-Route Bus, Demand Response, Flag Stops
Central Shenandoah Planning District Commission (BRITE)	Fixed Route	Fixed-Route Bus, Demand Response
Charlottesville Area Transit	Fixed Route	Fixed-Route Bus
Chincoteague Pony Express/PONY EXPRESS	Fixed Route	Fixed-Route Bus, Flag Stops
Danville Transit	Fixed Route	Fixed-Route Bus, Demand Response
District Three Public Transit (Mountain Lynx)	Fixed Route	Fixed-Route Bus, Demand Response, (Fixed, Flexible - Trillium addition)
Farmville Area Bus	Fixed Route	Fixed-Route Bus, Demand Response
Four County Transit	Fixed Route	Fixed-Route Bus
Graham Transit	Fixed Route	Fixed-Route Bus, Demand Response
Greater Lynchburg Transit Company	Fixed Route	Fixed-Route Bus, Demand Response
Greater Roanoke Transit Company (Valley Metro)	Fixed Route	Fixed-Route Bus, Demand Response
Greensville-Emporia Transit	Fixed Route	Fixed-Route Bus
Harrisonburg Department of Public Transportation	Fixed Route	Fixed-Route Bus, Demand Response
Jaunt	Fixed Route	Commuter Bus, Demand Response
Loudoun County Transit	Fixed Route	Fixed-Route Bus, Commuter Bus, Demand Response
Petersburg Area Transit	Fixed Route	Fixed-Route Bus, Demand Response
Pulaski Area Transit	Fixed Route	Fixed-Route Bus, Demand Response
RADAR	Fixed Route	Fixed-Route Bus, Demand Response
Radford Transit	Fixed Route	Fixed-Route Bus
STAR Transit	Fixed Route	Fixed-Route Bus, Demand Response
Suffolk Transit	Fixed Route	Fixed-Route Bus, Demand Response
Virginia Regional Transit	Fixed Route	Fixed-Route Bus, Demand Response
Williamsburg Area Transit	Fixed Route	Fixed-Route Bus, Demand Response
Winchester (WinTran)	Fixed Route	Fixed-Route Bus, Demand Response

Vulnerable Populations Index

To link equity considerations to existing demography in transit service areas across the Commonwealth, analyses in the six technical areas used a vulnerable population index (VPI). The VPI was evaluated using seven population groups that were determined to be vulnerable based on federal requirements and regional guidance. In recent years, analysis of equity impacts in the Commonwealth has relied on the use of Equity Emphasis Areas (EEAs) as defined in the Virginia's Transportation Plan (VTrans), which looked at similar population groups to determine whether census block groups in Virginia are or are not locations where equity is a concern. Building on that defined structure, this study applies a VPI to further assess impacts to vulnerable groups, which allows for a more nuanced evaluation of correlations between technical areas and their impacts at more granular level of detail. The vulnerable population groups considered in the VPI include:

- Poverty
- Minority (i.e., non-Hispanic, non-White)
- Hispanic
- Limited English Proficiency (LEP)
- Disabled
- Elderly
- Carless

The VPI was developed using US Census Tract Block Group-level populations data from the 2019 American Community Survey for each of the seven vulnerable population types listed above. Based on this data, each US Census Tract Block Group received a score on each of the seven vulnerable population types on a 0–2 scale based on how far that vulnerable population's concentration (in percentage relative to each US Census Tract Block Group's total population) is above the statewide average. The scores corresponding to each of those seven vulnerable population types were added for a total VPI score for each US Census Tract Block Group. Based on this scoring approach, the highest possible VPI score for any US Census Tract Block Group is 14, where the highest VPI score at a US Census Tract Block Group level for the Commonwealth has been evaluated to be 9. Therefore, all following analysis uses a 0–9 scale for VPI in Virginia. **Figure 2** shows the range of VPI scores for each block group in Virginia geographically, while **Figure 3** shows the population distribution for VPI scores.

Each vulnerable population group was treated equally in this approach, with no weights applied to develop the aggregate score.

Figure 2: Vulnerable Population Index (VPI) by Block Group for the Commonwealth of Virginia

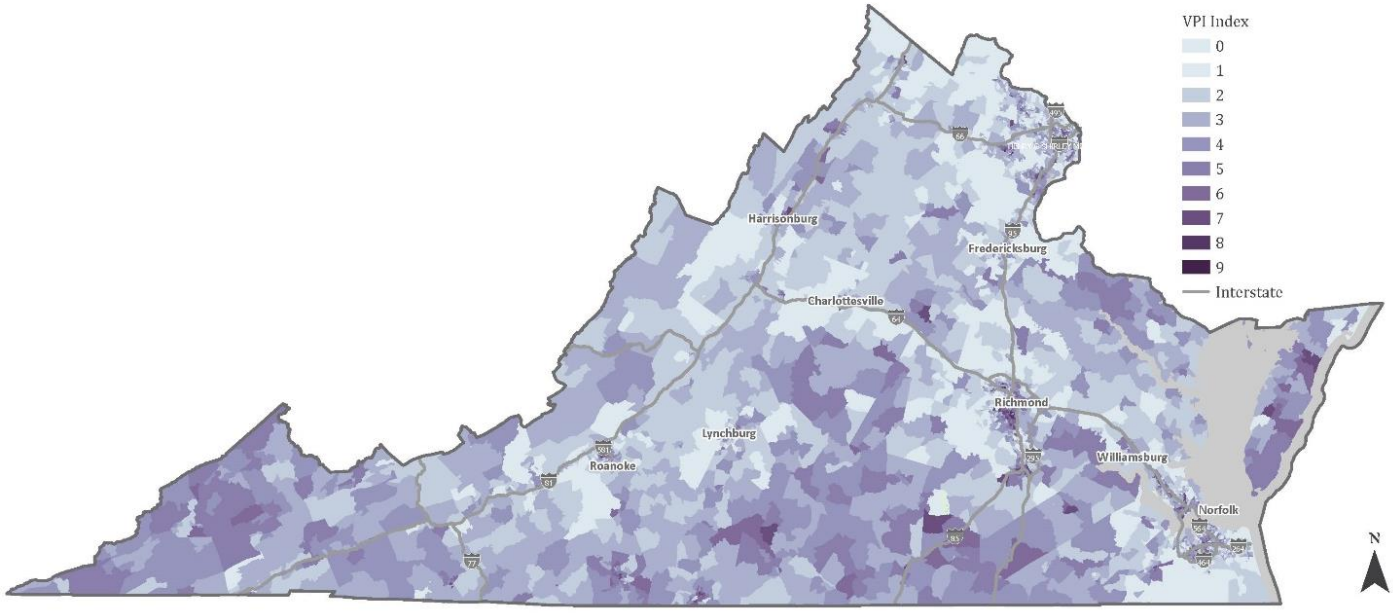
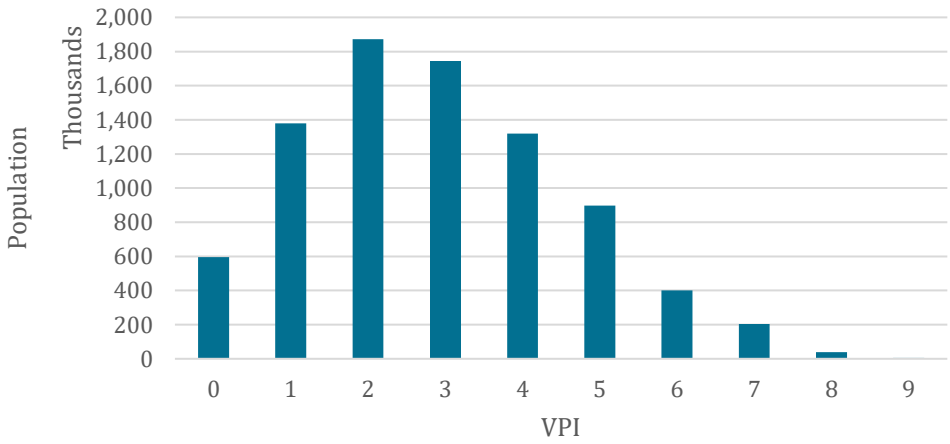
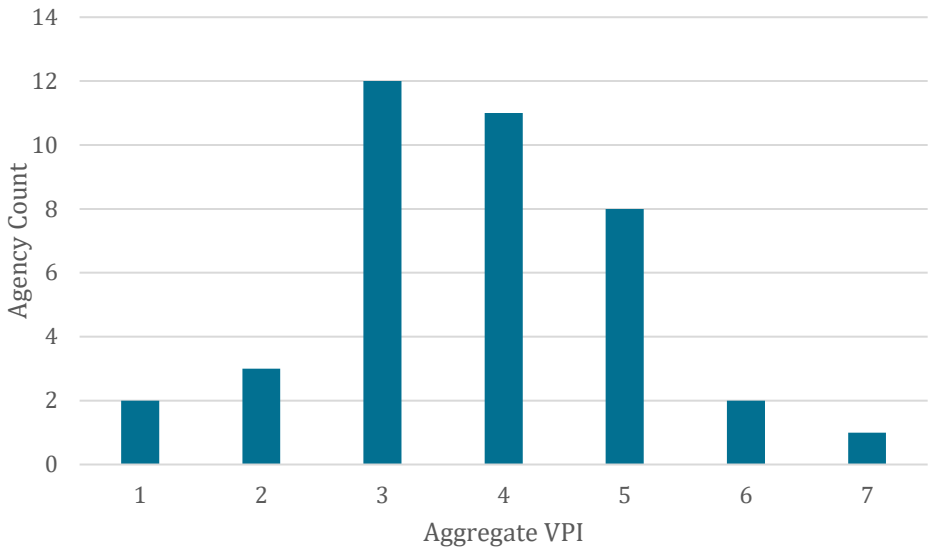


Figure 3: Population of the Commonwealth of Virginia by VPI



The US Census Tract Block Group-level scores are further aggregated or rolled up at a US Census Tract level and at a transit agency level to facilitate different types of analysis. Due to aggregating across multiple geographic areas, the agency scores on VPI range from 0–7. No agencies had a VPI aggregate score of zero or higher than seven. The number of agencies by aggregate VPI score is shown in **Figure 4.** For demand response-only agencies, aggregation was done based on the counties served. For enhanced fixed-route and fixed-route services, the location of routes determined the areas to aggregate, under the assumption that corresponding demand-response services provided by the same agencies would closely adhere to the same service area. For agencies like Jaunt, this assumption may not hold true as their demand-response services also are offered in the Charlottesville Area Transit (CAT) service area. Refinements for such agencies and how different modes are weighted should be considered in future analysis.

Figure 4: Transit Agencies by VPI Score



The VPI was developed for baseline analysis only, to allow for an understanding of broad infrastructure and transit trends across the Commonwealth. The measure can be disaggregated and/or refined through the course of the study, with input from the Virginia Department of Rail and Public Transportation (DRPT) and the Transit Equity Committee (TEC) on appropriate demographic data and weights. For example, income was not adjusted for cost of living to determine localized levels of poverty.

Methodology and Analysis

The following sections provide details on how equity and modernization were evaluated within the context of each technical area. Methodology is paired with results and analysis for each technical area in these sections, while the concluding portion of this memorandum will summarize key findings and opportunities identified within and across each technical area.

Transit Accessibility

Overview

Transit accessibility refers to people's ability to reach goods, services, jobs, and activities using transit. While this section will focus specifically on transit service levels and opportunities, it is important to acknowledge that accessibility of transit extends beyond service and destinations. In this study, all five additional technical areas (adequacy of infrastructure, safety, electrification, engagement and governance, and emerging technologies) contribute to a comprehensive outlook on the accessibility of a transit trip from origin to destination. For example, trip-planning information at the origin using real-time data, a part of the emerging technology technical area, is helpful for riders to plan trips easily and conveniently. Safe infrastructure that connects origins with transit stops is key to reducing barriers to access, especially for those who identify as having a disability, and is examined in the adequacy of infrastructure technical area. Each of the other technical areas also contribute to the entire experience of a rider from origin to destination.

Transit accessibility, service levels, and opportunities vary across the Commonwealth depending on a variety of factors including land use and the concentration of people and jobs (activity density). The analysis aims to

identify these variations and determine if there are gaps in service levels and accessible destinations. Providing access to destinations is integral for people to have opportunities that can lead to economic mobility and a better quality of life. Historically, specific populations have been underserved by transit systems both in the context of service levels and destinations accessible via transit. For example, service levels that provide short, peak-period headways and longer headways during the off-peak periods may increase the time burden on those who rely on transit during off-peak periods for employment. The types of destinations also are imperative to consider as access to employment, healthcare, and education, along with a variety of other destinations, are critical to create meaningful connections for riders. During the past 2 years, there has been a renewed focus on providing equitable transit, and this section of the study will aim to identify baseline conditions for service and opportunities and provide recommendations to enhance equitable service and destinations across the Commonwealth.

More specifically, the objectives of the baseline conditions and opportunities assessment for transit accessibility include:

- **Identifying potential transit service gaps** – locations in which the supported transit type (e.g., enhanced fixed route, fixed route, demand response, none), based on the activity density, differs from the maximum type of service currently provided
- **Understanding what populations are affected by the gaps** and how their access to opportunity varies
- **Assessing potential opportunities** in two key policy areas (zero-fare transit and equitable service planning)

Objectives

The objectives of the baseline conditions and opportunities assessments will be achieved through a multi-part analysis process.

I. Transit Service Levels Supply and Demand Gaps

Desired Outcomes:

- Develop an estimated transit demand based on population and activity density and identify the supported transit service type based on the transit demand
- Develop an estimated transit supply based on GTFS data and agency information
- Utilize demand and supply information to identify "gaps" in transit service provision throughout the state

Connections to Equity:

- Identify transit gap trends for different area type classifications
- Identify transit gap trends between vulnerable population groups and transit service through a statewide and area type lens

II. Transit Access to Opportunity

Desired Outcomes:

- Develop transit travel sheds based on GTFS data to determine the total number of jobs and destinations that are accessible in 30-, 45-, and 60-minute travel sheds for each census block group
- Determine an access to opportunity score for each census block group based on the number of jobs and destinations accessible on average (between 15-minute and 60-minue travel sheds)

Connections to Equity:

- Identify accessibility to opportunity score trends for different area type classifications and vulnerable populations
- Identify trends in the proportion of destinations accessible for different area type classifications and vulnerable populations

III. Transit Policy Assessments

Desired Outcomes:

- Determine the current state of zero-fare transit in the Commonwealth, present case studies, and develop considerations for Virginia
- Determine the current state of equitable service planning in the Commonwealth, present case studies and academic research, and develop considerations for Virginia

Transit Accessibility Key Terms

Virginia Area Type Classification

There are 5,315 census block groups in the Commonwealth of Virginia. The thresholds identified below were applied to each block group, using data available in the US Census's 2015–2019 American Community Survey and the 2018 Longitudinal Employer-Household Dynamics (the most recent data available at the time of the analysis) throughout the analysis. Recognizing that LEHD data does not fully capture federal jobs due to security concerns[1], federal employment totals were modified in the Northern Virginia, Hampton Roads, and Richmond areas with major military/federal bases, using the most recent base year traffic analysis zones (TAZ) data for that region's travel demand model[2].

Recognizing that transit service needs and service levels will vary depending on the location of a census block group, the state's census block groups were categorized based on the U.S. Census' definition of urbanized vs. rural areas for study area purposes. Note that this differs from transit service reporting designations as defined by FTA. Area designations used for this analysis are as follows:

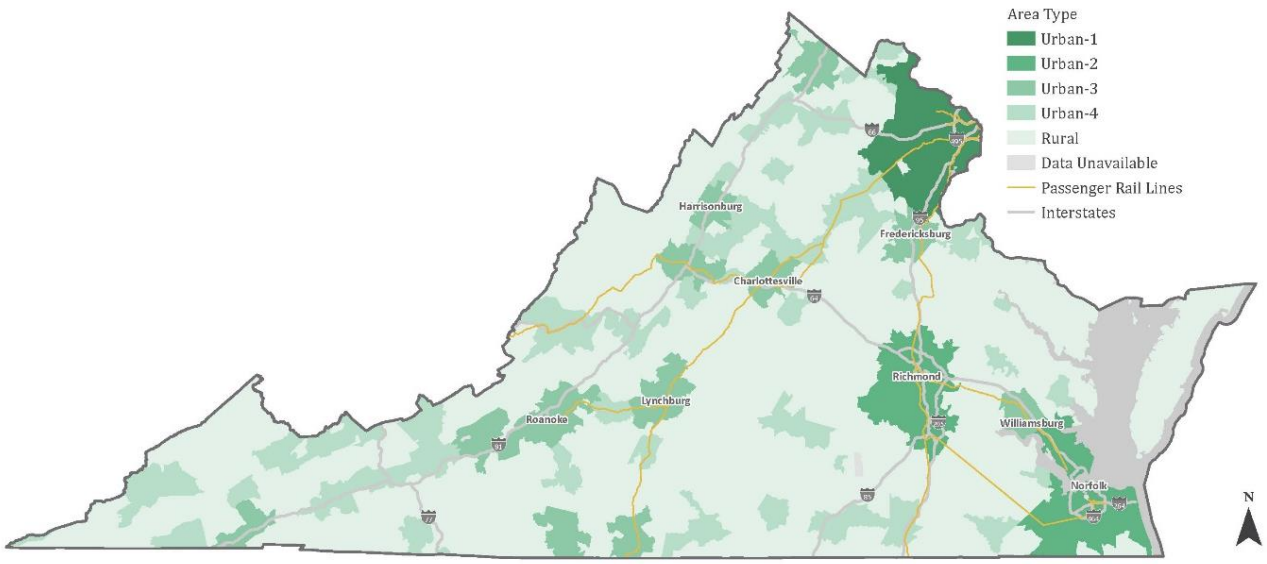
- **Urban-1** – All Virginia census block groups that fall within the Washington, DC-VA-MD urbanized area (as defined by the US Census)
- **Urban 2** – All census block groups that fall within either the Richmond or Virginia Beach (greater Hampton Roads) urbanized areas (as defined by the US Census)
- **Urban-3** – Most other urbanized areas as defined by the US Census. For purposes of this analysis, there are 12 urbanized areas that fall in this category: Roanoke, Fredericksburg, Lynchburg, Charlottesville, Blacksburg, Winchester, Harrisonburg, Williamsburg, Staunton-Waynesboro, Danville, Martinsville, and Bristol
- **Urban-4** – All other smaller urbanized areas and urban clusters, as defined by the US Census; there are 60 areas that fall in this category, ranging from Culpeper to the Middlesborough area.
- **Rural** – All census block groups defined as rural by the US Census

Figure 5 illustrates the five different classifications across the Commonwealth.

Area Type	Sample Locations	Supported Transit Transects
Urban 1	Washington DC, Northern Virginia	Enhanced Fixed Route, Fixed Route, Demand Response
Urban 2	Richmond, Virginia Beach (greater Hampton Roads)	Enhanced Fixed Route, Fixed Route, Demand Response
Urban 3	Roanoke, Fredericksburg, Lynchburg, Charlottesville, Blacksburg, Winchester, Harrisonburg, Williamsburg, Staunton-Waynesboro, Danville, Martinsville, and Bristol	Fixed Route, Demand Response
Urban 4	Over 60 areas ranging from Culpepper to Middlesborough	Fixed Route, Demand Response
Rural	All census block groups defined as rural by the US Census	Demand Response

[1] https://lehd.ces.census.gov/doc/help/onthemap/FederalEmploymentInOnTheMap.pdf
[2] MWCOG [2020 model], Hampton Roads [2015 model], and Richmond [2017 model]

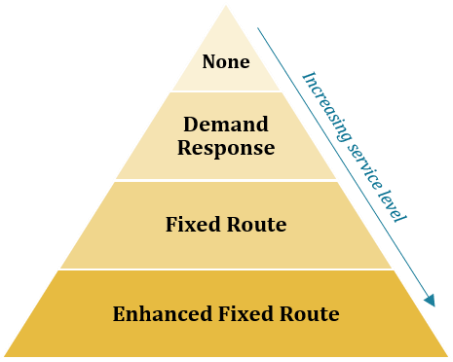
Figure 5: Area type classifications in the Commonwealth



Virginia Maximum Transit Service Transects

Transit service transects are defined at a jurisdiction level and indicate the highest level of transit service available within the jurisdiction. A significant portion of the state is served by fixed-route and enhanced-route services. For clarification on how transects were categorized, if a jurisdiction is served by both demand response and fixed-route service, the jurisdiction will appear as fixed route (the higher service level available).

- **Enhanced Fixed Route:** A premium transit service, such as light rail, heavy rail, and bus rapid transit, with high service frequencies
- **Fixed Route:** A public transit service with a published fixed schedule and service alignment
- **Demand Response:** Public transit services that operate on flexible routes with flexible schedules that are driven by passenger service requests
- **None:** No transit service is available



Baseline Conditions

Supply and Demand Gap Analysis

Introduction

This section begins with the methodology used to determine transit service needs and service supply across the state, potential service gap locations, and findings regarding equity impacts to various demographic groups.

Methodology and Assumptions

The primary sources used for this supply and demand gap analysis are as follows:

- US Census American Community Survey (ACS) and Longitudinal Employer-Household Dynamics (LEHD) data at the block group level. The most recent available data was used for this analysis, which was 2015–2019 ACS data and 2018 LEHD data
- General Transit Feed Specification (GTFS) data from Virginia transit agencies

Transit Service Needs

Population and employment densities are the primary driver of transit service needs. There are many other characteristics that influence the likelihood of a trip being made by transit, such as the type of job at a location or the household income level; however, it generally begins with density characteristics. Information provided in the Transit Cooperative Research Program's (TCRP's) *Transit Capacity and Quality of Service Manual* (2nd and 3rd editions) was used as a starting point to categorize transit service needs by census block group across the state. This manual provides guidance on typical densities needed to support 60-minute, 30-minute, and 10-minute transit service frequencies. These thresholds, however, are more corridor-focused, whereas this analysis is using census block group data, which may include land uses such as public parks that reduce a block group's average density. Thresholds used for this analysis were reduced to account for a block group-focused analysis. For the purposes of this study, those density thresholds have been used to define high, medium, and low transit service needs. Resulting thresholds used in this analysis are presented in **Table 2.**

Table 2: Thresholds Used to Define Service Needs

Thresholds	Population	Employment	Total Activity (Pop. + Empl.)	Supported Transit Transect
High Need	24+ persons per acre	12+ persons per acre	18+ persons per acre	Enhanced Fixed Route
Medium Need	12-24 persons per acre	6-12 persons per acre	9-18 persons per acre	Fixed Route
Low Need	5-12 persons per acre	2-6 persons per acre	3-9 persons per acre	Fixed Route
No Need for Fixed-Route Service	<5 persons per acre	<2 persons per acre	<3 persons per acre	Demand Response

An interactive dashboard has been created for this analysis that allows a user to zoom in and review area type designations, service needs, service levels, and resulting service gaps. The link to the dashboard is provided here.

Transit Service Supply

Transit service supply was determined from GTFS data that was collected from Virginia transit agencies. Transit trip visits were calculated for each census block group to measure accessibility to transit. Specifically, quarter-mile buffers were defined around each fixed-route stop (half-mile buffers around rail and BRT stops). This was used to measure a block group's accessibility to transit. The number of trip visits at each transit stop was tabulated by time period, and then factored based on coverage within each block group (i.e., how much of the quarter-mile buffer falls within each block group). Transit visits were measured for the following days and time periods:

- Weekday Day (6:00 a.m. to 6:00 p.m.)
- Weekday Evening (after 6:00 p.m.)
- Saturday Day (6:00 a.m. to 6:00 p.m.)
- Saturday Evening (after 6:00 p.m.)
- Sunday Day (6:00 a.m. to 6:00 p.m.)
- Sunday Evening (after 6:00 p.m.)

As noted earlier, an interactive dashboard has been created for this project that allows a user to zoom in and review area type designations, service needs, service levels, and resulting service gaps. The link to the dashboard is provided here.

Demand Results

As noted previously, block groups in Virginia were defined by area type and demand was defined by need (high, medium, low, or no need for fixed-route service). **Table 3** provides a summary of minority and poverty population characteristics for each area type and classification of service need. Significant findings are as follows:

- 89 percent of all Urban-1 (NOVA)-defined block groups were identified as having a high, medium, or low service need; this compares to 82 percent for Urban-2 area types, 54 percent for Urban-3 area types, and 15 percent for Urban-4 area types.
- For all Urban-1 through Urban-3 defined area types, there generally are higher minority and below-poverty population percentages in block groups with high and medium needs vs. those with low needs

or no fixed-route service needs; this indicates that potentially vulnerable population groups tend to be in areas with higher densities.

Table 3: Demographic Characteristics by Transit Service Needs

Area Type	Demographic Characteristic	All BGs	High Needs BGs	Medium Needs BGs	Low Needs BGs	No F. Route Needs BGs
Urban-1	Block Groups	1,419	389	406	468	156
	Population	2,574,789	676,141	725,991	876,656	390,833
	Employment	1,346,066	702,829	306,936	241,469	94,832
	Minority Population %	48.7%	59.3%	53.4%	43.0%	30.1%
	Below 125% Poverty	8.1%	13.6%	8.4%	5.2%	3.6%
Urban-2	Block Groups	1,654	146	447	764	297
	Population	2,611,207	247,562	672,004	1,193,152	498,489
	Employment	1,444,922	450,822	403,266	402,138	188,696
	Minority Population %	46.8%	54.6%	57.8%	44.8%	32.8%
	Below 100% Poverty	11.3%	17.8%	15.0%	9.7%	6.9%
Urban-3	Block Groups	840	42	95	314	389
	Population	1,358,238	68,371	141,012	509,125	639,730
	Employment	707,736	125,142	102,935	249,722	229,937
	Minority Population %	26.8%	32.2%	39.2%	31.5%	19.7%
	Below 100% Poverty	13.2%	25.8%	21.9%	13.6%	9.7%
Urban-4	Block Groups	479	1	9	60	409
	Population	711,253	11,458	12,500	75,044	622,251
	Employment	275,163	1,489	10,805	48.897	213,972
	Minority Population %	20.7%	22.6%	30.8%	25.9%	19.9%
	Below 100%Poverty	12.8%	0.0%	18.8%	15.6%	12.4%
Rural	Block Groups	923	3	1	2	917
	Population	1,198,976	4,247	2,444	2,023	1,190,262
	Employment	240,071	1,456	314	2,313	235,988
	Minority Population %	20.0%	73.0%	64.5%	23.0%	19.7%
	Below 100% Poverty	12.0%	0.0%	0.0%	22.8%	12.1%

Note: For Urban-1 (NOVA)-defined block groups, the ACS' "Below 125% Poverty" used to account for higher costs of living

Supply Results

As noted earlier, transit supply at a block group basis has been defined based on coverage with quarter-mile buffers around transit stops (half-mile buffer for rail stations) and the number of transit vehicle trips within a defined period at each stop. A transit supply score was developed for each block group, then normalized based on activity (population and employment). Block group transit supply scores were aggregated into four categories: high, medium, low, or no service. Breakpoints between high, medium, and low are based on breakpoints that were determined for transit needs. For example, 11 percent of block groups defined Urban-2 block groups with an identified transit need fell in the "high" category (146/1,347 block groups). Ideally, this should match up with the top 11 percent of block groups with high transit service supply scores. Thus, the highest 11 percent of transit supply scores were categorized as having a high service supply for Urban-2 classified block groups.

Service gaps were identified for those block groups where there was a significant mismatch in service supply when compared to service needs. For high needs block groups, a potential service gap was identified for block groups with a low level of service or no service. For medium and low needs block groups, a potential service gap was identified for block groups with no service gap. **Figure 6** and **Figure 7** illustrate the distribution of service supply compared to service needs for Urban-1 classified (NoVA) and Urban-2 classified (Richmond and Hampton Roads) block groups. As noted in these figures, the distribution of high, medium, and low service

supply can vary within each needs category. The circled portions of each bar graph identify potential service gaps. This same exercise was completed for the Urban-3 and Urban-4 classified block groups.

Figure 6: Transit Needs vs. Service Supply for Uban-1 Block Groups

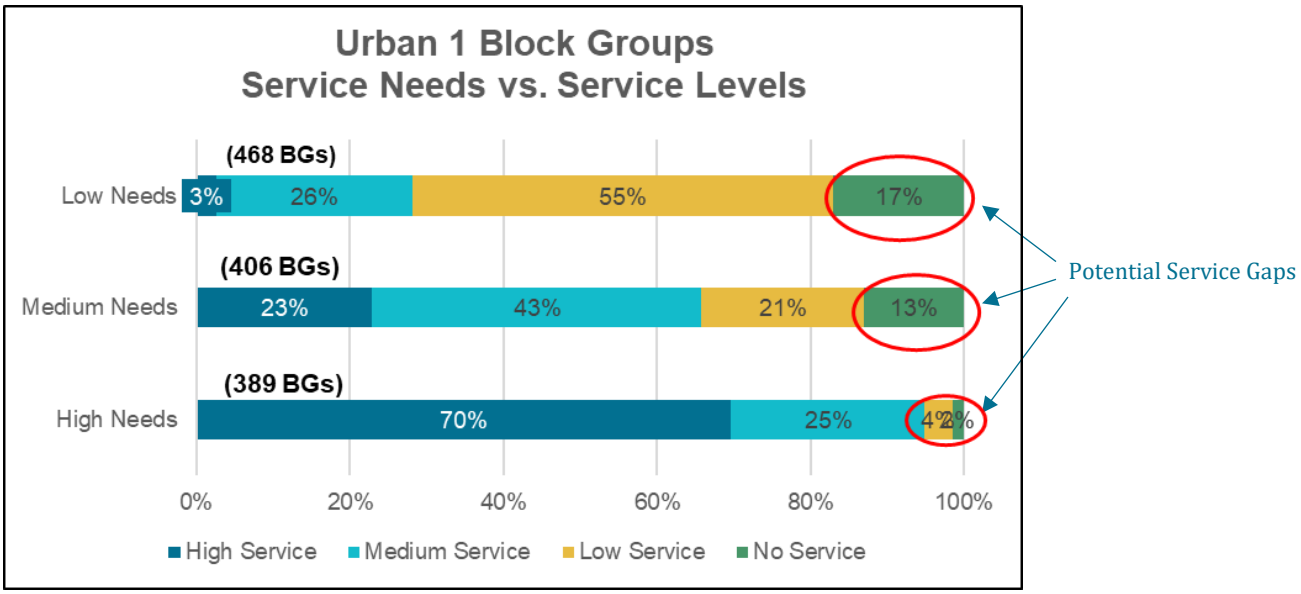
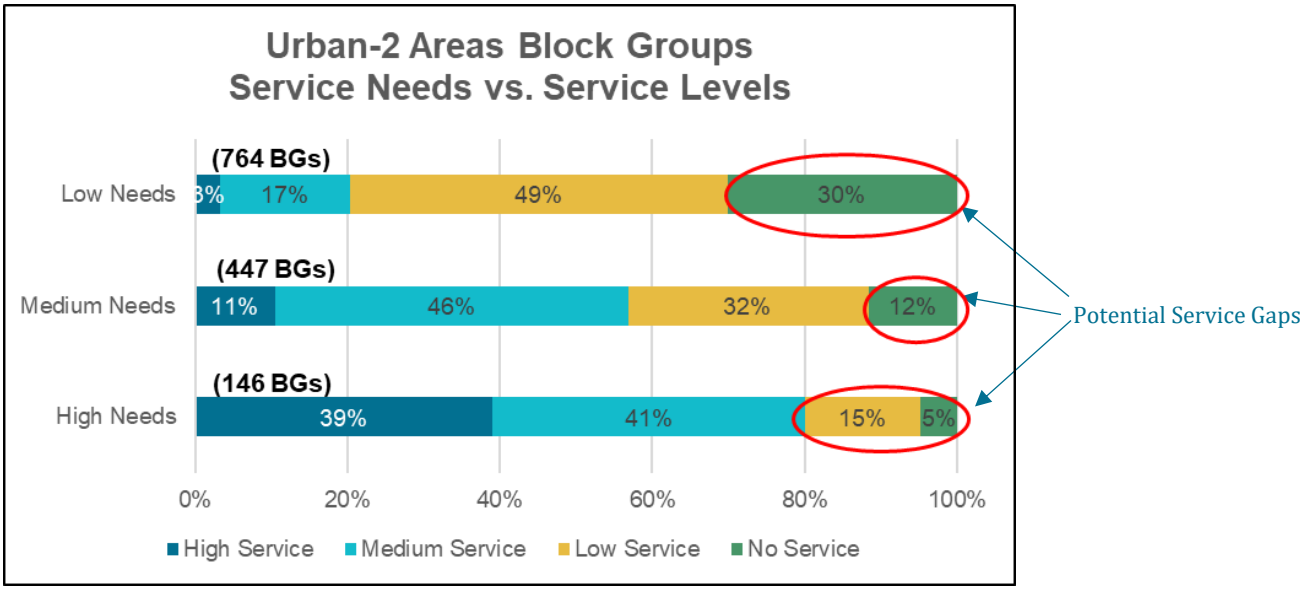


Figure 7: Transit Needs vs. Service Supply for Urban-2 Block Groups



As noted earlier, an interactive dashboard has been created for this project that allows a user to zoom in and review area type designations, service needs, service supply and resulting service gaps. The link to the dashboard is provided here.

Potential Fixed-Route Service Level Gaps

Transit needs were compared to transit supply to determine potential service gaps. As noted earlier, a potential fixed route service gap has been defined if one of the following two conditions is met:

- A block group is defined as having a high transit service need but has a service supply score that falls in the low category, or has service supply score of 0(i.e., no fixed route transit accessibility)
- A block group is defined as having either a medium or low service need for fixed-route service but has a service supply score of 0 (i.e., no fixed route transit accessibility)

The areas listed here are described in more detail in the following sections and can be viewed statewide using the web dashboard here.

Gap Definition

Transit needs were compared to transit supply to determine potential service gaps. As noted earlier, a potential fixed route service gap has been defined if one of the following two conditions is met:

- A block group is defined as having a high transit service need but has a service supply score that falls in the low category, or has a service supply score of 0 (i.e., no fixed route transit accessibility)
- A block group is defined as having either a medium or low service need for fixed-route service but has a service supply score of 0 (i.e., no fixed route transit accessibility)

The areas listed here are described in more detail in the following sections and can be viewed statewide using the web dashboard here.

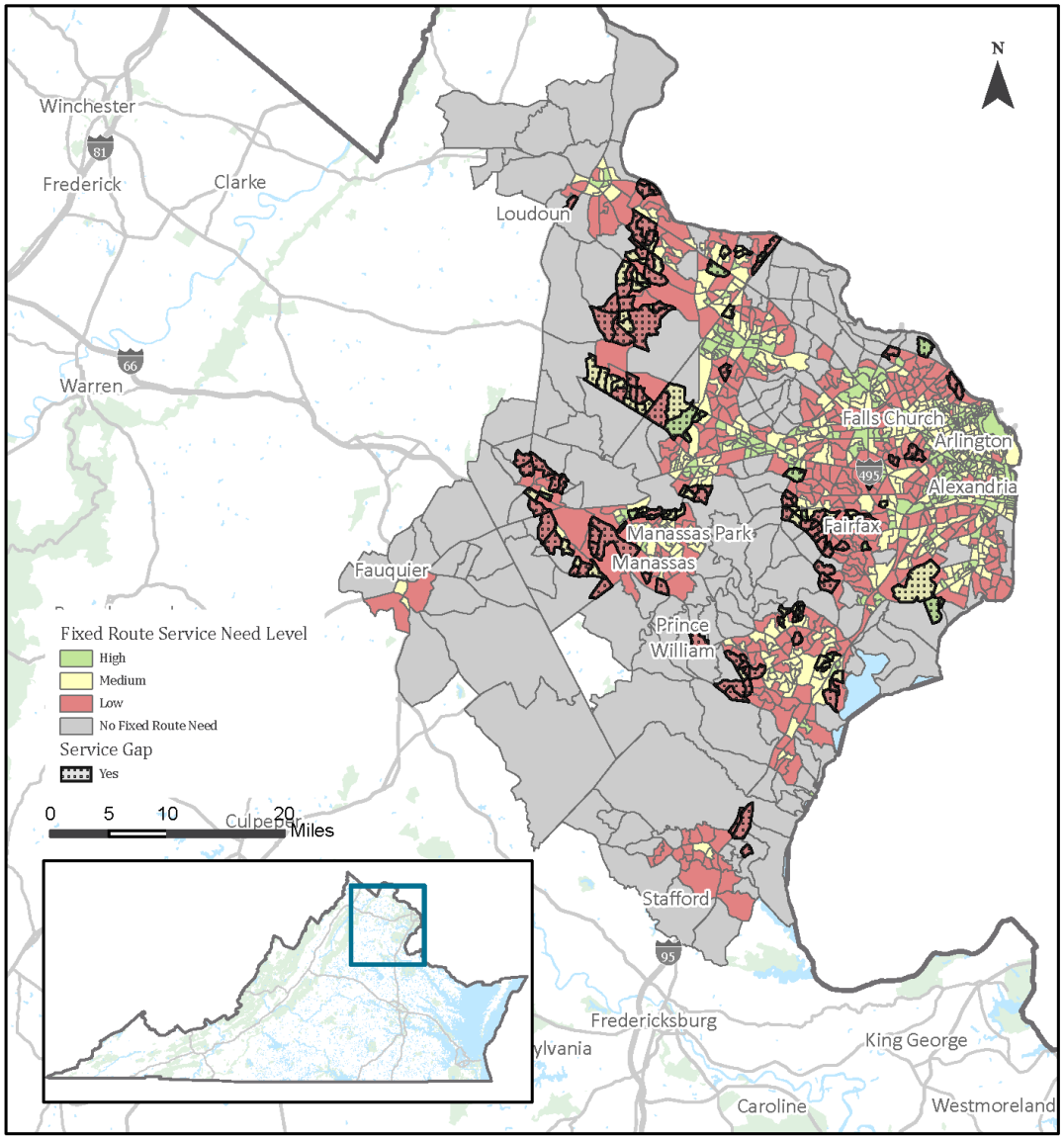
Urban-1 Areas (NoVA)

Areas defined as Urban-1 (NoVA) have 1,419 block groups, of which 1,263 (89 percent) were identified as having a high, medium, or low fixed-route transit service need. There are 155 block groups in the Urban-1 classified area that were identified as having a potential transit service supply deficiency (i.e., having a low, nominal or no transit supply score). These are block groups that met the service gap definition noted above. The 155 block groups represent 340,000 residents (13 percent of NoVA's population) and 150,000 jobs locations (11 percent of NoVA's employment). **Table 4** presents demographic characteristics of the potential service gap block groups and all other block groups. In general, all the demographic characteristics for the potential service gap block groups do not differ significantly from all other block groups. **Figure 8** identifies all block groups in the Urban-1 (NoVA) area with high, medium, and low service needs, and those that were identified as having a potential fixed-route service gap.

Table 4: Demographic Characteristics for Urban-1 Block Groups with an Identified Service Need

Characteristic	All Block Groups	Percentage	Service Gap Block Groups	Percentage	All Other Block Groups	Percentage	Low BG Point Difference
Block Groups	1,263		153		1,110		n/a
Activity	3,530,022		482,091		3,047,931		n/a
Population	2,278,788		334,982		1,943,806		n/a
Employment	1,251,234		147,109		1,104,125		n/a
Minority Populaton	1,165,896	51.2%	164,811	49.2%	1,001,085	51.5%	-2.3%
Disabled Population	156,252	6.9%	20,448	6.1%	135,805	7.0%	-0.9%
Below 125% Poverty Line	198,909	8.7%	16,174	4.8%	182,735	9.4%	-4.6%
College Student Population	186,607	8.2%	30,228	9.0%	156,379	8.0%	1.0%
0-Car Population	109,378	4.8%	6,280	1.9%	103,098	5.3%	-3.4%
Senior Population	244,982	10.8%	28,489	8.5%	216,493	11.1%	-2.6%
Low English Prof. Population	296,643	13.0%	33,890	10.1%	262,753	13.5%	-3.4%

Figure 8: Transit Needs and Potential Service Gaps for the Urban-1 (NOVA) Area



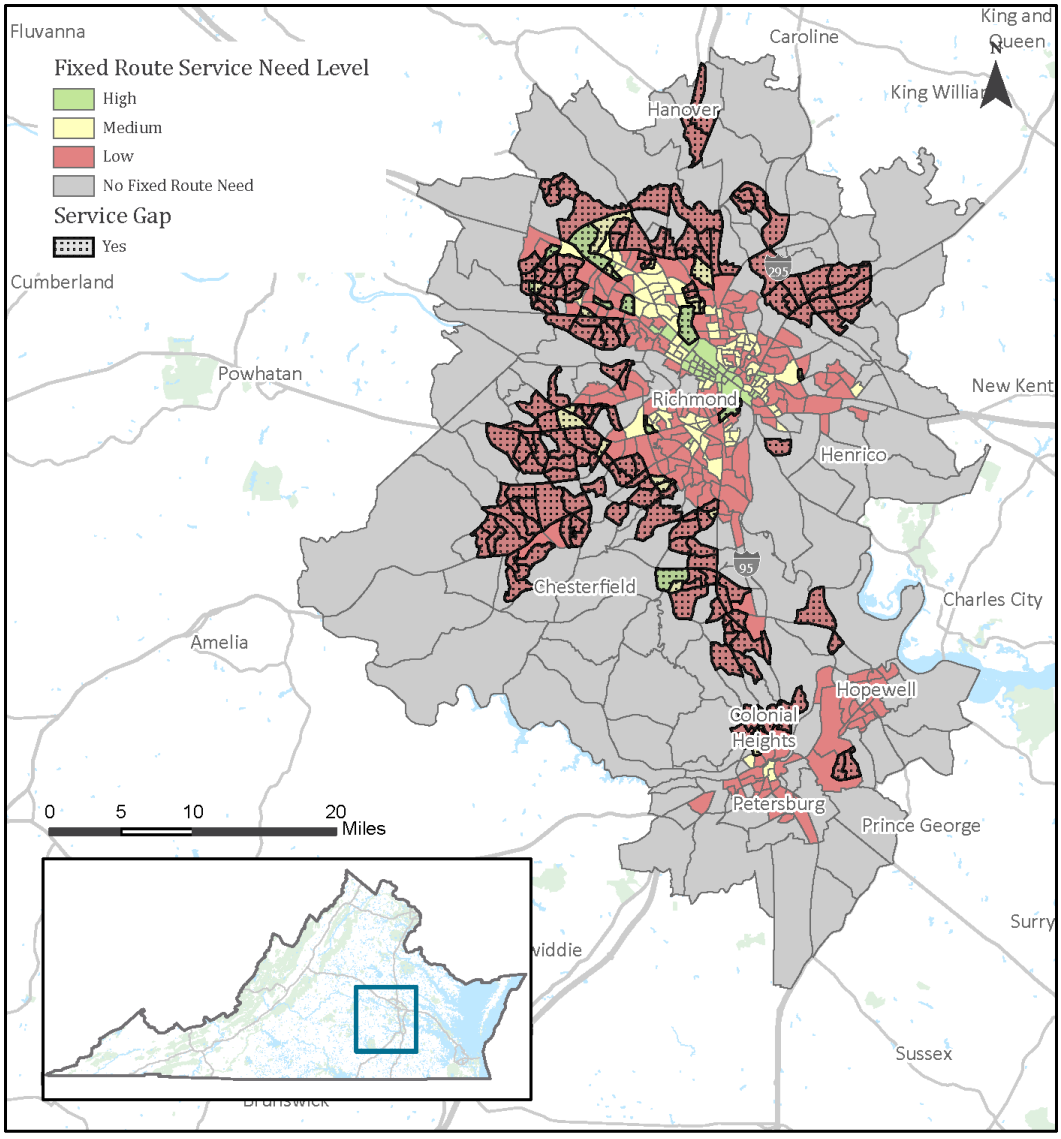
Urban-2 Areas (Richmond and Hampton Roads)

The Urban-2-defined areas consist of block groups in Richmond and in the Hampton Roads region. There are 1,654 block groups in these two regions, of which 1,357 (82 percent) were identified as having a high, medium, or low service need. There are 311 block groups in the Urban-2 category that were identified as having a potential transit service supply deficiency (i.e., having a low, nominal or no transit supply score). The 311 block groups represent 608,000 residents (18 percent of the Urban-2 areas' population and 357,000 job locations (22 percent of Urban-2 areas' employment). **Table 5** presents demographic characteristics of the potential service gap block groups and all other block groups. There are some significant differences in minority and persons below poverty percentages for block groups identified as having a potential service gap vs. those that do not; however, the higher concentrations of minority and persons below poverty are higher for those block groups without an identified service gap. **Figure 9** and **Figure 10** identify all block groups in the Richmond and Hamptons Roads areas with high, medium, and low service needs, and those that were identified as having a potential fixed-route service gap.

Table 5: Demographic Characteristics for Urban-2 Block Groups with an Identified Service Need

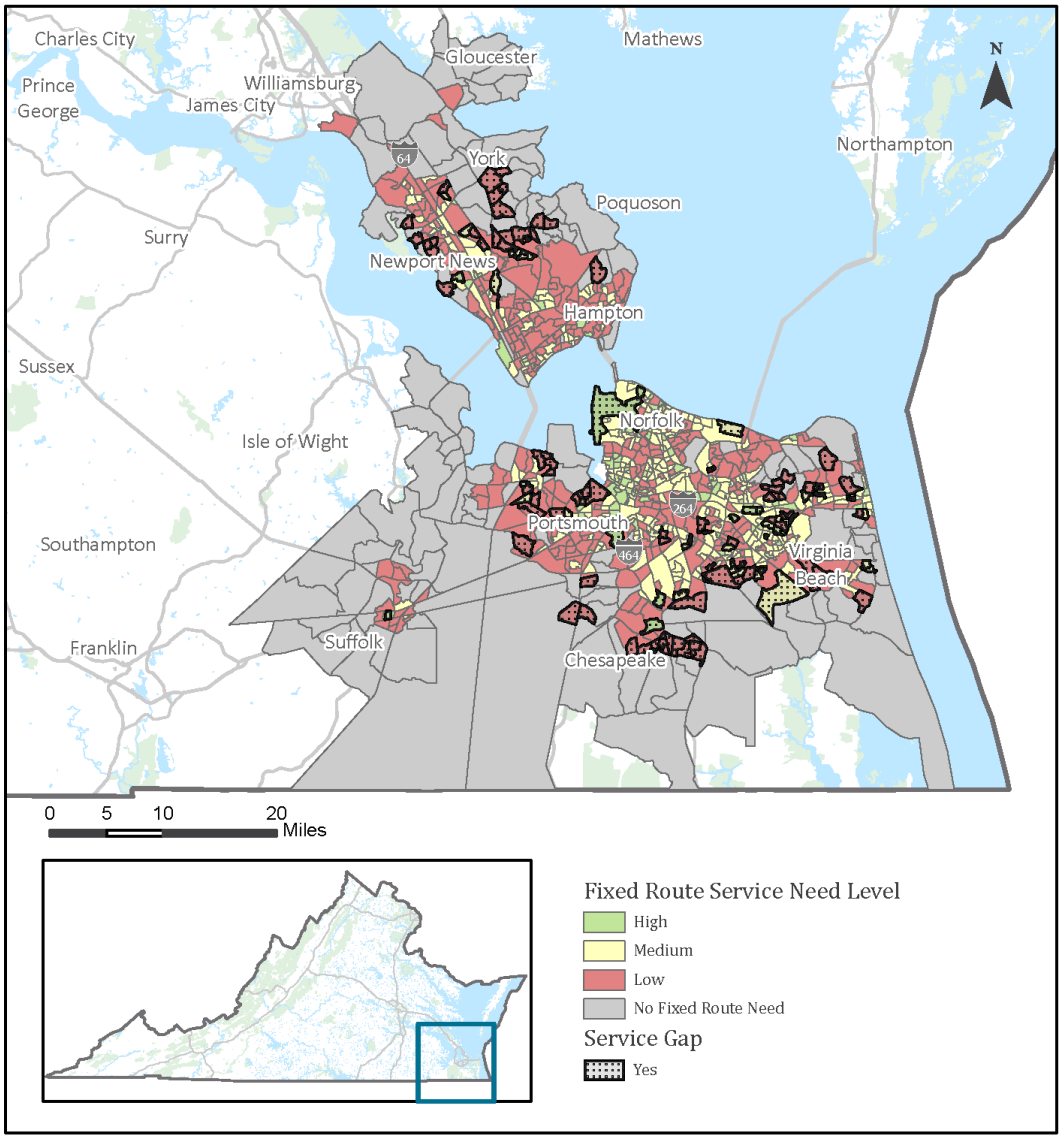
Characteristic	All Block Groups	Percentage	Service Gap Block Groups	Percentage	All Other Block Groups	Percentage	Low BG Point Difference
Block Groups	1,357		311		1,046		n/a
Activity	3,368,944		965,367		2,403,577		n/a
Population	2,112,718		608,039		1,504,679		n/a
Employment	1,256,226		357,328		898,898		n/a
Minority Populaton	1,057,748	50.1%	228,159	37.5%	829,589	55.1%	-17.6%
Disabled Population	260,461	12.3%	60,454	9.9%	200,006	13.3%	-3.3%
Below Poverty Populaton	260,804	12.3%	38,322	6.3%	222,482	14.8%	-8.5%
College Student Population	227,762	10.8%	60,783	10.0%	166,979	11.1%	-1.1%
0-Car Population	165,375	7.8%	20,150	3.3%	145,225	9.7%	-6.3%
Senior Population	280,036	13.3%	80,333	13.2%	199,703	13.3%	-0.1%
Low English Prof. Population	80,124	3.8%	23,640	3.9%	56,484	3.8%	0.1%

Figure 9: Transit Needs and Potential Service Gaps for the Urban-2: Richmond Area



Note: Richmond area consists of the following communities: Chesterfield, Colonial Heights, Hanover, Henrico, Hopewell, Petersburg, Prince George, Richmond.

Figure 10: Transit Needs and Potential Service Gaps for the Urban-2: Hampton Roads Area exclud



Note: Hampton Roads area consists of the following communities: Chesapeake, Hampton, James City, Newport News, Norfolk, Portsmouth, Suffolk, Virginia Beach, Williamsburg.

Urban-3 Areas

The Urban-3-defined areas consist of block groups in cities such as Roanoke, Charlottesville, and Bristol. There are 12 cities that fall in this category. There are 840 block groups in this category, of which 451 (54 percent) were identified as having a high, medium, or low service need. There are 38 block groups in the Urban-3 classified areas that were identified as having a potential transit service supply deficiency (i.e., having a low, nominal or no transit supply score). The 38 block groups represent 73,000 residents (5 percent of this classification's population) and 37,000 job locations (5 percent of this classification's employment). **Table 6** presents demographic characteristics of the potential service gap block groups and all other block groups. In general, there are not significant differences in potential vulnerable population percentages for potential service gap block groups vs. all other block groups. Because of the small size of Urban-4 areas, a statewide map has not been developed. The interactive project dashboard can be used to zoom in to any specific Urban-4 area.

Table 6: Demographic Characteristics for Urban-3 Block Groups with an Identified Service Need

Characteristic	All Block Groups	Percentage	Service Gap Block Groups	Percentage	All Other Block Groups	Percentage	Low BG Point Difference
Block Groups	451		38		413		n/a
Activity	1,196,307		110,046		1,086,261		n/a
Population	718,508		73,413		645,095		n/a
Employment	477,799		36,633		441,166		n/a
Minority Populaton	237,596	33.1%	16,024	21.8%	221,572	34.3%	-12.5%
Disabled Population	83,639	11.6%	7,610	10.4%	76,029	11.8%	-1.4%
Below Poverty Populaton	117,922	16.4%	4,599	6.3%	113,323	17.6%	-11.3%
College Student Population	131,822	18.3%	6,390	8.7%	125,432	19.4%	-10.7%
0-Car Population	61,378	8.5%	2,219	3.0%	59,159	9.2%	-6.1%
Senior Population	101,945	14.2%	12,173	16.6%	89,772	13.9%	2.7%
Low English Prof. Population	29,737	4.1%	1,919	2.6%	27,818	4.3%	-1.7%

Urban-4 Areas

The Urban-4 defined block groups consist of urbanized clusters, such as Crozet, Alta Vista, Galax, and Farmville. There are 479 block groups in these two regions, of which 70 (15 percent) were identified as having a high, medium, or low service need. It is important to note that of the 409 block groups identified as being below thresholds for fixed route services, there may be corridors within some of those block groups that have sufficient densities for fixed route service. The methodology used in this analysis focuses on overall block group densities.

There are 27 block groups in the Urban-4 classification that were identified as having a potential transit service need (i.e., having a low, nominal or no transit supply score). Of this group, 17 were identified as having no transit supply, representing 41,000 residents (6 percent of this classification's population) and 25,000 job locations (9 percent of this classification's employment). **Table 7** presents demographic characteristics of the potential service gap block groups and all other block groups. Because of the small size of Urban-4 areas, a statewide map has not been developed. The interactive project dashboard can be used to zoom in to any specific Urban-4 area.

Table 7: Demographic Characteristics for Urban-4 Block Groups with an Identified Service Need

Characteristic	All Block Groups	Percentage	Service Gap Block Groups	Percentage	All Other Block Groups	Percentage	Low BG Point Difference
Block Groups	70		31		39		n/a
Activity	150,193		65,939		84,254		n/a
Population	89,002		41,045		47,957		n/a
Employment	61,191		24,894		36,297		n/a
Minority Populaton	23,639	26.6%	11,796	28.7%	11,843	24.7%	4.0%
Disabled Population	18,222	20.5%	6,379	15.5%	11,843	24.7%	-9.2%
Below Poverty Populaton	14,029	15.8%	5,697	13.9%	8,332	17.4%	-3.5%
College Student Population	12,097	13.6%	3,358	8.2%	8,739	18.2%	-10.0%
0-Car Population	6,726	7.6%	3,009	7.3%	3,717	7.7%	-0.4%
Senior Population	15,316	17.2%	7,499	18.3%	7,817	16.3%	2.0%
Low English Prof. Population	2,199	2.5%	443	1.1%	1,756	3.7%	-2.6%

Summary of Gap Analysis Results

Table 8 presents a summary of population and employment by area type that have been identified as having a potential service gap, where the level of service supplied appears to differ significantly from the service need. Residents and job locations identified in this table are in locations where there is either no fixed-route transit service supply or a very low service supply. It is important to note that this analysis was not completed for Rural-defined block groups in the Commonwealth; thus, total percentages shown in this table reflect totals for just NoVA and the various Urban-defined block groups. This gap analysis has focused on fixed-route service in non-rural areas (as defined by the U.S. Census). On-demand service needs may be appropriate in certain rural areas of the Commonwealth.

As noted in this technical memorandum, this analysis did not find any significant disparate impacts for potentially vulnerable populations. On a statewide basis, minority and below-poverty population groups were not found to be overrepresented in block groups identified as having a potential service gap when compared to those block groups that did not.

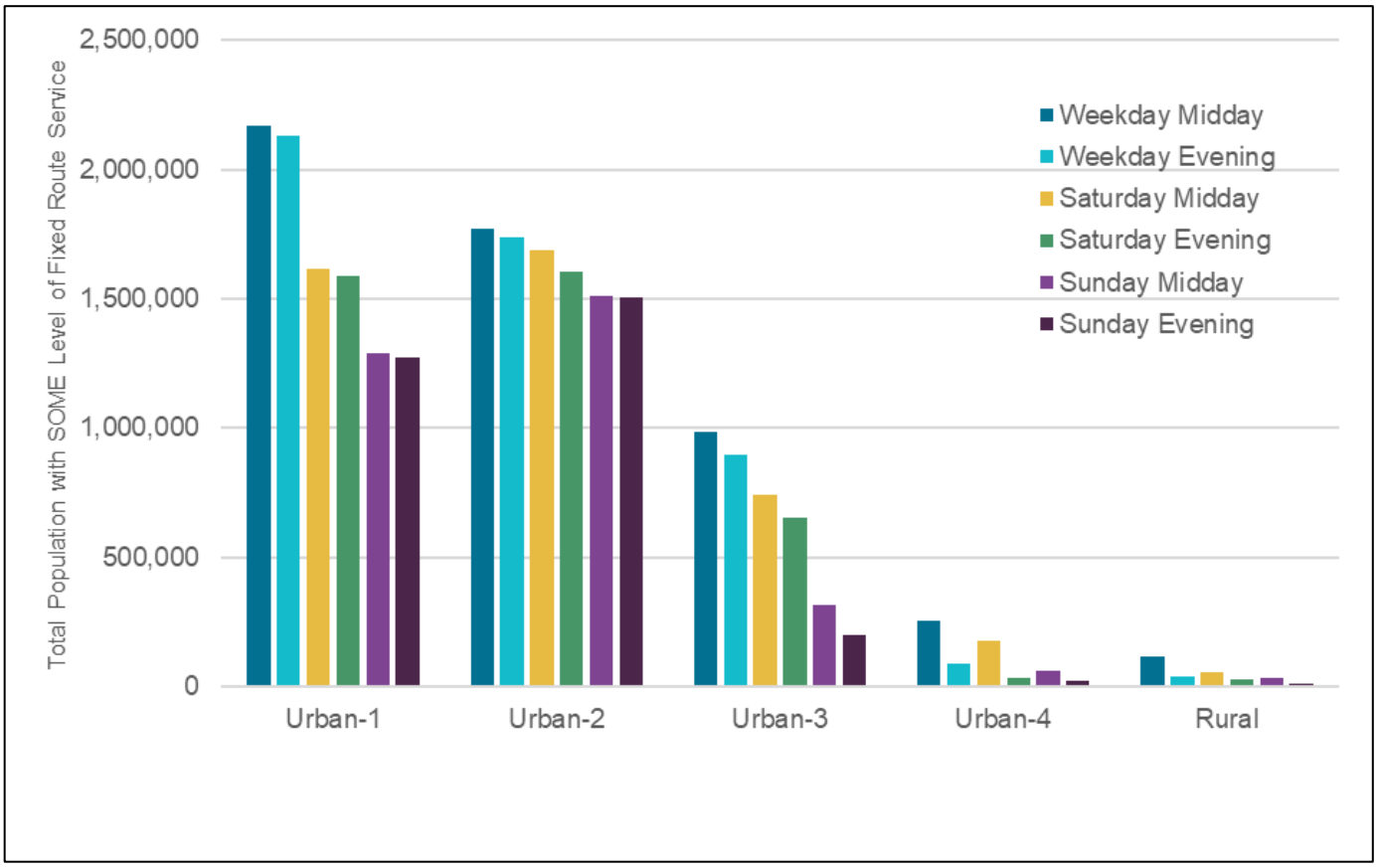
Table 8: Summary of Fixed-Route Service Gap Impacts

Area Classification	Population	% of Area Type Population	Employment	% of Area Type Employment
Urban-1	335,000	13.0%	147,000	10.9%
Urban-2	608,000	23.3%	357,000	24.7%
Urban-3	73,000	5.1%	37,000	5.2%
Urban-4	41,000	5.8%	25,000	9.0%
Totals (without Rural BGs)	1,057,000	12.5%	566,000	14.1%

Fixed-Route Service Gaps by Time of Day

To summarize potential service gaps by time of day, all block groups with any level of transit service were identified by geographic area and different time periods. As expected, Urban-1 and Urban-2 classified areas have higher numbers of population and employment served by some level of fixed-route transit service. They also have greater accessibility to weekend service and tend to have more service that is primarily peak- or commuter-oriented. Because this summary measures any presence of service, as compared to the transit service levels discussed above, it does not tell the full story of the quality of service or the duration of the service within that timeframe.

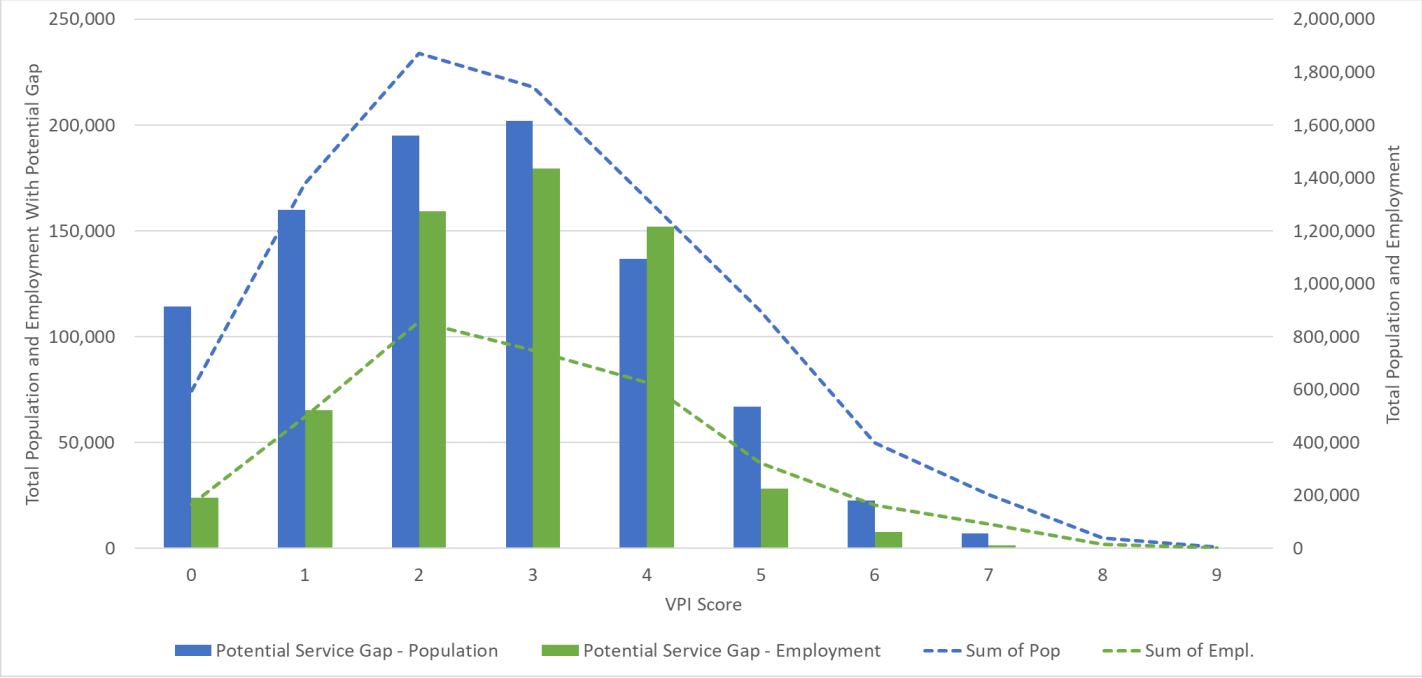
Figure 11: Summary of Available Service by Time of Day



Fixed-Route Service Gaps by VPI Score

VPI scores for each census block group can be used to assess the relative concentrations of vulnerable populations. Using the fixed-route gap analysis discussed above, the population and employment census block groups with a gap were tallied by VPI score and compared against the total population and employment. **Figure 12** below shows the solid bars as the total population and employment with potential fixed-route gaps (left axis) compared with the overall population and employment (right axis) statewide. Comparing the population and employment with a gap to the overall population and employment curve results in a very similar pattern. This is consistent with the findings that the percentages of different populations groups that are affected by a potential fixed-route service gap are similar to the overall percentages in the geographic area.

Figure 12: Summary of Service Gaps by VPI



Supply and Demand by Transect

The analysis summarized above has focused on fixed-route service; however, as noted, a large percentage, from a geographic perspective, of the state does not have densities that support fixed-route transit. Populations who live in lower-density areas still may need to rely on public transportation to go to work or other destinations. To summarize the service gaps at the transect, and look further at demand-responsive service areas, certain generalizations were made based on the need levels from the fixed-route service gaps assessment to apply them to a transect. A low or medium need was defined as fixed-route demand. A high fixed-route need was defined to coincide with enhanced fixed-route demand, whereas no fixed-route need could either include no need or a demand-responsive service demand. To look at supply on the transect level, the presence of any bus or rail stop in a block group level was used for fixed-route service. The best available data for demand-responsive service coverage areas was the jurisdictions to which the transit agency provides service. The figure below summarizes the assumptions and source information. The map in **Figure 14** shows this information at a statewide level and be viewed in more detail in on the

Figure 13: Summary of Assumptions for Transit Service Gaps by Transect

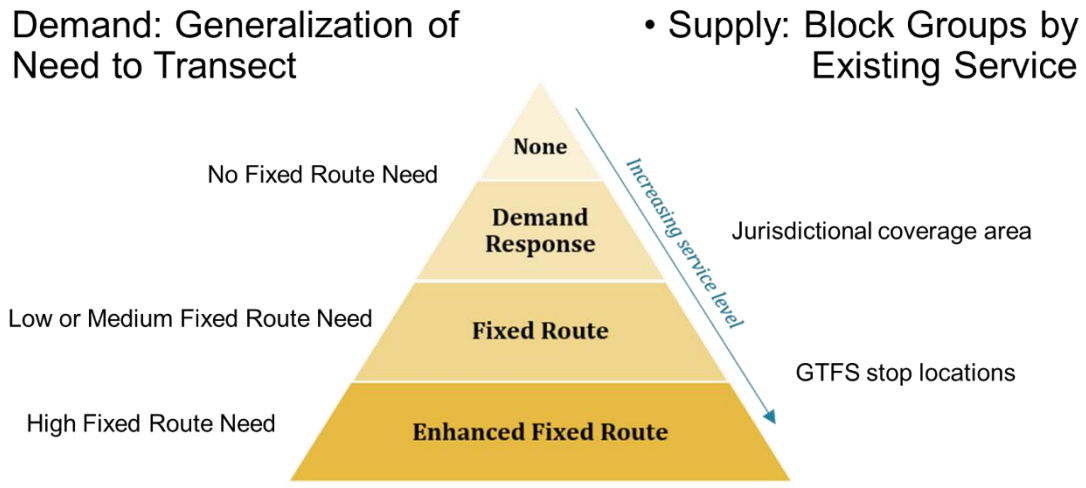
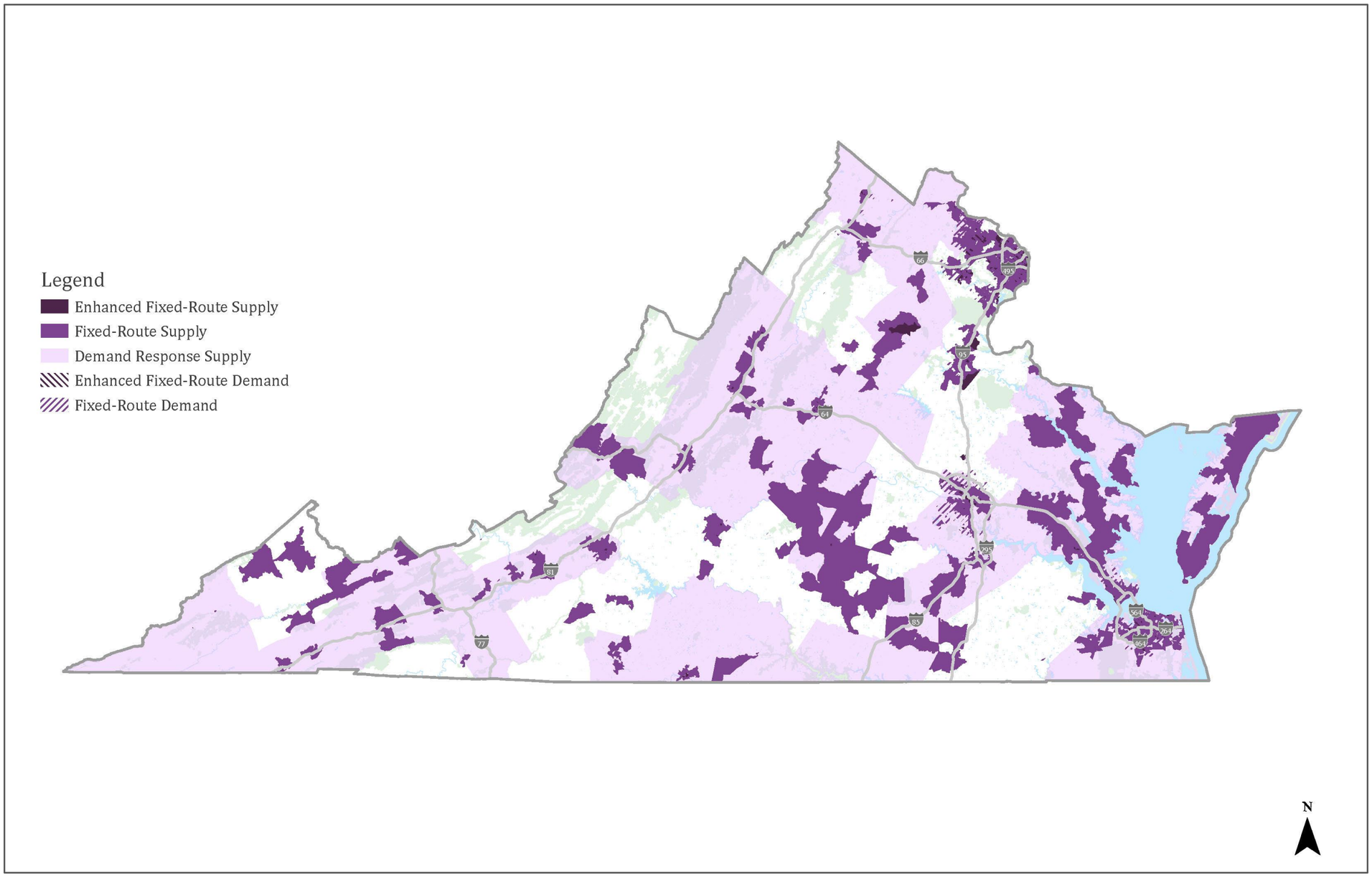


Figure 14: Statewide Transit Supply and Demand Map



VTrans Needs Assessment

The Virginia Statewide Transportation Plan (VTrans) has conducted a comprehensive transportation mid-term needs assessment for census block groups, roadway segments, and nodes across the Commonwealth.

This analysis provides locations throughout Virginia that were identified as a need for "Transit Access for Equity Emphasis Areas" (block groups and roadway segments) and "Needs for Transit Access" (nodes) based on transit and census data from 2017. The "Transit Access for Equity Emphasis Areas" need looks to identify locations are Equity Emphasis Areas that are viable for transit and are currently underserved by transit. The "Needs for Transit Access" identify nodes that were classified as Local-Serving and Knowledge-Based and scored poorly for competitiveness of transit access relative to highway access.

While the analysis as part of this Equity and Modernization Study uses more current transit and census data and is targeted at assessing overall statewide and regional trends and service levels as opposed to individual roadway segments or locations, the VTrans analysis provides additional context to transit accessibility challenges. The census block groups and nodes referenced above are included in the interactive maps located in this chapter. More information about the VTrans Assessment and a full interactive map can be found on the project website[3].

Access to Opportunity

Introduction

This analysis aims to quantify the "opportunity"—in this case, meaning jobs and destinations—that is accessible via fixed-route transit across the Commonwealth. This analysis goes beyond "who has access to transit?" to "what opportunities does this transit access connect to?" It may be that some transit systems provide high-quality coverage and/or frequent service but do not adequately connect to major employment centers and destinations; alternatively, it may be that some providers are adequately connected to major employment centers and destinations but do not have adequate coverage or frequency to facilitate these connections.

The gap assessment (described above) examined where frequency and quality of service align with potential demand based on density. The resulting gaps are areas in which there is a potential to increase service to meet the needs of the populations and jobs in that area, and the analysis quantifies the number of people and jobs in these locations. This access to opportunity (A2O) analysis builds on that to understand the implications of those, and other gaps. It also explores the effect of service frequency and how frequency changes access to opportunity.

Desired Outcomes

- Quantify the total number of destinations and jobs are accessible in 30-, 45-, and 60-minute ttravel sheds (via fixed-route transit) for each census block group served by fixed-route transit in the Commonwealth
- Develop a scoring methodology to allow for comparisons of A2O for census block groups across various factors, such as those block groups with similar vulnerable population indices (VPIs) or among similar area types

Methodology and Assumptions

Develop Travel sheds

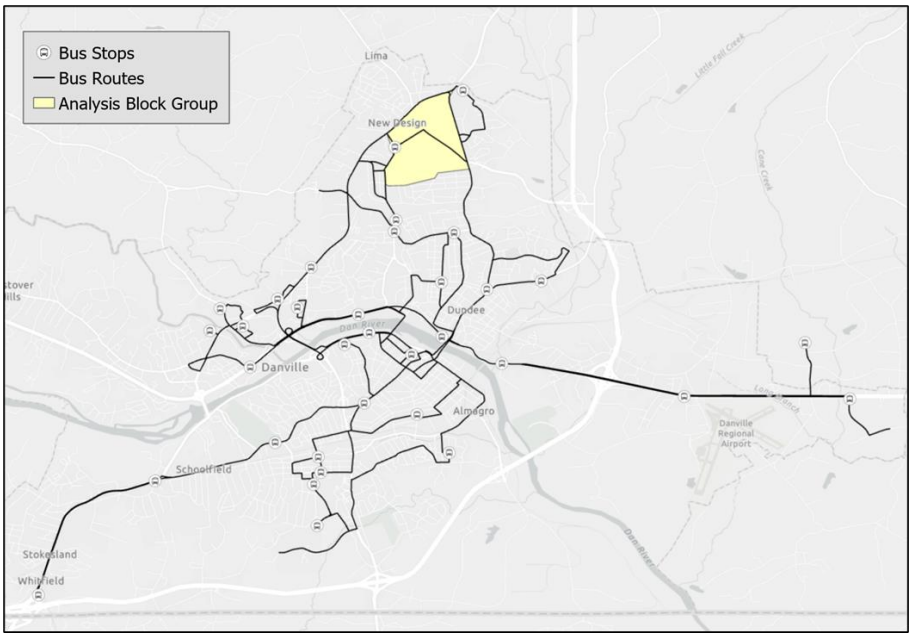
To conduct this analysis, ravel sheds via transit were generated for each census block group in areas of the state served by fixed-route service. These travel sheds were generated for 30-, 45-, and 60-minute travel times and

[3] https://www.vtrans.org/

for a weekday AM, weekday midday, and weekend midday period for each census block group.[4] Travel sheds were generated for Wednesday morning, Wednesday midday, and Saturday midday time periods to capture variations in service throughout the week.

Figure 15 shows the initial step of the analysis process—defining a specific census block group and the transit stops and service accessible within the GTFS data.

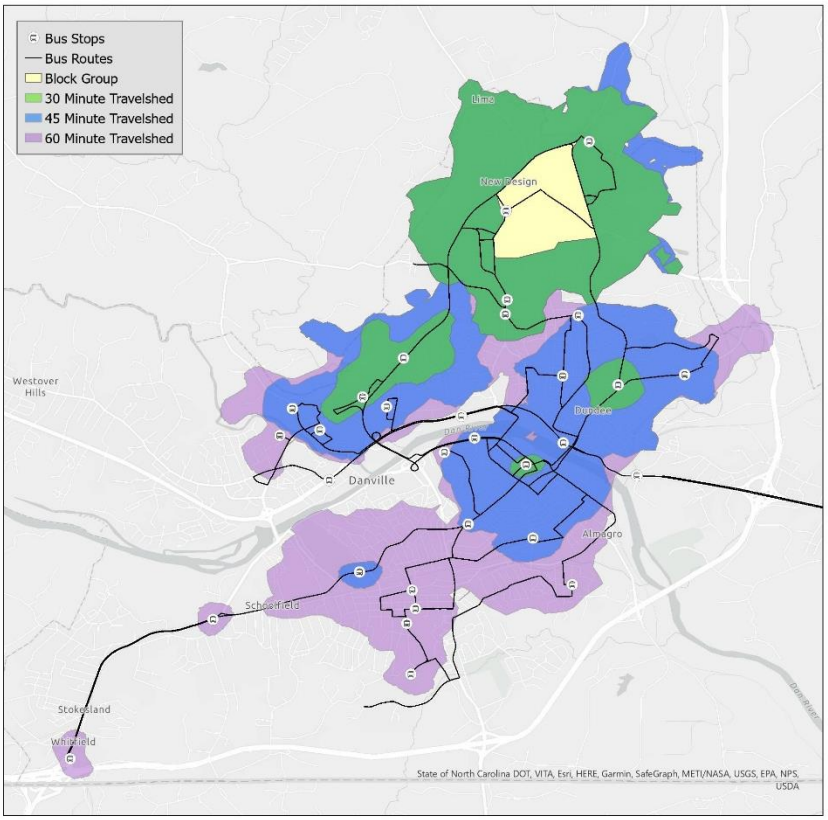
Figure 15: Example Danville census block group and transit stops/routes



The next step of the analysis is to determine the travel shed for a transit rider at three intervals of time. **Figure 16** illustrates the 30-, 45-, and 60- minute travel sheds for the example yellow census block group.

[4] In order to account for a range of departure times from a stop, multiple travel sheds in 10-minute intervals were dissolved to create a single representative travel shed. For example, travel sheds generated at 7:00am, 7:10am, and 7:20am were combined to create the "weekday AM" travel sheds. Through preliminary iterations of the analysis, it was identified that access varies for different locations within a block group; adjusting the methodology to account for this, travel sheds were created for 9 random points within each block group in addition to the block group's centroid. This allowed the score for the block group to more comprehensively represent access across the entire block group geography.

Figure 16: Example Danville census block group 30-, 45-, 60-minute interval travel sheds



Aligning with expectations, longer transit trips result in larger travel sheds. In locations where multiple transit services provide transit, the analysis area for the travel sheds was expanded to include all providers. **Appendix A** outlines each of the analysis areas and included transit providers, and a more detailed methodology for the generation of each travel shed.

Primary data sources for the development of travel sheds include:

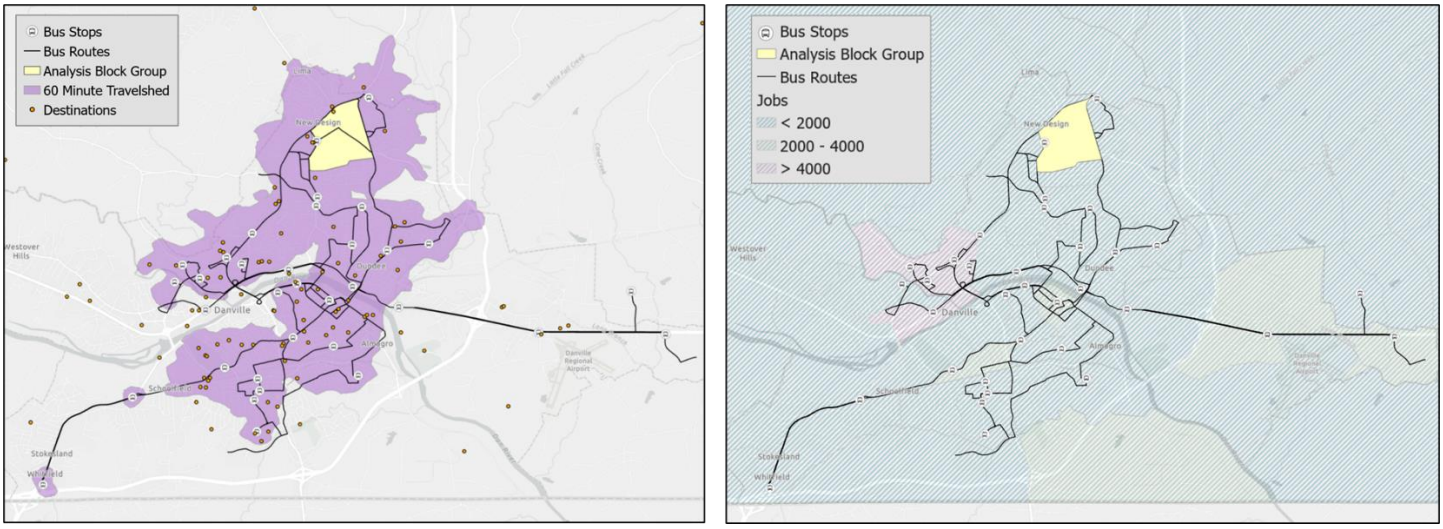
- **Transit system information**, including stop locations, schedules, and route setup, which was derived using each agency's GTFS dataset. The Virginia GTFS data repository provides links to these datasets for all agencies providing fixed-route service in Virginia.[5]
- **Various other open-source products** that allow for automatic querying of roadway network links from OpenStreetMap (OSM), an open-source, crowdsourced database, and generating transit travel sheds along the OSM network using the GTFS-provided schedules.

[5] In general, GTFS data is sourced for service levels in July 2021. Without current data, WMATA GTFS data is sourced from Open Mobility Data for January 2020. Additionally, given that service providers may vary service throughout the year with seasonal or university schedules, GTFS files were updated for the purpose of analysis to show the greatest combination of service provided over the course of a year (2021).

Develop A2O Scores

After generating travel sheds for each Census Block Group served by fixed-route or enhanced fixed-route service throughout the Commonwealth, each travel shed was then analyzed using GIS to quantify the raw number of jobs and destinations accessible within that travel shed. A2O scores are *relative indicators* on a scale of 0 to 1. Scores closer to 1 have higher raw numbers of jobs and destinations along with transit service that provides access to those opportunities. Conversely, scores closer to 0 either have lower numbers of jobs and destinations and/or transit service that does not provide access to opportunities. **Figure 17** shows the destinations, shown as points, and number of jobs per block group, symbolized with gradient shading, included in the analysis of the example block group. Destinations include locations such as healthcare, public spaces, government buildings, and schools/childcare (full list included in **Appendix B**).

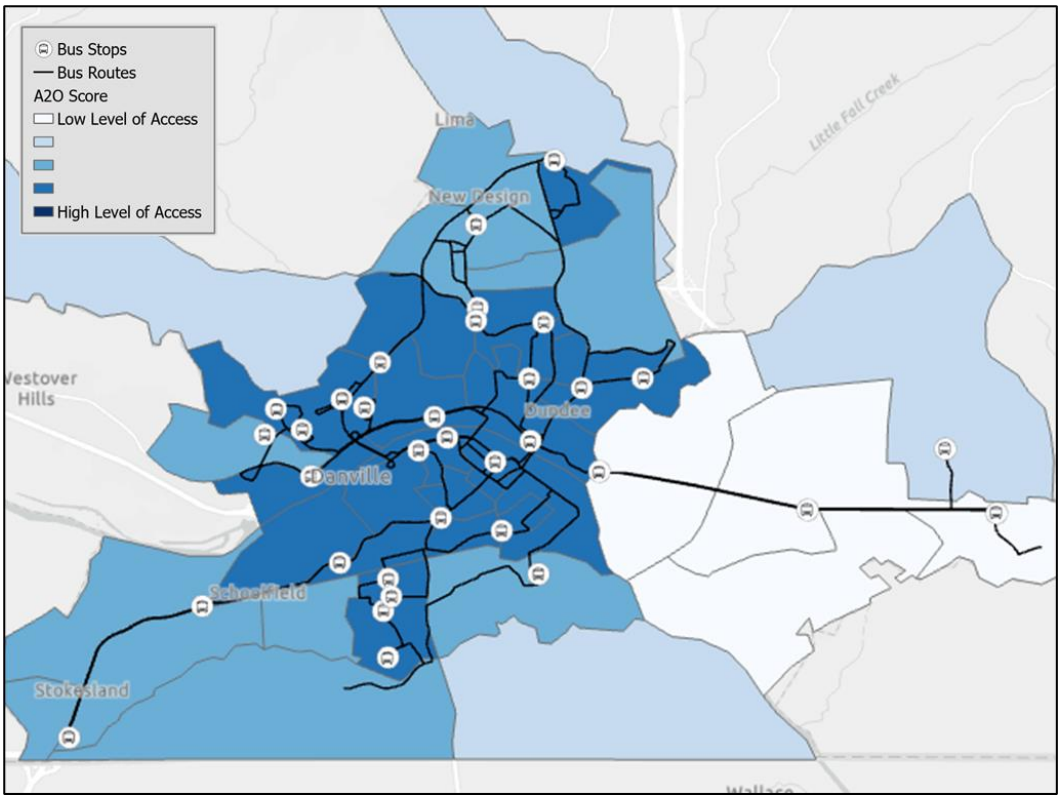
Figure 17: Example Destinations and Jobs in Danville



Total A2O scores were developed by averaging the jobs and places counts separately over the 30-, 45-, and 60-minute travel sheds and then averaging over weekday morning, weekday midday, and weekend midday time periods. These scores were then initially normalized on a 0-to-1 scale across the entire state. The development of an A2O score allows for a comparison of census block groups against each other to provide a better understanding of whether transit is facilitating access to opportunity.

As an example, **Figure 18** shows the relative opportunity scores for Danville for the weekday midday period.

Figure 18: Access to Opportunity scores for census block groups in Danville



Primary data sources for the development of the A2O scores include:

- The **underlying travel network** is obtained using OSM, which also provides data on **specific destination types** used in this analysis, such as parks, schools, healthcare facilities, etc. A complete list of included destination types can be found in **Appendix B**.
- Data on jobs at the census block group level, including a breakdown of jobs at various salary levels, comes from US Census LEHD/Origin-Destination Employment Statistics (LODES) data.

A2O Score Results

The results of the A2O analysis provide insight into how transit service supports riders in accessing jobs and destinations across the Commonwealth. Across the Commonwealth, fixed-route and enhanced fixed-route transit riders (in 3,438 block groups served in total) have access to more than 3 million jobs and 9,000 destinations via transit. The analysis included block groups in the Commonwealth that had access (within the block group or within ¼ mile) to a fixed-route or enhanced fixed-route transit service stop. The following sections examine how A2O scores vary across the Commonwealth, and how access to opportunities vary for vulnerable populations and block groups with high transit needs.

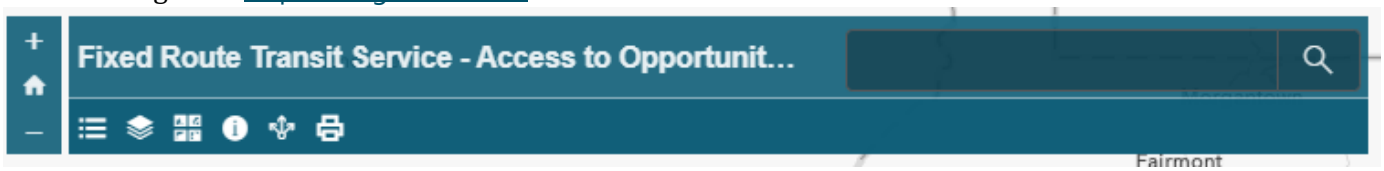
Table 9 shows the area type distribution of block groups included in the A2O analysis. The distribution of block groups included in the analysis aligns with the expectation that urban areas are more likely to have fixed-route or enhanced fixed-route service.

Table 9: Distribution of Block Groups by Area Type

Distribution of Block Groups by Area Type included in A2O Analysis				
Rural	Urban - 4	Urban - 3	Urban - 2	Urban - 1
157	216	628	1185	1240
5%	6%	18%	35%	36%

Online GIS Map

Supplemental to the findings and graphics below is a dynamic Arc GIS Online Map that can be accessed through the following link: https://arcg.is/04m4He



In the upper right corner, the rectangular navigation pane allows the viewer to turn on and off the legend and layers menus. Layers included in the analysis can be turned on and off by clicking the check boxes. Using the Arc GIS Online Map, the viewer can zoom into specific locations across the Commonwealth.

A2O Scores Across the Commonwealth

The A2O analysis is centered on available transit service along with the total number of jobs and destinations accessible within a travel shed. This analysis aims to answer the question, "what is accessible with the transit service provided?" The variation in the level of service and the numbers of jobs and destinations across the Commonwealth contributes to the variations in access to opportunity scores shown in **Figure 19** (which shows a histogram of scores across the state) and **Figure 20** (which provides a statewide map).

The shape of the histogram in **Figure 19** emphasizes the significant variation in the total number of jobs and destinations. Most of the block groups in the Commonwealth received A2O scores of less than 0.3. This indicates that there are a few outliers throughout the Commonwealth that have dramatically more jobs and destinations, particularly in more urban areas, that skew the data down in the normalization process. The A2O score should be interpreted as a *relative indicator* of access. Given each block group has a unique set of characteristics, including geography, activity density, jobs, and destinations, it may not be realistic to expect that a block group in Danville would have the same A2O score as a block group with access to Washington, DC. Thus, using the A2O score as a *relative indicator* within a specific jurisdiction allows judications and/or service providers to focus in on specific areas and identify locations scoring lower than the surrounding areas as locations to potentially analyze further.

Figure 19: A2O Score Distribution (Statewide)

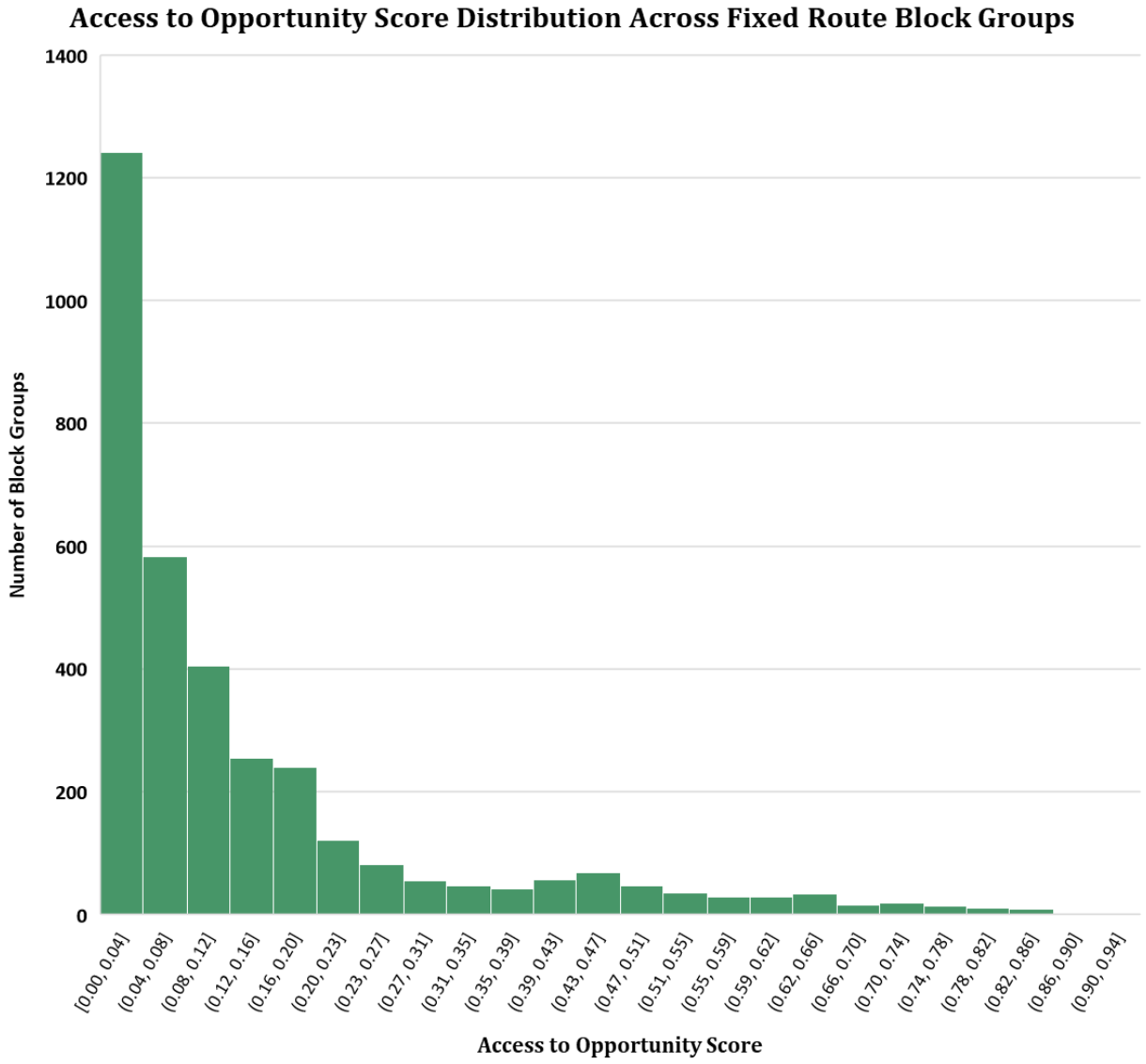
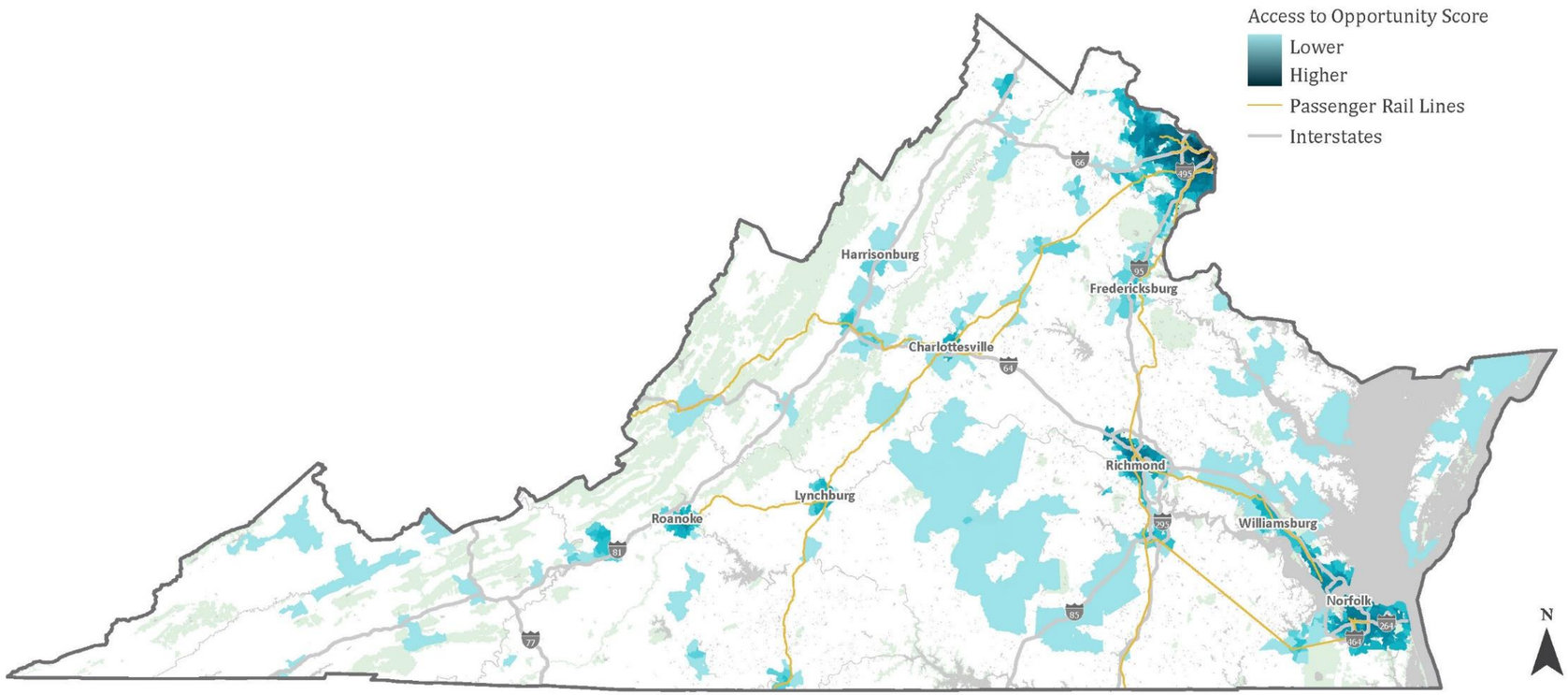


Figure 20: Statewide A2O Scores Map (DRAFT)



)

Further examination of the distribution of scores across the Commonwealth provides insight into the area types that tend to have higher A2O scores (darker shading in **Figure 20**) and lower A2O scores (lighter shading). **Table 10** shows the average A2O score by area type. As expected, the more dense and urban area types have the highest average A2O scores given the density of jobs and destinations. The highest A2O scores are in the Urban-1 area type, as expected, and the Rural area types see the lowest A2O scores.

Table 10: Average A2O Score by Area Type

	Area Type (by population density)					Statewide Average
	Rural	Urban-4	Urban-3	Urban-2	Urban-1	
Average A20 Score of all periods	0.001	0.005	0.032	0.101	0.255	**0.130**

As transit service changes over the course of the week and throughout the day, so does the ability to access jobs and destinations. **Figure 21** illustrates how A2O score vary by area type and analysis period. Aligning with the trend in **Table 10**, the higher the density, the higher the A2O score. Interestingly, the more urban areas see larger decreases in A20 scores moving from Wednesday morning to Wednesday midday and Saturday midday, whereas more rural and small urban areas see less variation across the three analysis periods. The statewide averages are higher for all the area types except for Urban-1, indicating that the A2O scores in Urban-1 play a key role in statewide average.

Figure 21: Average A2O Score by Time of Day and Area Type

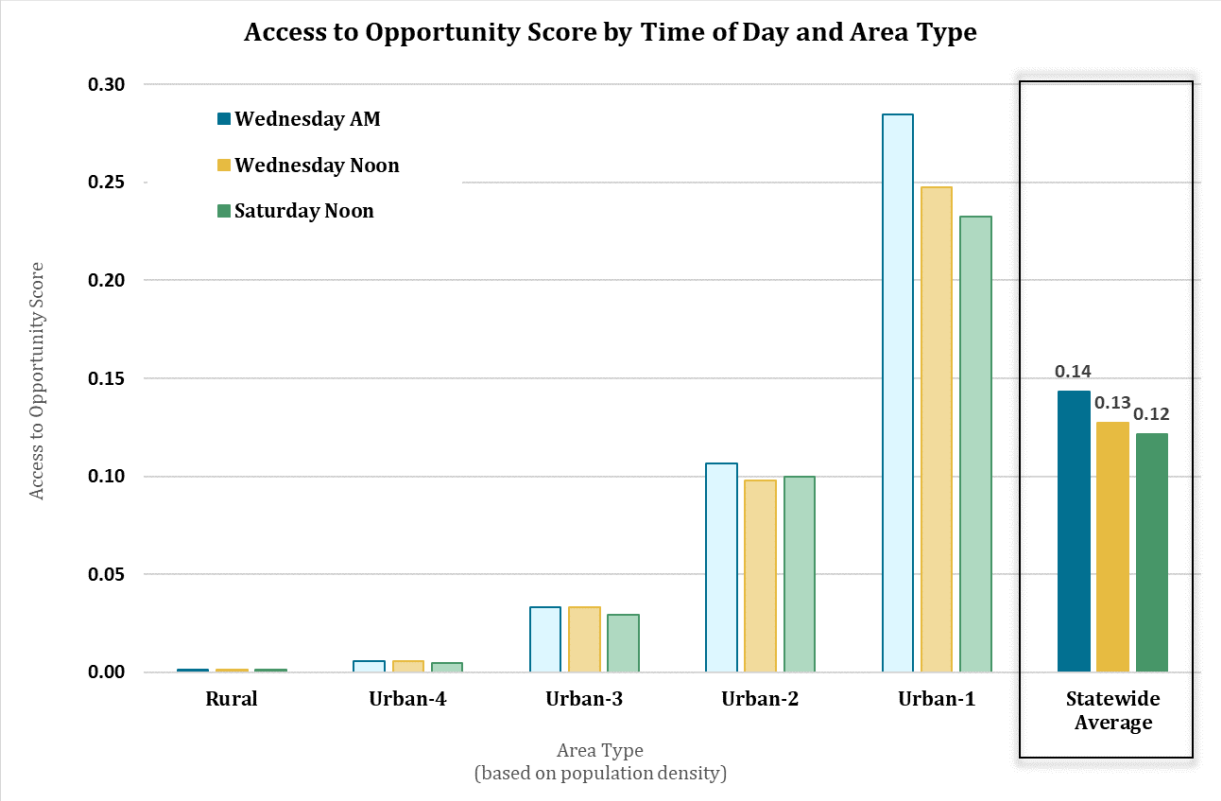


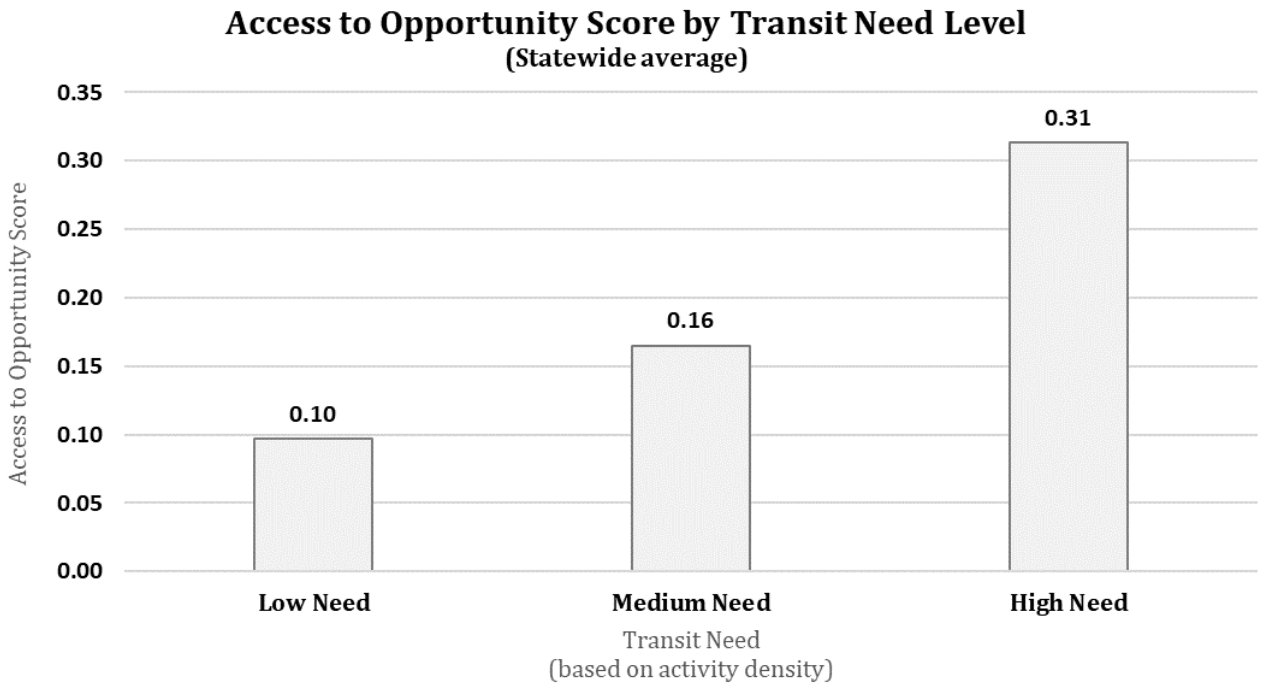
Table 11 illustrates how the A2O score varies by time of day and area type from the average A2O score for a specific area type. During the Wednesday morning period, the statewide A2O score is 9.6 percent higher than the overall statewide A2O score (across all three periods), whereas the statewide score is 2.5 percent lower and 7.1 percent lower during the Wednesday midday and Saturday midday periods, respectively. Similar to **Figure 21**, Rural, and Urban 4-3 area types experience less variation and decrease in A2O scores during the midday periods, whereas more urban areas experience decreases in A2O scores in the midday periods. This likely corresponds to the variations in service frequency offered by time of day in the more urbanized areas of the state. Lastly, the Saturday midday period experiences decreases in A2O scores across all area types. This likely corresponds to the reduced service frequency offered by most providers on weekends.

Table 11: Difference from Overall A2O Score by Time of Day and Area Type

	Difference from Overall A2O Score by Time of Day and Area Type					
Time/Day	**Rural**	**Urban-4**	**Urban-3**	**Urban-2**	**Urban-1**	**Statewide Average**
Wednesday AM	↑ 3.3%	↑ 3.3%	↑ 3.9%	↑ 5.0%	↑ 11.8%	↑ 9.6%
Wednesday Noon	↑ 4.2%	↑ 4.7%	↑ 3.7%	↓ -3.3%	↓ -3.0%	↓ -2.5%
Saturday Noon	↓ -7.5%	↓ -8.0%	↓ -7.6%	↓ -1.7%	↓ -8.8%	↓ -7.1%

Block groups with higher population and employment densities are classified as locations with a higher need for transit service, as described previously. **Figure 22** illustrates that the A2O score increases moving from low to medium and high need block groups. Not surprisingly, the locations identified as needing fixed-route or enhanced fixed-route service are more often in dense urban areas that have this type of service.

Figure 22: Average A2O Score by Transit Need Level

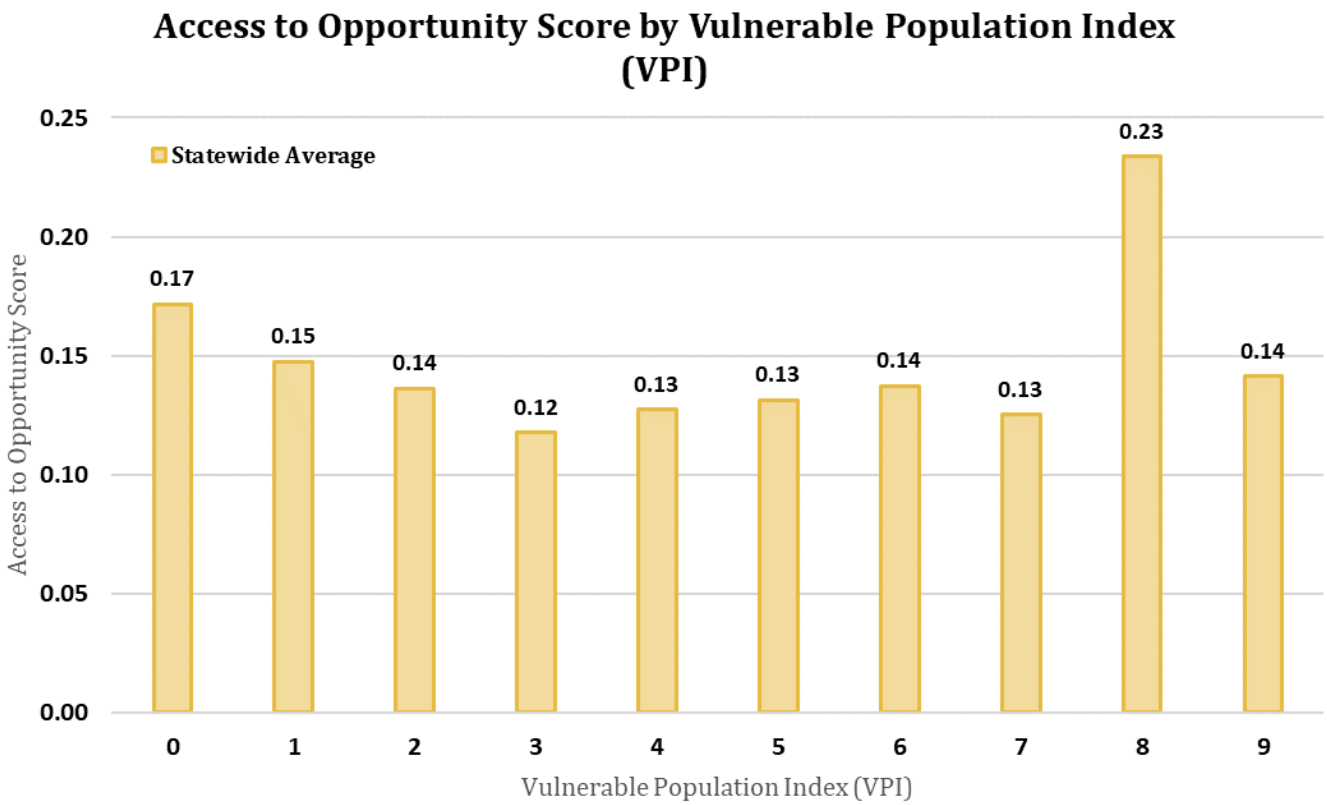


Building on trends for block groups that have higher needs, the following analysis examines how A2O scores vary by VPI classifications. **Table 12** and **Figure 23** illustrate that access to opportunity varies by approximately 0.04 points statewide between less vulnerable populations (VPI = 0) and vulnerable populations (maximum included in analysis is VPI = 9). In general, more vulnerable populations have lower access to opportunity scores. An outlier to the above trend is block groups with a VPI score of 8. These 23 block groups are in the Hampton Roads, Roanoke, Richmond, and Northern Virginia areas, which have access to higher numbers of jobs and destinations along with enhanced transit service resulting in the higher A2O scores.

Table 12: Average A2O Score by Vulnerable Population Index and Time of Day

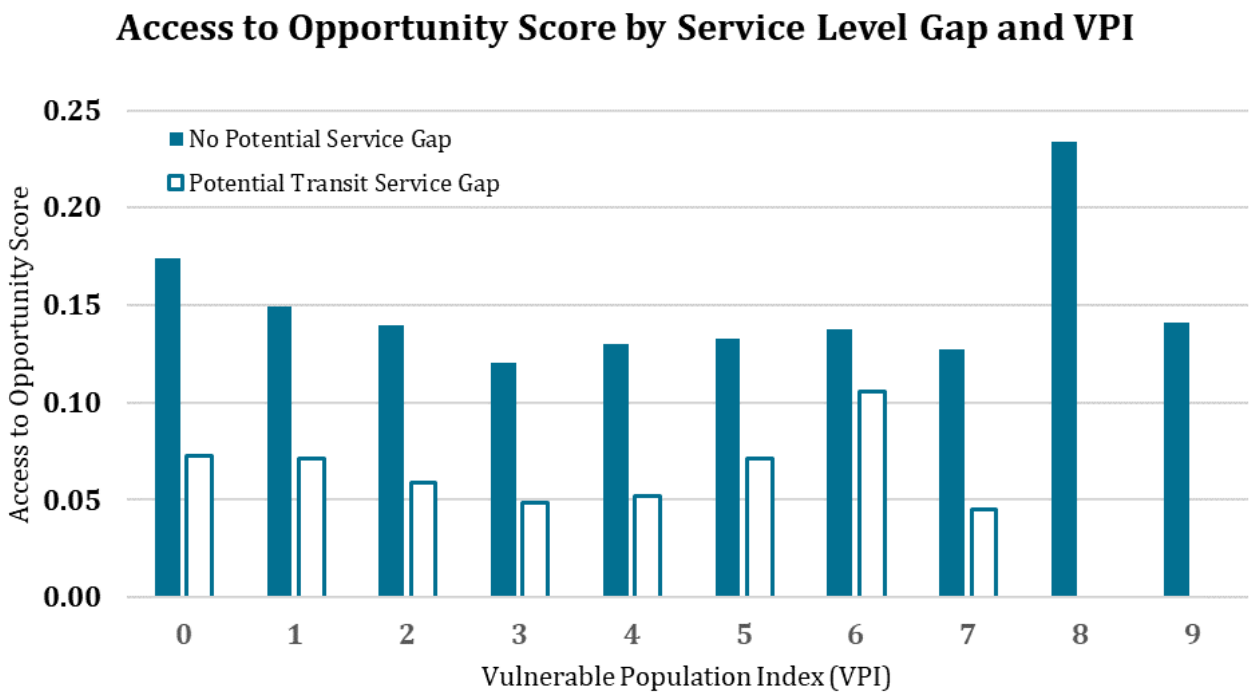
Vulnerable Population Index (VPI)	Number of Block Groups	Wednesday AM	Wednesday Noon	Saturday Noon	Statewide Average
0	160	0.19	0.17	0.16	**0.17**
1	429	0.16	0.14	0.14	**0.15**
2	651	0.15	0.13	0.13	**0.14**
3	694	0.13	0.11	0.11	**0.12**
4	599	0.14	0.12	0.12	**0.13**
5	482	0.14	0.13	0.12	**0.13**
6	242	0.15	0.13	0.13	**0.14**
7	121	0.14	0.12	0.12	**0.13**
8	23	0.25	0.23	0.22	**0.23**
9	6	0.15	0.14	0.14	**0.14**

Figure 23: Average A2O Score by Vulnerable Population Index



The gap assessment described previously identified specific block groups in which there are potential gaps in frequency and service levels based on the density. Comparing the identified block groups with gaps to the A2O scores receive, shown in **Figure 24**, block groups with potential transit service gaps often received lower A2O scores across all applicable VPIs. As the VPI score increases, the gap between A2O scores also becomes greater.

Figure 24: Average A2O Score by Transit Service Level Gaps and VPI



Proportion of Jobs and Destinations Accessible

Introduction

Building on the Access to Opportunity analysis, this analysis aims to determine the proportion of jobs and destinations that are accessible via transit. As noted in the Access to Opportunity findings, the raw numbers of jobs and destinations vary by geography and density levels across the Commonwealth. Census block groups in areas with higher densities and more urban character tend to have higher numbers of destinations and jobs in comparison to census block groups with lower densities and more rural character. This analysis attempts to normalize the variations in raw numbers of destinations and jobs by determining how many of the *available* jobs and destinations are *accessible* via transit. Through this analysis, a rural area with access to 80 of 100 available jobs via transit may score similarly to a location that has transit access to 12,000 of 15,000 jobs if both census block groups have access to approximately the same percentage of the available jobs.

Desired Outcomes

- Develop a methodology to determine the *available* number of jobs and destinations for a specific census block group.
- Determine the proportion of available number of destinations and jobs accessible in 60-minute transit travel sheds (via fixed-route transit) for each census block group served by fixed-route transit in the Commonwealth

- Identify statewide trends in the proportions of destinations and jobs accessible for census block groups served by fixed-route transit.

Methodology and Assumptions

Calculate Available Number of Jobs and Destinations for Each Census Block Group

To conduct the analysis, the total number of available jobs and destinations needed to be calculated to compare to the number of jobs and destinations accessible by fixed-route transit service. There are approaches to determine the boundaries to calculate the number of available jobs and destinations including, but not limited to, a fixed radius circle around the centroid of the block group, the county associated with the block group, all the counties served by the transit service, metropolitan and micropolitan statistical area boundaries (MSA's), and drivesheds.

Many of the approaches above were tested using GIS and Excel to determine which approach best quantifies the available number of jobs and destinations. A challenge with many of the approaches is that while an approach may work for one area type it may not be the best for another area type. Additionally, some of the approaches generated an unrealistically large boundary to capture the number of jobs and destinations. Differences in the geographic coverage of the transit service, the size of the census block group, and the census block group's location relative to its county are all examples of challenges in accurately depicting the number of jobs and destinations accessible at a statewide level. Ultimately it was determined that the most appropriate approach was to determine the number of jobs and destinations accessible with a 60-minute driveshed for each census block group.

The methodology to generate the 60-minute drivesheds was similar to the methodology to calculate the transit travel sheds in the A2O analysis. The 60-minute drivesheds were generated for Wednesday midday. The drivesheds consider historical congestion along roadways at the time of analysis using data from HERE[6].

Develop Proportions of Jobs and Destinations Accessible

Once the 60-minute drivesheds were developed for each census block group, each travel shed was then analyzed using GIS to quantify the number of jobs and destinations available within that the 60-minute driveshed. For each of the census block groups the proportion of accessible jobs and destinations was calculated for Wednesday 7am, Wednesday midday, and Saturday midday using the following equation:

$$Proportion\ of\ Jobs\ Accessible = \frac{Number\ of\ jobs\ accessible\ via\ \ 60\ \text{min fixed route}\ transit\ travelshed}{Number\ of\ jobs\ available\ via\ \ 60\ \text{min}\ driveshed}$$

$$Proportion\ of\ Destinations\ Accessible = \frac{Number\ of\ destinations\ accessible\ via\ 60\ \text{min fixed route}\ transit\ travelshed}{Number\ of\ destinations\ available\ via\ 60\ \text{min}\ driveshed}$$

Results of Proportions of Jobs and Destinations Accessible Analysis

The results of the proportion analysis provide insight into differences in the proportion of accessible jobs and destinations across the Commonwealth and for different population groups. The proportions indicate the percentage of jobs and destinations accessible with fixed route transit relative to those accessible with a 60-minute driveshed. While the maximum possible proportion is 100%, that value is likely unrealistic in that it would imply that the access for that census block group is the same between a 60-minute driveshed and a 60-minute transit travel shed. Acknowledging that not all area types or regions have the same relationship between jobs/destinations and transit service lends that 100% should not be the goal for each area or agency. **Figure 25**

[6] Provider of information derived from mobile devices, including roadway network travel times.

and **Figure 26** illustrate the distribution of the proportion scores for jobs and destinations, individually, across the Commonwealth. To determine potential locations for improvements, the Online GIS Map can be used to isolate a specific area and identify census block groups that have a relatively lower proportion of accessibility than other census block groups served in the same area or by the same agency.

Figure 25: Job proportion statewide (Wednesday-midday-60min travelshed)

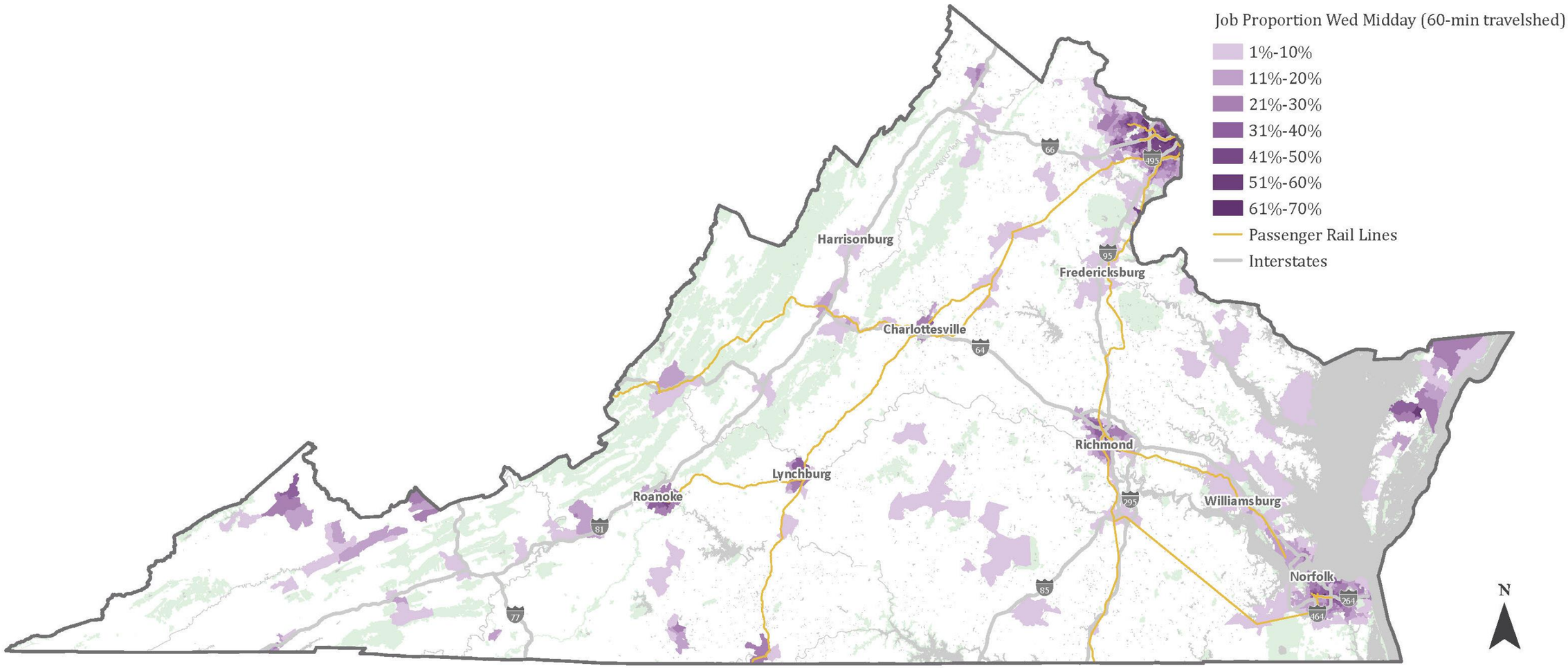
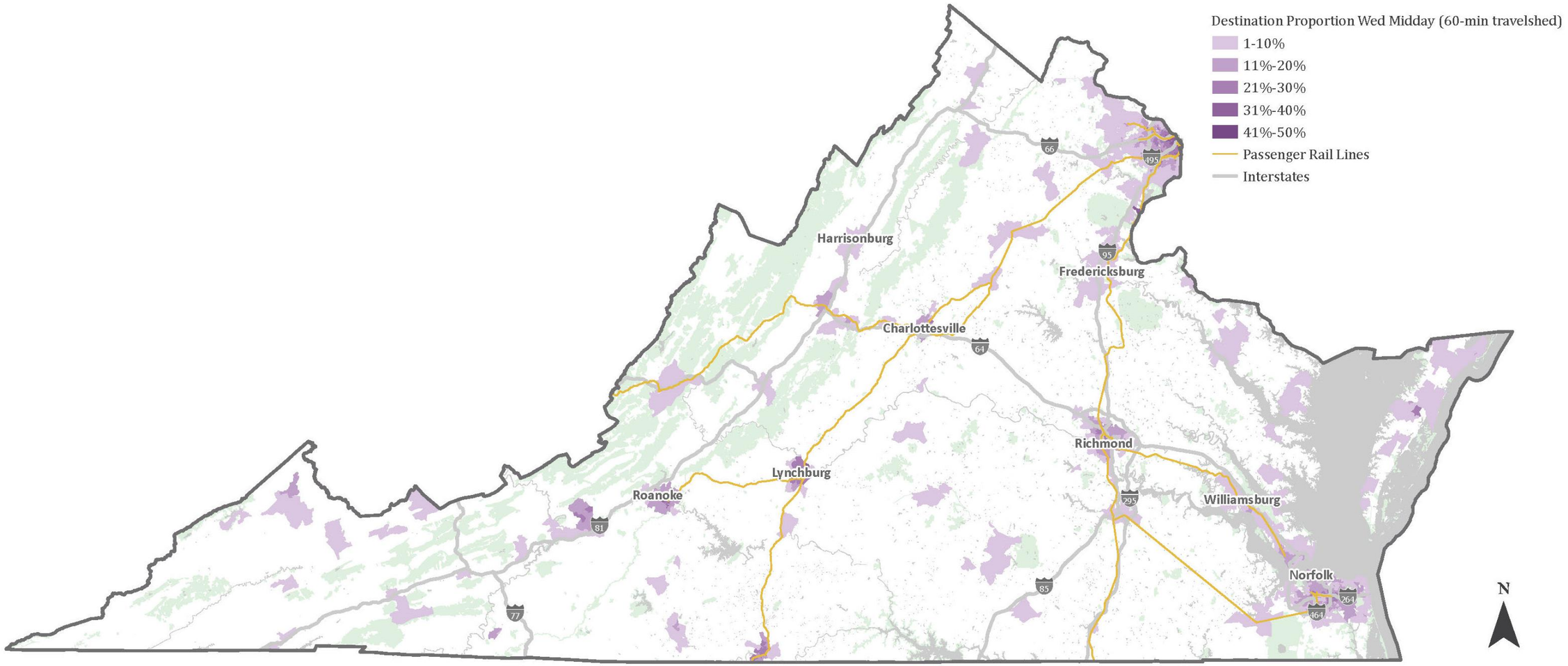


Figure 26: Destination proportions statewide (Wednesday-midday-60min travel shed)



The analysis for the Commonwealth resulted in proportions of fixed route transit accessibility between 0% and 70% of jobs available. **Figure 27** illustrates the distribution of job and destination proportions across the census block groups for the Wednesday 7am transit travel sheds. The distribution of proportions for jobs is much wider than the distribution of destinations. Furthermore, of the 1,761 census block groups that fall into 0%-10% bins for destinations, 717 of those census block groups are shifted upward out of the lower bins for the proportion of *jobs* accessible. The greater access to jobs, relative to destinations, may be based on the nature of how transit is planned and implemented around higher densities and employment hubs rather than some of the destinations included in the analysis (e.g., parks, healthcare, etc.).

Figure 27: Proportion Distribution (Statewide)

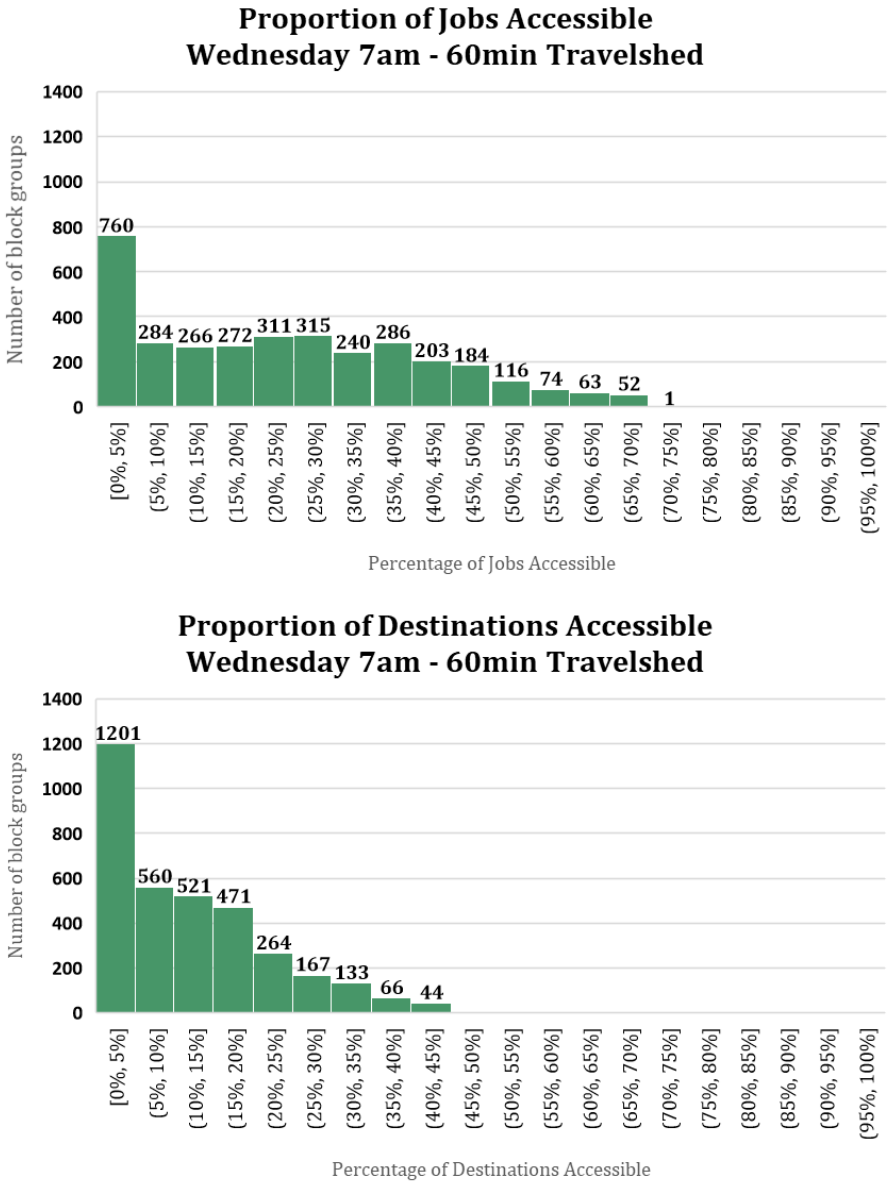
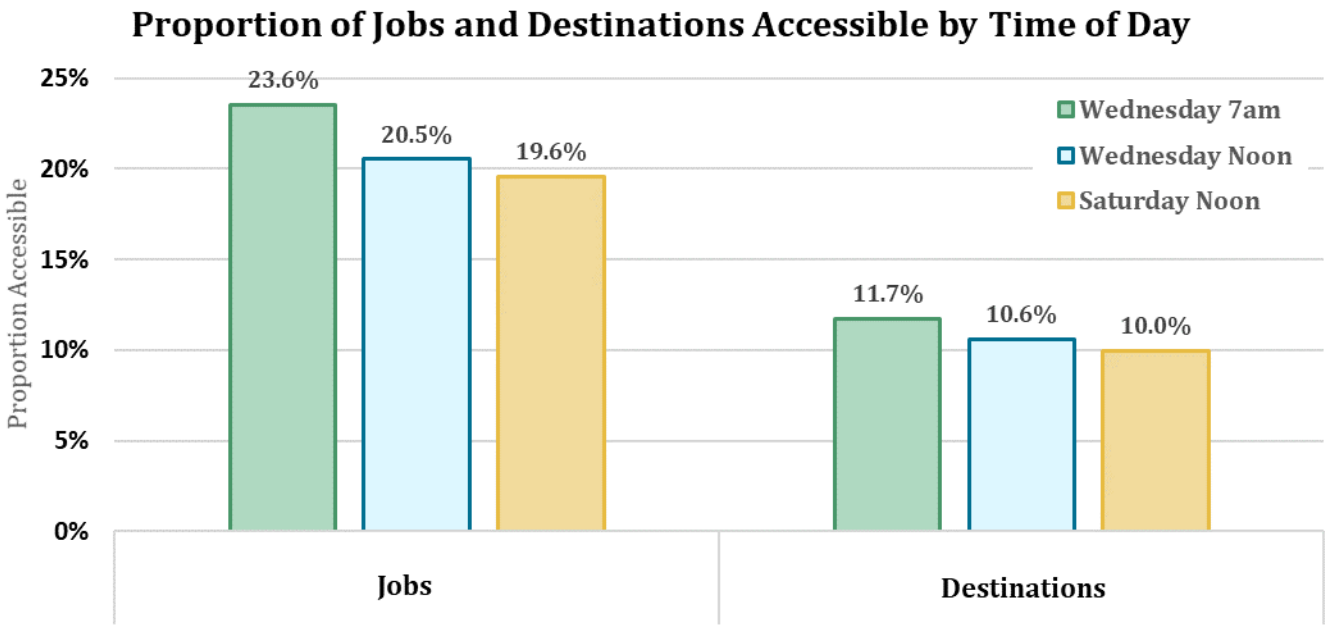


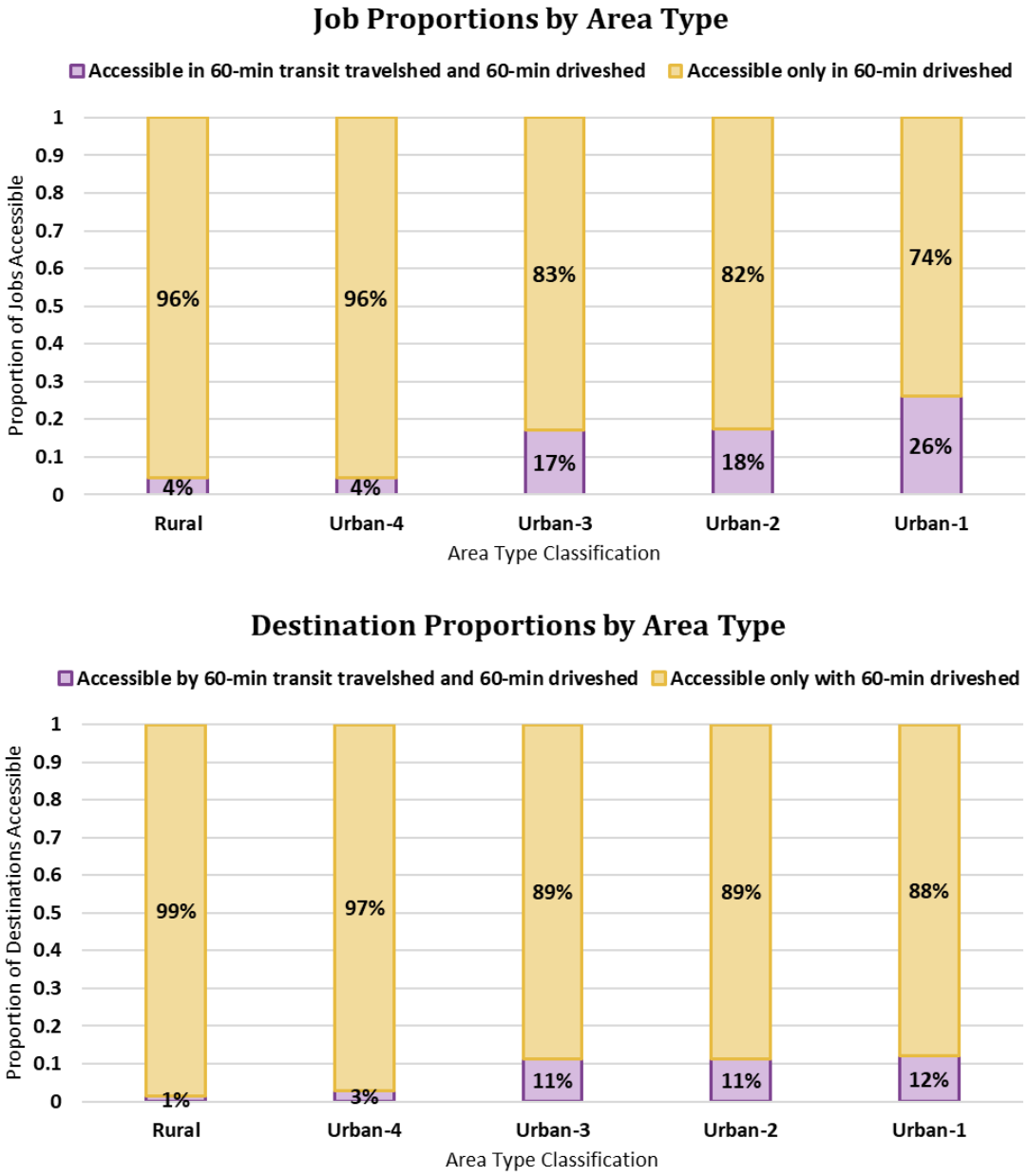
Figure 28 illustrates the difference between the proportions of jobs and proportion of destinations accessible during different time periods. Similar to Figure 27, the average proportion of jobs accessible is approximately double the average proportion of destinations accessible with a 60-min transit travel shed. Figure 28 also highlights the decrease in proportions from Wednesday 7am, to Wednesday midday, to Saturday midday. The difference of job proportions between Wednesday 7am and Saturday midday is approximately 4%, while time of day is less influential on the destination proportions. Again, this may suggest that the increased transit service during the Wednesday 7am peak may be concentrated on access to jobs rather than access to destinations.

Figure 28: Proportion of jobs and destinations accessible by time of day



Interestingly, the proportions of accessible jobs and destinations follows a similar area type trend, shown in **Figure 29** and **Table 13**, to the trends identified in the A2O analysis. In general, more rural areas have lower A2O scores and lower proportions of accessibility for jobs and destinations. Conversely, more urban areas have higher A2O scores and higher proportions. Of note, the difference between urban and rural areas is more dramatic in the A2O analysis (for reasons elaborated on above) in comparison to the proportion analysis which aims to normalize statewide by using the proportion of jobs and destinations accessible. For example, a the average A2O score for rural area types is very close to zero, whereas the proportion is closer to 5%. This may suggest that there may not be a high quantity of jobs and destinations available, but the transit service is providing access to some of the available opportunities. Again, it is important to note that it may not be realistic, or feasible, for rural agencies to provide access to anywhere near 100% of jobs and destinations accessible by driving due to spread and low densities in the surrounding areas. Figure 29 also illustrates that the destination proportions are relatively constant for area types greater than Urban-4 whereas job proportions increase from Urban-3 to Urban-1.

Figure 29: Job and destination proportions by area type[7]



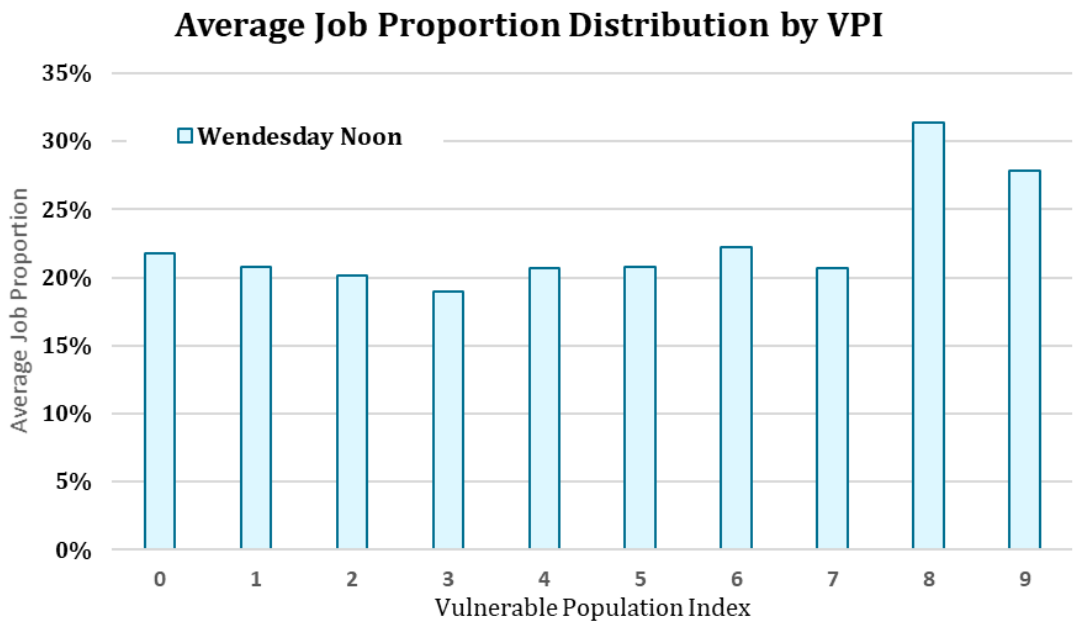
[7] Comparison of the Wednesday midday 60-minute transit travel shed and Wednesday midday 60-minute driveshed.

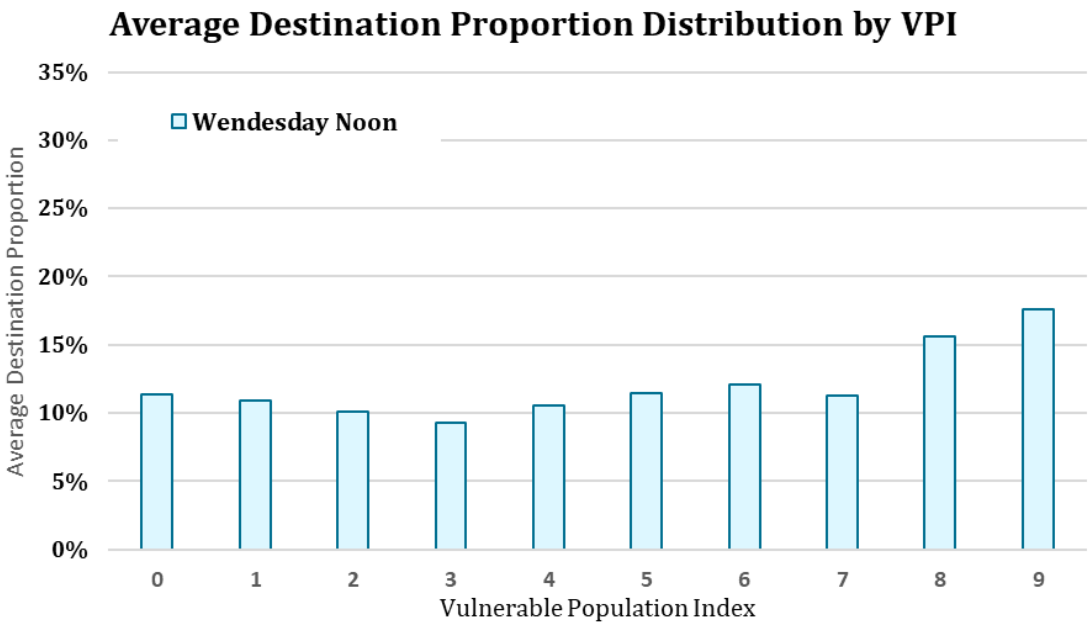
Table 13: Percentile values for proportions by area type

Area Type	Jobs Proportion Percentiles			Destinations Proportions Percentiles		
	25th	50th	75th	25th	50th	75th
Rural	0%	0%	4%	0%	0%	1%
U-4	1%	3%	6%	0%	2%	4%
U-3	4%	15%	26%	3%	8%	17%
U-2	11%	18%	26%	7%	11%	16%
U-1	7%	30%	44%	2%	8%	22%

The following analysis, illustrated in **Figure 30**, examines how proportions vary by vulnerable population index (VPI). In general, for both jobs and destinations, as the VPI increases so does the proportion of jobs and destinations available in a 60-minute driveshed are accessible within the 60-minute transit travel shed. Census block groups with VPI indices of 3 and 7 show slightly lower proportion scores relative to the other VPI's. Those census block groups with the highest VPIs (indices of 8 or greater) have higher proportion scores relative to the other VPI indices.

Figure 30: Jobs and Destinations Proportions by VPI





Key Takeaways

- Proportions across the Commonwealth range from approximately 0%-75%, with majority of census block groups scoring between 20%-40%. With only 20%-40% of jobs and destinations accessible via fixed route transit service, there could be discrepancies in the number of opportunities available for those who have access to a vehicle versus those who do not.

- Accessibility proportions are higher for jobs relative to destinations. This trend is true for all area types and vulnerable populations.
- Some locations with more rural characteristics that scored relatively lower in the A2O analysis proportions have job proportion scores between ~15%-50%, similar to some locations with more urban characteristics. Examples include, the eastern peninsula, and the southwest corner of the Commonwealth.
- The difference between proportion scores across area types is less dramatic than the distribution of A2O scores suggesting that while more rural areas may have less jobs and destinations overall, service providers are able to connect riders to the jobs and destinations that are available.
- In general, for both jobs and destinations, as the VPI increases so does the proportion of jobs and destinations available in a 60-minute driveshed are accessible within the 60-minute transit travel shed

Policy Assessments

This section explores two areas of policy related to transit accessibility—zero-fare transit and equitable service planning. Both topics have received significant attention both in Virginia and around the country as agencies explore different ways to modernize transit service. Each section uses existing research, national case studies, and insight from agencies in Virginia to highlight the current state of practice and ultimately provide findings and opportunities for Virginia at the statewide and agency levels.

Zero-Fare Transit

What is Zero-Fare Transit?

Many transit systems in the United States use fares as a source of revenue to operate service. While not a new idea, the idea of "zero-fare" transit, or transit service for which riders do not need to pay a fare to use, has become a popular discussion topic for transit agencies, advocates, and researchers.

This section of the report will examine zero-fare transit policy and its potential impacts on providing equitable transit service. First, this section will document prior efforts in the Commonwealth to implement zero-fare transit service and provide in-depth analysis on two agencies seeking to implement zero-fare service in the future. Second, three agencies from across the US representing different scales of service will be evaluated based on their experience for going zero-fare. The third and final section will look at potential considerations for Virginia, including the benefits and tradeoffs of implementing zero-fare service, and potential opportunities for Virginia transit agencies and the Commonwealth to support or implement zero-fare policies.

This assessment focuses on zero-fare transit policies, which is just one strategy agencies could employ to increase the equity benefits of their service. For instance, reduced-fare policies have the potential to provide equity benefits like zero-fare policies do, but reduced-fare policies are already a common practice and have been tried by agencies in the Commonwealth and are therefore not the prime focus of this section of the memo.

Contributing Factors Behind Zero-Fare Policy

The COVID-19 pandemic significantly reduced ridership for agencies across the US, decreasing the amount of farebox revenue agencies were taking in. Some agencies realized they would not be able to sustain operations without farebox revenue for the riders who continued to rely on the service, who were often low-income essential workers who had no other means of transportation. Additionally, many agencies were attempting to reduce tactile interactions associated with fare collection, whether it's operator and rider exchanges or human

bottleneck points at ticketing stations. The Coronavirus Aid, Relief, and Economic Security Act (CARES Act) was passed by the federal government to allow transit agencies to continue operation, and many agencies in Virginia used this money to provide zero-fare service to their riders. After more than a year of zero-fare operations, many agencies in Virginia are looking to implement zero-fare service long term.

Before the pandemic, DRPT had begun to consider how it could support local efforts to implement and sustain zero or reduced fare programs. The Transit Ridership Incentive Program (TRIP) is a new grant program administered by DRPT accepting applications in September 2021. The need for for TRIP was originally identified in the 2020 Transportation Omnibus Bill and has two main goals—improve regional connectivity in urbanized areas and reduce barriers to transit use by supporting low-income and zero-fare programing.

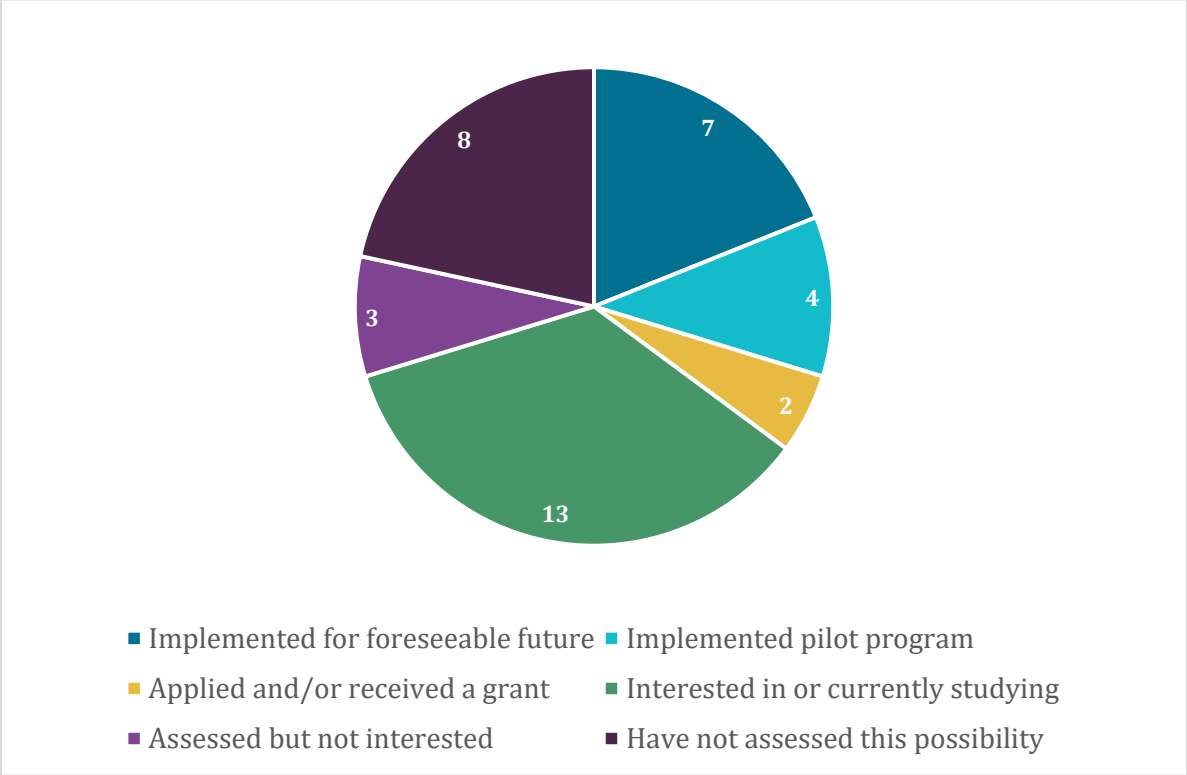
Parallel to the COVID-19 pandemic and impetus to continue providing service to those riders who need it most, there also is a prevalent idea among transit activists to recognize transit service as a public right provided to riders free of charge. While the majority of transit systems around the United States charge riders fares to use the service, most motorists do not need to pay fees to access interstate highways or their local urban roads. Instead, roadways infrastructure is financed through large amounts of federal funding programs, and local and state excise taxes. Proponents of zero-fare transit see the policy as a strategy to recognize transit as a public right, removing the individual financial burden associated with using the service in the form of a fare and transferring that cost to the public realm.

State of Zero-Fare Policy in Virginia

Prior Implementation Efforts

Zero-fare transit service had not been implemented in Virginia prior to the COVID-19 pandemic. Though the pandemic had a drastic impact on ridership numbers and, as a result, farebox revenue, the CARES Act allowed many agencies to sustain operations and prevent cuts to service. Several agencies in Virginia used CARES Act funding to provide continued service and suspend fares in an attempt to alleviate the financial burden on their transit-dependent riders. A survey of all transit agencies in the Commonwealth was conducted as part of this study. One of the questions asked was, “Rate your agency’s level of interest in implementing the zero-fare service.” The results from that question of the survey are summarized in **Figure 31**. During the pandemic, DRPT conducted a survey of transit agencies asking whether or not the agency provided zero-fare service at the time of responding. To understand whether size, geography, and service types provided affect an agency’s appetite for implementing zero-fare transit, survey responses were cross-referenced with transit agency National Transit Database reporting status. Below are some takeaways of the of the transit agency survey. Results indicate that full reporting agencies have expressed greater interest in implementing zero-fare transit have had had implemented zero-fare service more than small system reporting and rural reporting agencies.

Figure 31: Transit Agency Interest in Implementing Zero-Fare Transit



Full reporting agencies (Agencies that have received FTA Section 5307 funding, have more than 30 vehicles, or operate a fixed guideway system)

- 5 of 14 full reporting agencies have implemented a zero-fare transit program for the foreseeable future, implemented a pilot program, or applied and/or received a grant to implement a program. 8 agencies are interested in or currently studying the possibility of implementing zero-fare transit service.

Small systems reporting agencies (Agencies that have received FTA Section 5307 funding and have less than 30 vehicles)

- 5 of 9 small systems reporting agencies have implemented a program for the foreseeable future or implemented a zero-fare transit pilot program. 1 agency has applied for and/or received a grant, and one is interested in or currently studying the possibility of implementing zero-fare transit service.

Rural reporting agencies (Agencies that receive FTA Section 5311 funding)

- 2 of 15 rural reporting agencies have implemented a zero-fare transit program for the foreseeable future and 6 are interested in or currently studying it.

At any point throughout the pandemic and the life of the survey, up to 23 agencies operated zero-fare service in some capacity.

The Northern Virginia Transportation Commission (NVTC) published a white paper, "Zero-Fare and Reduced-Fare Options for Northern Virginia Transit Providers,"[8] in September 2021 outlining policy and technical considerations that Northern Virginia transit-operating decision-makers should consider before implementing zero-fare and reduced-fare programs. The white paper outlines the potential scenarios for implementing zero-fare service, including promotional or limited time periods, targeted customer groups, route- or zone-specific programs, time of day, service type, and systemwide implementation. The white paper also talks about the challenges and opportunities an agency might encounter when implementing zero-fare service. These challenges and opportunities also apply to agencies outside of Northern Virginia and are referenced later in this section as well.

State Resources and Programs

TRIP

One of the two types of projects TRIP awards funding for is reduced- or zero-fare programs. TRIP provides funding equal to 80 percent of the maximum project cost and can be applied to a project for a maximum of 3 years. In the second and third years, it is anticipated that the state share will decrease and the local commitment will increase. In the fourth year of the program, the agencies must fund their zero-fare transit service programs using 100 percent local funds and require no funding commitment from the Commonwealth. Reduced- or zero-fare programs are scored on four weighted criteria. The maximum score a project can receive is 100 points. The four criteria and their maximum point allocation are outlined below.

- **Impact on ridership** – applicants are required to estimate the increase in ridership by 2025 *(30 points)*
- **Applicant commitment** – applicants are evaluated on their previous planning efforts and their financial ability to see the project through to completion *(30 points)*
- **Implications for equity and accessibility** – applicants are required to analyze the impact the project will have on low-income and marginalized community members *(30 points)*
- **Project schedule and readiness –** applicants are required to submit an implementation schedule for their project *(10 points)*

While the TRIP program will certainly help agencies implement zero-fare transit service, only providing funding for a maximum of 3 years does not guarantee long-term equity benefits. While many agencies who have implemented zero-fare programs report an increase in ridership in the first year, the actual benefits from going zero-fare may not be realized within that 3-year timespan. TRIP is codified as a percentage of the Mass Transportation Trust Fund, but the General Assembly has only authorized funding for FY22. Increasing the amount and duration of funding for future TRIP grant cycles could assist with long-term zero-fare implementation programs. Finally, only 30 percent of a reduced- or zero-fare project's score is allocated to metrics that are related to providing an equity benefit. Given the current funding allocation for TRIP and the proportion of application scores weighted by non-equity metrics, there is certainly room for TRIP to be refined and improved in the future.

The TRIP application period opened on August 1, 2021 and closed on September 17. Applicants have until October 1 to submit supplemental information such as letters of support and board approvals for their projects.

[8] https://novatransit.org/uploads/studiesarchive/Zero-Fare%20and%20Reduced-Fare%20White%20Paper%20Final%202021-08-30.pdf

Virginia Transit Association (VTA) Temporary Assistance for Needy Families

Temporary Assistance for Needy Families (TANF) is a federal block grant designed to provide cash assistance to families living in poverty to help them achieve self-sufficiency. In 2020, VTA was awarded $2 million for FY21 and FY22 to provide competitive grants to organizations providing transportation to TANF-eligible persons and individuals with a dependent child whose income is at or below 200 percent of the federal poverty level. **Table 14** shows the results of the TANF program in its two years of being offered to agencies. In each year four applications were submitted and all four were selected for funding. The total cost of the program in FY21 was about $90k, which is significantly less than the $1M appropriated for that year. The COVID-19 pandemic has changed commuter demand and needs, and this has adversely affected the TANF program. Riders became increasingly cautious about taking transit and it became difficult for agencies to begin new vanpool routes with a driver shortage.

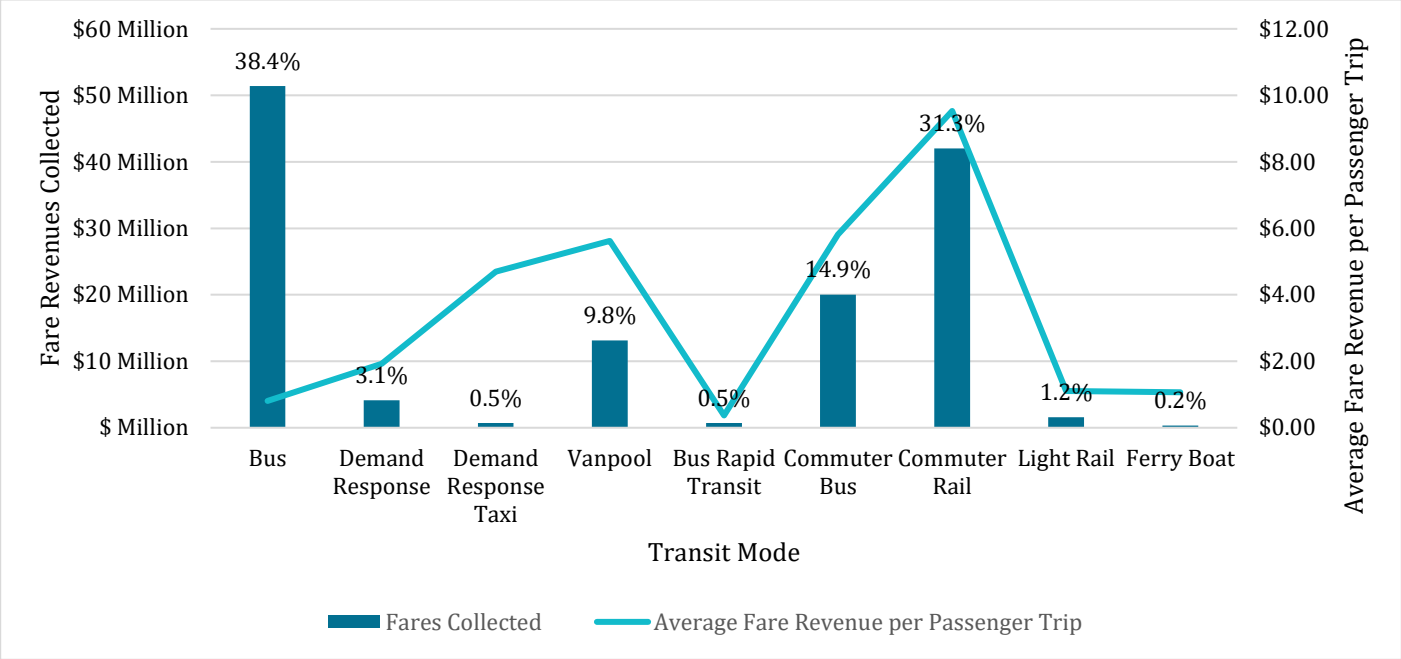
Table 14: Temporary Assistance for Needy Families Grant Program Results

	FY21	FY22
Number of Applications	4	4
Number of Selected Applicants	4	4
Cost of Selected Projects	$87,948	$14,202

Statewide Financial Assessment

Zero-fare service has the potential to provide significant benefits to traditionally underserved populations and increase access to transit and should seriously be considered by the Commonwealth in its commitment to providing equitable transportation options to its communities. Using National Transit Database (NTD) fare collection data from 2019, it was estimated that the cost of implementing zero-fare transit service for every transit agency in the Commonwealth (including VRE, but not WMATA) combined would be about $134 million per year. For reference, **Figure 32** shows the farebox revenue and average fare revenue per passenger trip collected by each transit agency in Virginia for each mode of service provided. This includes eliminating fares for paratransit service associated with fixed-route service as well. The $134 million estimate to eliminate fares does not include the reduction of costs associated with the elimination of capital and operating costs associated with fare collection practices, or the employee time spent on fare collection.

Figure 32: Farebox Revenue and Average Fare Revenue Per Passenger Trip by Mode



Source: FY19 NTD Data

To illustrate the cost of providing zero-fare transit for all agencies in the Commonwealth, a low and high scenario were developed due to the uncertainty surrounding future ridership levels, and by extension fare revenues. It should be noted that both the low and high-cost estimate scenarios represent the total cost of eliminating fares, regardless of funding source or agency that would provide the funds.

Table 15 and **Figure 33** shows the low and high scenarios for implementing zero-fare transit for FY22 through FY27. The low scenario assumes a baseline of about $60 million of fare revenue in FY22 since that is what agencies expected to collect that year based on the SYIP. It was assumed that ridership and fare revenues would recover gradually each year to pre-pandemic levels by FY25. A 3 percent inflation factor was used to scale the estimated farebox revenue for each fiscal year. For this estimate, the pre-pandemic fare revenue used for reference was $134 million from FY19 NTD data. In FY26 and FY27, the percent difference in total statewide DRPT operating assistance from the year prior was used to determine the expected increase in fare revenue.

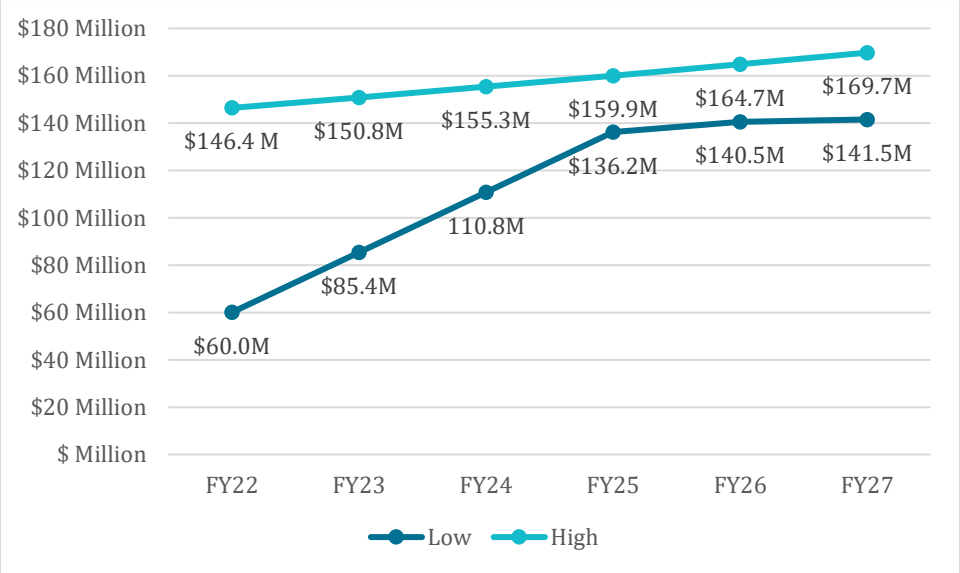
The high scenario assumes no drop in ridership from FY22 to FY27 and instead applies a 3 percent inflation factor each year, starting with NTD reported farebox revenue in FY19 ($134 million). Given that trends before 2019 showed ridership decreasing over time, assuming constant ridership through the pandemic years and onward is a high estimate of where ridership and fare revenues will be in the future.

Table 15: Cost of Zero-Fare Transit

	Low	High
FY22	60.0 M	$146.4 M
FY23	$85.4 M	$150.8 M
FY24	$110.8 M	$155.3 M
FY25	$136.2 M	$159.9 M
FY26	$140.5 M	$164.7M
FY27	$141.5 M	$169.7 M
Total	**$674.5 M**	**$947.0M**
Source: Estimates are shown in $YOE (year of expenditure)		

Source: FY19 NTD, FY22 DRPT SYIP

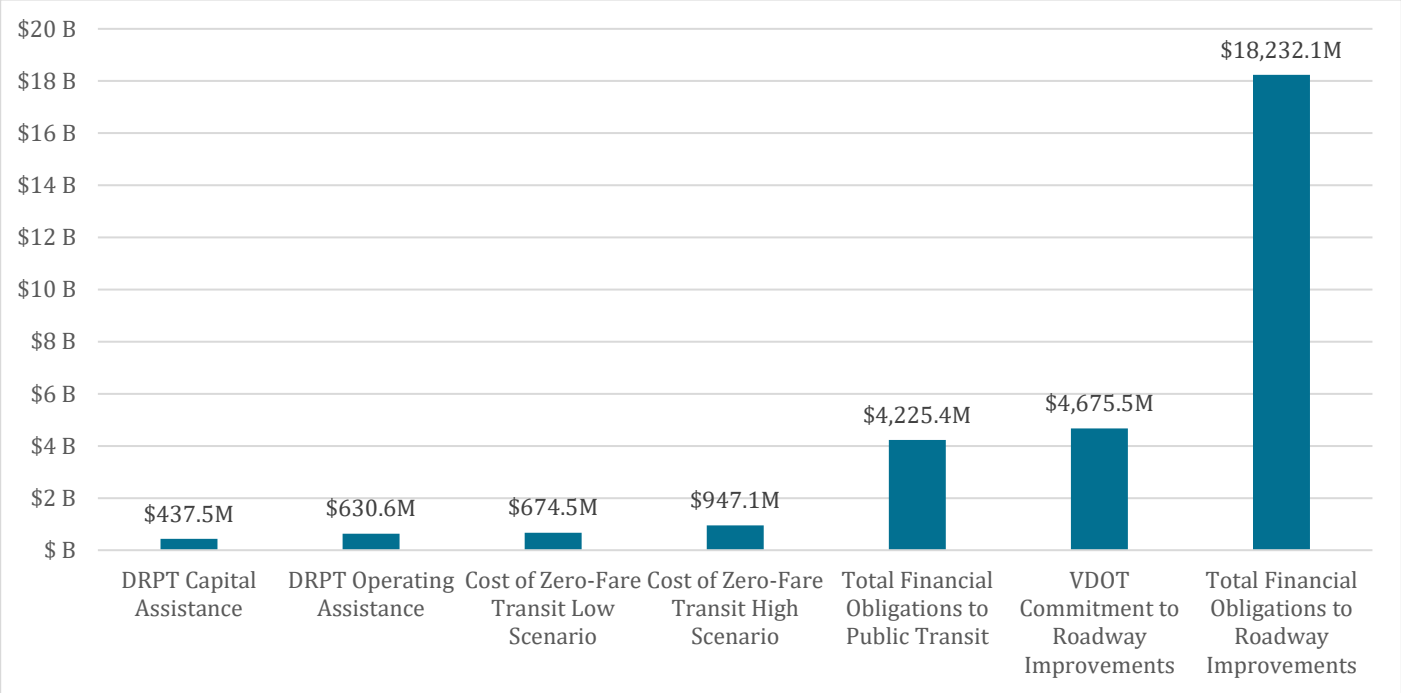
Figure 33: Cost of Zero-Fare Transit



Source: FY19 NTD, FY22 DRPT SYIP

These low and high estimates are significantly less than the estimated $18.2 billion allocated for roadway improvements in the FY2022–FY2027 Virginia Department of Transportation (VDOT) Six-Year Improvement Plan (SYIP). The SYIP includes funding for capital and operating expenses related to constructing and maintaining Virginia's roadway system. It would cost between $675 million and $950 million to implement zero-fare transit service in that same timeframe. **Figure 34** compares the cost of implementing zero-fare transit service for all agencies in Virginia to the funds allocated for DRPT Capital and Operating Assistance and VDOT roadway improvement projects. The total state commitments to public transit and roadway improvements include all of the state's funding commitments, including federal sources of revenue and special programs, not just DRPT and VDOT dedicated funds. For reference, the General Assembly dedicated just $20 million to TRIP projects for FY22, with $12.5 million of those funds allocated toward zero-fare policy projects.

Figure 34: Comparison of the Cost of Implementing Zero-Fare Transit in Virginia from FY22-FY27



Virginia Transit Agency Interviews (2)

Representatives from two Virginia transit agencies, GRTC and Bluefield/Graham Transit, were interviewed to gain a better understanding of each agency's motives for implementing zero-fare service. Findings and takeaways from the interviews with each agency are detailed below in addition to some background data on each agency.

GRTC

GRTC operates demand response, fixed-route, and enhanced fixed-route (BRT) transit service in the Richmond metro area and has been one of the most vocal supporters of zero-fare transit in the Commonwealth. GRTC began operating zero-fare service during the pandemic but has indicated it would like to provide zero-fare service long term. One of the main reasons the agency wants to provide zero-fare service is to alleviate the financial burden on low-income and minority populations. According to the agency, 27 percent of its riders have a combined household income of less than $10,000 per year. More than half of riders earn less than the federal poverty rate for Virginia of $26,500 for a family of four, and 89 percent of riders have household incomes below the state median income. Finally, 75 percent of the system's riders are people of color.

GRTC needs approximately $5 million annually to maintain zero-fare service and spends approximately $1.7 million to collect $7 million in fares, meaning approximately 25 percent of the fares GRTC collects go toward collection of fares alone.[9] GRTC has had success in using automated passenger counters (APCs) and does not need to rely on farebox equipment to estimate ridership.

[9] https://www.virginiamercury.com/2021/04/06/virginia-bus-systems-could-go-fare-free-for-at-least-three-years/

Primary Motivations

In the interview, GRTC identified three primary factors for implementing zero-fare service—economy, environment, and equity. First, eliminating fare makes sense economically for GRTC because many of its riders are low-income and could spend money spent on fares on other critical expenses, such as healthcare. Moreover, GRTC rider data shows that after removing fares during the pandemic, even transit-dependent populations are using transit more, indicating that for some fares are a significant barrier to using transit. GRTC pointed out that more riders using transit is a signal to businesses of the Richmond region's strong employment market, leading to more private investment in the region.

GRTC also mentioned that eliminating fares would reduce the environmental impact of its services. When operators do not need to collect fares or enforce fare policies, they spend less time idling at stations. Reducing idle times also makes buses more efficient, leading to a more reliable and predictable service for riders.

Finally, GRTC emphasized that eliminating fares is an effective strategy to make its service for equitable for riders and potential riders in the region. Other programs related to fare collection such as reduced-fare, route- or zone-specific programs, time of day, and service type benefit some riders and not others. Systemwide zero-fare policies are the only strategies that provide benefits to everyone and provide a specific benefit to transit-dependent riders.

Other Key Takeaways

GRTC highlighted some issues that were not encountered in the review of national case studies or academic literature. First, opponents of zero-fare transit argue that if riders are not required to pay fares to use buses, they will abuse the service and agencies will then be faced with issues they may not have had to deal with before like homelessness or bus cleanliness. However, these are issues that are not specific to transit and therefore should not be considered reasons for not implementing zero-fare transit, especially since these issues can be addressed through better coordination with law enforcement and partnerships with social service providers.

Should GRTC go zero-fare long term, it also has a plan for its fare collection machines. Since the majority of GRTC's fare collection expenses are funded using state and federal dollars, GRTC would be willing to gift its fare collection assets to a sister transit system within Virginia, recognizing that for some agencies zero-fare transit may not currently be feasible.

Moreover, GRTC spoke about partnerships with large institutions and employers as a way to sustain zero-fare transit service. There have been hesitations from agencies that have existing partnerships with universities or institutions to explore zero-fare service given the concern of potentially losing that existing revenue source. Most partnerships with private entities are based on how many riders from that institution use the service, and based on that number, the institution provides funding to the agency for their employees or students to use the service for free. GRTC is advocating a new form of partnership that is based on frequency (i.e., the number of times a bus route goes to the institution) instead of ridership. This is a fundamental shift in structure but is more supportive of better-quality service.

Advice for Other Agencies

When asked about what other agencies should do to implement zero-fare transit, GRTC recommended that agencies analyze their current services offered, separate each mode, and look at ridership demographics. Understanding who is using the service most frequently, who is paying for the fares to use the service, and how much are they paying are questions that can help guide an agency's decision to implement zero-fare service. In

the case of GRTC, zero-fare service made sense given the demographics of the riders in the system and the benefits they would receive from not paying fares.

Resources Needed from the State

GRTC identified a long-term, sustained funding source as the most effective method for the Commonwealth to support zero-fare transit. TRIP funding is only for 3 years, and it could take longer for GRTC and other like-minded agencies to find supplemental funding sources through greater local contributions or partnerships with large employers and educational institutions. Long-term sustained funding can help agencies transition their budgets to zero-fare models over time.

Bluefield/Graham Transit

Bluefield/Graham Transit operates just three fixed bus routes in its small service area and charges $0.25 fares to riders. The agency has indicated it would like to pursue zero-fare service in the future given their low farebox revenue and high costs of fare collection. In 2019, the agency collected $8,000 in farebox revenue, which was only 2.6 percent of its $300,000 annual budget.[10] The cost of fareboxes in each of the agency's buses totals $7,468 alone, not including the staff time and resources spent collecting or counting fares. While the push to provide zero-fare service makes sense financially, Bluefield/Graham Transit also sees this as an opportunity to provide more access to transit since one the routes where much of the service's ridership comes from goes to a large, low-income area. Moreover, Bluefield/Graham Transit is a rural transit agency that receives Section 5311 funding. Section 5311 funding is based on the percentage of expenses after fares have been taken into consideration. If an agency does not collect fares, the agency's 5311 funding allocation increases. Therefore, the increase in Section 5311 funding could supplement Bluefield/Graham Transit's budget deficit after suspending fare collection. This phenomenon is unique to rural agencies that receive Section 5311 funding since the federal funding source for urban agencies, Section 5307, is based on a funding formula and is unrelated to expenses and fare collection.

Key Takeaways

In the interview, Graham Transit indicated that although it would like to implement zero-fare transit, it did not submit a TRIP grant application. The agency only collects about $8,000 in fares annually and decided that it was not worth the time and effort applying for a TRIP grant to cover that gap in funding after eliminating fares.

Graham Transit cited making the service easier to use as the primary motivator for eliminating fares. At $0.25, most riders can afford the service already, and Graham Transit would not expect many new riders to be picked up as a result of eliminating fares. Graham Transit did not receive feedback from riders to reduce or eliminate fares—the impetus for eliminating fares came from within the agency and City.

Finally, Graham Transit explained that although they did not submit a TRIP grant application in this cycle, they might consider applying next cycle or finding the necessary funding through increased local contributions.

[10] https://www.virginiamercury.com/2021/04/06/virginia-bus-systems-could-go-fare-free-for-at-least-three-years/

National Case Studies

Three case studies of transit systems around the country have been researched to examine the other agency experiences with going zero-fare. The following questions were considered when evaluating these zero-fare programs that might be beneficial for Virginia transit agencies:

- What were the steps of implementation?
- Why was zero-fare policy implemented?
- What are common funding sources used to supplement farebox revenues?
- How is the program tracked and success measured?

Intercity Transit (Olympia/Thurston County, WA)

Intercity Transit Proposition 1 was approved by voters at the November 2018 election. One of the improvements proposed in Proposition 1 was to make collection of transit fares easier and faster to reduce delays and simplify access to transit for riders. This was one of the community-identified priorities that resulted from a 2-year public engagement process.[11]

In December 2019, the Intercity Transit Authority approved the implementation of a 5-year zero-fare demonstration project that went into effect on January 1, 2020. The Intercity Transit website lists several expected benefits as rationale for implementing zero-fare service, including:

- Increases ridership and reduces dependency on cars
- Enhances access and equity by removing financial barriers
- Makes service more efficient by making boarding easier and faster

So far Intercity Transit has not identified additional funding sources to supplement revenue lost from farebox sales. Fares accounted for less than 2 percent of the system's net revenue. Considering the capital and operational costs of operating a fare system, 2 percent of the overall revenue was considered to be negligible given the benefits of faster service, increased ridership, and improved access to transit.

No definable performance metrics or thresholds were identified for Intercity Transit following the completion of the demonstration project in 2024. The 5-year time horizon is intended to give Intercity Transit enough time to promote its service and measure the impacts of going zero-fare. Since implementing the zero-fare service, Intercity Transit has seen a 20 percent year-over-year ridership increase since January 2019 and has had noticeably faster service.[12]

Cache Valley Transit District (Logan/Cache County, UT)

Since its inception in 2000, the Cache Valley Transit District (CVTD) has operated zero-fare bus service to Logan and Cache Counties. CVTD is somewhat unique compared to other agencies that have zero-fare policies because CVTD has never collected fares and therefore never had to supplement lost farebox revenue. In the 2012 Short-Range Transit Plan, an entire chapter was devoted to evaluating CVTD's zero-fare policy and answering the question: "If CVTD were to introduce a fare, what would it cost from a capital and operating perspective and how much revenue would CVTD expect to gain?" The plan recommended not changing the agency's fare policy at the time and the decision was reaffirmed in the 2017 Short-Range Transit Plan. To arrive at this conclusion,

[11] https://www.intercitytransit.com/zerofare-faqs
[12] https://nelsonnygaard.com/fare-policy-and-zero-fares-can-help-transit-agencies-and-the-communities-they-serve-recover-post-pandemic/

the planning team conducted a comprehensive analysis that estimated the farebox revenue for three tiers of fares (low, medium, and high) and what the impact on ridership would be for each tier of fares. The following are some of the key reasons for maintaining a zero-fare system:

1. Expenses of collecting fare are generally greater than the revenue collected from fares
2. Charging fares would result in significant ridership losses
3. Collecting a fare would cause scheduled travel times to be lengthened because of additional time needed to board and deposit fares
4. Charging fares would make it more difficult to meet CVTD goals of reducing automobile dependency and supporting efforts to improve air quality by reducing ridership
5. Collecting fares could create real and perceived barriers to transit

In addition to these findings, the report also details questions to consider should there be continuing interest in instituting fares, which highlight issues agencies in Virginia might consider when evaluating zero-fare policies:

- What is our primary objective in establishing a fare?
- What should the farebox recovery goal be?
- Who are our key markets and what fare discounts should we offer to attract and maintain them?
- What type of fare instrument should we offer?

Kansas City Area Transportation Authority (Kansas City, MO)

In December 2019, the Kansas City Council made national headlines when it unanimously passed a resolution directing the City Manager to include a funding request in the next fiscal year budget to make fixed-route public transit zero-fare within the city. Though the City of Kansas City does not own or offer public transit services, the Kansas City Transportation Authority (KCATA) offers public transit services for the metro area. This action was lauded by transit advocates because, at the time, Kansas City was the largest urbanized area that was seriously considering zero-fare transit. Zero-fare service was incrementally offered over 4 years prior, first to veterans, high school students, and then to at-risk consumers.

Three months later, at the start of the COVID-19 pandemic, KCATA suspended fares for all its fixed-route bus services and will continue to operate zero-fare service through 2023. KCATA also has developed a robust marketing campaign to promote zero-fare transit service that includes frequently asked questions (FAQs) explaining the benefits of zero-fare transit and testimonials from supporters. KCATA highlights several benefits of eliminating fares, including eliminating the number of fare disputes, increasing ridership, reducing administrative costs associated with fare collection, and putting money back into the pockets of transit riders.

Farebox revenues generate less than 10 percent of KCATA's annual budget and removing fares will save the system more than $750,000 in administrative costs associated with fare collection. In addition to the financial benefits provided to the agency, KCATA highlights the economic benefits to its riders. KCATA partnered with the Center for Economic Information at the University of Missouri, Kansas City, to analyze the impact of free bus service on the region. Currently, 30,000 rides are taken daily, which translates to $1 million per month that is returned to the local economy instead of spent on fares. The study found that the money that riders would have spent on fares would instead go toward housing, medical, retail, and insurance expenses.

No specific performance metrics or supplemental funding sources were identified on the website, but KCATA's approach to promoting zero-fare transit policy and prioritizing the benefits that riders receive can be a model for agencies in Virginia.

Summary of Benefits and Tradeoffs

Potential Benefits and Tradeoffs

There are several potential benefits and tradeoffs associated with zero-fare policies. There is no denying that zero-fare transit service can alleviate financial burdens on riders, but whether it is the most effective policy action to promote equitable transit service is another consideration. This section evaluates some potential benefits and tradeoffs of implementing zero-fare policies. These findings are based on academic research and news articles reporting on zero-fare policy implementation case studies from around the country.

Access to Transit

Removing fares from transit makes it easier to use transit and removes barriers for riders, especially riders who do not use transit frequently. Zero-fare policies can potentially enhance community livability by providing a free mode of reliable transportation. Zero-fare policies support equity goals by making transit more accessible to low-income and other transit-dependent populations.

Ridership

In most instances, zero-fare policies lead to increased ridership. If ridership grows enough, buses may become overloaded and begin servicing too many stops, which could cause bus performance to decline if adjustments are not made to service. It is important to recognize that this ridership comes from all groups of people, not just underserved, low-income, or marginalized populations.

TransitCenter surveyed riders, and results indicated that low-income riders tend to cite improving service as a higher priority than reducing fares. This finding contradicts the assertion that going zero-fare will improve access to disadvantaged populations and make service more equitable because the riders who need transit the most are those who are already using it and desire better service.[13]

Some research indicates that only small percentages of added transit trips experienced were made by riders who switched from making trips with their car or another motorized transportation mode. New transit trips were instead made by individuals who formerly walked, rode their bike, or would not have made trips at all. TCRP's "Implementation and Outcomes of Fare Free Transit" study states that ridership increases and mode shift percentages as a result of zero-fare policies depend widely on local factors such as transit availability and driving conditions. In addition, a disproportionate number of new trips were made by existing riders, as well as students and seniors who are typically more sensitive to transit pricing. Together, these findings contradict the popular assertion that removing fares will precipitate automobile drivers to switch to transit.

Transit Performance

Removing fare collection from fixed-route bus service has the potential to reduce dwell time since customers no longer have to scan a card or pay for bus tickets. Faster service makes transit a more attractive mode compared to automobile traffic, potentially leading to more people using transit and providing time and cost savings benefits to riders. Removing fares also allows for all-door boarding, meaning riders no longer have to queue at the front door to get on the bus and can use doors in the front and back.

Removing collection of fares also reduced the number of rider-operator conflicts resulting from fare disputes, which can drastically affect bus travel time performance. When fares are no longer required, riders can enter

[13] https://transitcenter.org/should-transit-be-free-part-two/

and exit the bus freely without needing to show proof of a transit pass or card and operators can focus on driving the bus and keeping passengers safe.

Since bus schedules in many systems that utilize fare collection build extra time into bus timetables, transit planners will likely need to revise bus schedules along with implementing zero-fare policies to account for the improvements in transit performances.

Technology

Fare collection technology can include the farebox machines and digital software used for the advertisement and sale of fare passes. Farebox machines can represent a significant capital expenditure for transit agencies, and become less cost-effective as ridership declines and the cost/rider decreases. These machines also need to be maintained over time, be it through physical repairs and maintenance or with digital software patches to update the machines with the latest technology. This cost also doesn't include the time that agency staff spend maintaining these machines, and the cost borne by the rider who is not able to use the farebox and must seek other methods for obtaining the necessary fare pass. Some technological applications, such as mobile fare payment, alleviate the cost of providing fareboxes, however, even mobile payment systems require some capital expenditure and ongoing maintenance expenses, which can be costly for agencies in both time and money.

System Financing

Zero-fare policies eliminate the costs for fare collection, which include the employee time spent on collecting fares, developing marketing materials, managing fare and transit pass programs, and resolving fare disputes, in addition to the upfront capital and ongoing operating expenses for fare collection equipment. This is an especially important benefit for smaller agencies, which typically have smaller budgets and low ridership, meaning the average cost per rider is higher than a system with lots of riders and service available. Smaller agencies typically also have a smaller number of full-time staff, and those staff fill many roles within the agency based on demand for different services at different times. Removing the time spent on fare collection activities allows these staff to devote their time and energy to other activities, such as developing marketing materials and interfacing with riders.

The biggest challenge when implementing policies is finding the funds to continue and maintain service without farebox revenues. Even small agencies with low ridership rely on some farebox revenue to balance the budget. Agencies that are looking to implement zero-fare policies should plan years into the future how they might supplement the lost revenue from fares. Common sources of additional income are:

- State assistance
- Local general funds
- Sales tax
- Regional funds
- Federal funds
- Private partnerships – large employers, hospitals, non-profits, universities

Ridership tends to fluctuate from year to year and, as a result, expected revenues from fareboxes also can vary. The COVID-19 pandemic demonstrated how vulnerable some agencies can be to declines in ridership and farebox revenue. Eliminating fares will likely make transit agency budgets more resilient and predictable in the long run since they aren't relying on ridership for revenue.

Individual Economic Benefit

By eliminating the riders' transit expense, zero-fare policies put more money in the hands of riders. While everyone and the entire economy benefits from this, this especially benefits low-income and other transit-dependent populations that now have more disposable income to spend on other vital expenses in their lives they would not have had otherwise.

Equitable Service Planning

Background on Equitable Transit Service Policy

Community access to employment, education, and other opportunities requires a robust mobility network with a backbone of transit service. Public transit that is inaccessible and unreliable means people with disabilities, the elderly, and people who work irregular hours are left without safe and affordable transportation. The historical, systemic, and cyclical inequities facing many populations have resulted in underrepresentation in past and existing decision-making processes. The inequities include underfunding and disregard for marginalized communities, inequal distribution of public resources, and definitions of success that do not include providing reliable connections to communities in need. Equitable access to high-quality, reliable, safe transit service has the potential to connect people to resources, jobs, and services while addressing disparities in distribution of opportunities. The assessment of equity in this report will primarily be focused on service planning and policy, but equity in transit is a comprehensive effort to implement technology, engagement strategies, fare policy, physical accessibility, and safety measures that provide quality service to historically underserved populations.

What is Equity in Transit Service Planning?

Equity can be defined as the shared and just distribution of benefits and burdens that accounts for the needs of disadvantaged populations when providing public goods and service. Equity in service planning starts with the identification of where underserved transit needs exists within a community. Census data, while important, does not create a holistic picture of a community. It is imperative to understand the needs of the community by setting up a framework of robust public participation in identifying and prioritizing how to address outstanding need. Using a combination of quantitative, measurable data and the lived experiences of the community being served, service changes can be used to prioritize addressing outstanding need in underserved communities. Beyond providing additional service in these areas, it is important to measure the outcomes using performance indicators that identify if the investments in these communities are closing gaps in access.

State of Equitable Transit Policy in Virginia

State Resources, Initiatives, and Programs

Transit Strategic Plans (TSP)

The Virginia General Assembly and DRPT require that public transportation agencies serving an urbanized area of 50,000 residents or more and operating a fleet of at least 20 buses develop a TSP to ensure that services are planned in a way that meets the mobility needs of communities throughout the state. This gives agencies an opportunity to evaluate and update their services and networks to respond to changes in demand. One requirement of the TSP is an evaluation of transit market demand and underserved areas. Based on the evaluation of this information, the TSP is required to respond with opportunities for improvement, which include a description of areas with high transit demand and underserved areas that would benefit from additional service and a description of areas with low transit demand that may have too much service and a description of specific solutions to any gaps or service deficiencies for fixed-route and demand response

services. At the time of this analysis, three transit agencies had submitted TSPs to DRPT—Greater Lynchburg Transit Company, Suffolk Transit, Hampton Roads Transit, and OmniRide.

TRIP

TRIP is a new statewide grant program dedicated to improving transit's regional connectivity in urban areas with a population of more than 100,000 and reducing barriers to transit use by supporting low-income and zero-fare programming. The program was created by the passing of House Bill 1414 in the 2020 General Assembly session. Prior to applying for TRIP funds, applicants will have conducted a study or performed research to develop project justification and prepare an implementation plan. The project justification must provide a clear and demonstrable unmet need that will be met by the project and a thorough description on the mitigation of the implementation plan. This identified need should outline the project's purpose and the proposal's vision. The applicant should also provide justification to the regional significance of the transit route being considered. Conducting a Transit Boardings Estimation and Simulation Tool (TBEST) Title VI analysis or identifying potential benefits to equity emphasis areas will be beneficial in application scoring. Each applicant should provide a measurable target to increasing ridership. That objective can focus on system-wide ridership or a specific community/population (with an equity approach).

Making Efficient and Responsible Investments in Transit (MERIT)

MERIT is DRPT's statewide public transportation grants program. This program provides financial assistance to support public transportation services throughout the state and is designed to support DRPT's core mission:

"To facilitate and improve the mobility of the inhabitants of Virginia, and to promote the efficient transport of goods and people in a safe, reliable, and cost-effective manner."

Funding is available for operating assistance, capital assistance, demonstration project assistance, technical assistance, and public transportation intern programs. The capital investment program scoring methodology for major expansion projects accounts for disadvantaged community impact; however, the majority of capital investment programming is distributed to minor enhancement and state of good repair projects and the associated funding is not distributed with community impact in mind.

Human Services Grant Program

DRPT awards Federal Transit Administration (FTA) Section 5310 funding for the enhanced mobility of seniors (ages 65 and older) and individuals with disabilities through a competitive, discretionary award process. Section 5310 funding can be awarded for capital projects to replace or expand vehicle fleets, mobility management projects to coordinate transportation, operating projects to provide transportation, and other capital projects to support programs serving the eligible populations.

Funding is available for traditional capital (vehicles), mobility management, operating, and other capital. Advancing mobility for seniors and people with disabilities contributes to breaking down inequities in access to transportation.

Mobility for All

In 2020, FTA awarded DRPT a discretionary grant under the Mobility for All Pilot Program. DRPT sought funding for a two-part project aimed at improving information access for Virginians. The project aims to develop a Stage One One-Call/One-Click System, which includes web pages dedicated to providing complete information about transportation services in the Commonwealth of Virginia. Transportation Navigator, released in October 2021, is now the most thorough online archive of public transportation information in Virginia,

providing a directory of public transit, human service, and specialized transportation providers, programs, and services.

Additionally, DRPT has developed a consolidated statewide General Transit Feed Specification (GTFS) directory for public transit. The project leverages the existing structure of the industry standard GTFS to deliver two types of information: resource listings on the Transportation Navigator platform, and transit route, schedule, and stop information to help riders plan their trips through a variety of trip planning platforms including Google Maps and other mobile apps.

Moving forward, DRPT is working with a team of master's candidates from the L. Douglas Wilder School of Government and Public Affairs at Virginia Commonwealth University to determine future growth opportunities for the public-facing platform.

Coordinated Human Services Mobility Plan

Culminating a more-than-yearlong effort, the 2019 Coordinated Human Services Mobility (CHSM) Plan identifies gaps and challenges related to transportation for seniors, individuals with disabilities, low-income individuals, and veterans. The plan was developed with significant public input received through public meetings, ride-alongs, surveys, and interviews during a period of several months. The plan presents statewide and regional gaps and strategies to improve human services transportation in Virginia.

Programs funded under the FTA Section 5310 program must align with strategies defined in the CHSM Plan. When applying for Section 5310 funding through DRPT, applicants will demonstrate how their project aligns with the CHSM strategies and actions. This document can also be used to guide other transportation projects across the Commonwealth, and should represent statewide needs, challenges, and goals for the next three years.

Agency Perspectives

Equity and Modernization Study Survey Reponses

All 39 local agencies responded to a survey about their approach to defining equity, defining disadvantaged and underserved populations, historical inequity, and approach beyond Title VI.

In the context of transit service planning, agencies used similar language to define equity as fair, impartial, and equal service to all people. Agencies commonly included low-income, zero-vehicle households, elderly, and disabled descriptors when defining disadvantaged and underserved communities.

Agencies also were asked to identify equity policy beyond Title VI; 18 percent of the local agencies indicated that they have policy exceeding the requirement (see **Figure 35**). Some examples of these policies that were identified include:

- The creation of an internal Diversity, Equity, and Inclusion group that aids in informing external-facing partners such as elected officials and other regional partners
- Public-facing transit service goals documented in the TSP
- Policy that commits the agency to intentionally consider equity when drafting policy and delivering services

Figure 35. Transit Agencies Equity in Policy beyond Title VI

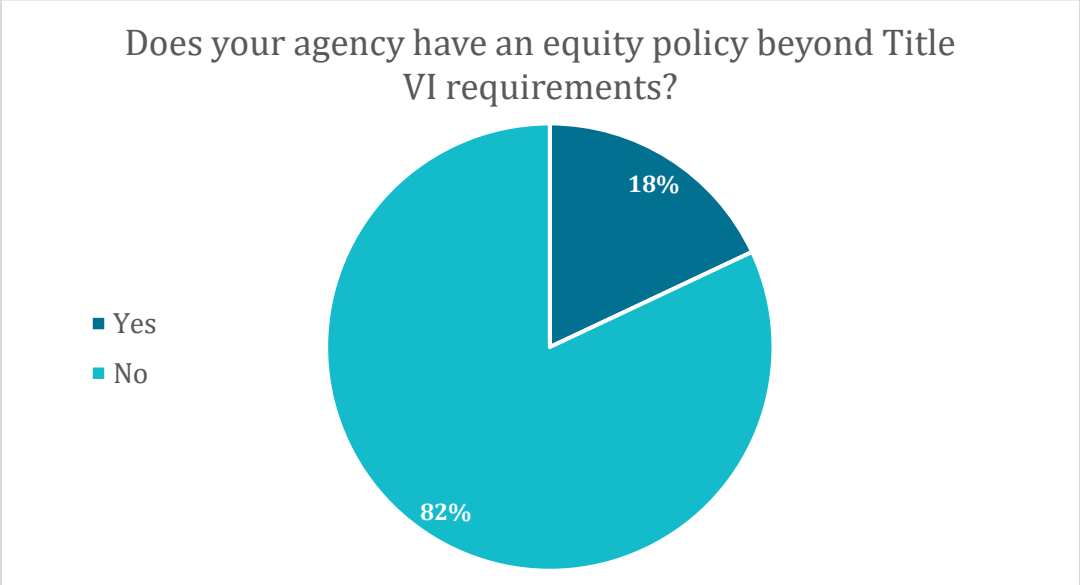


Figure 36. Relative Importance of Equity in Transit Service Planning to Agencies

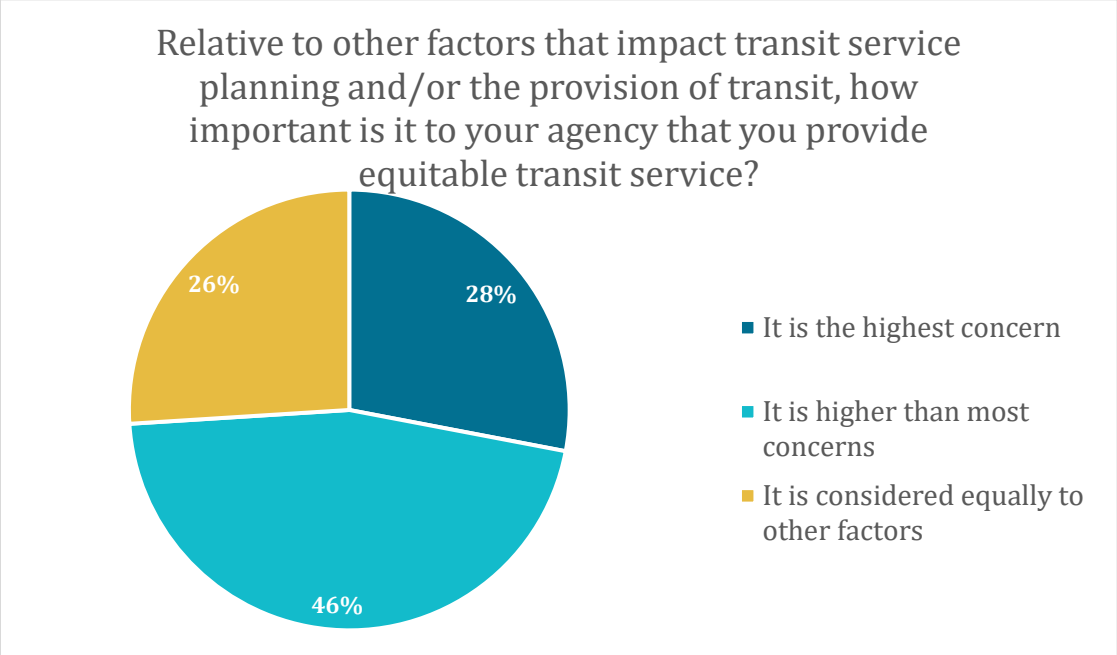
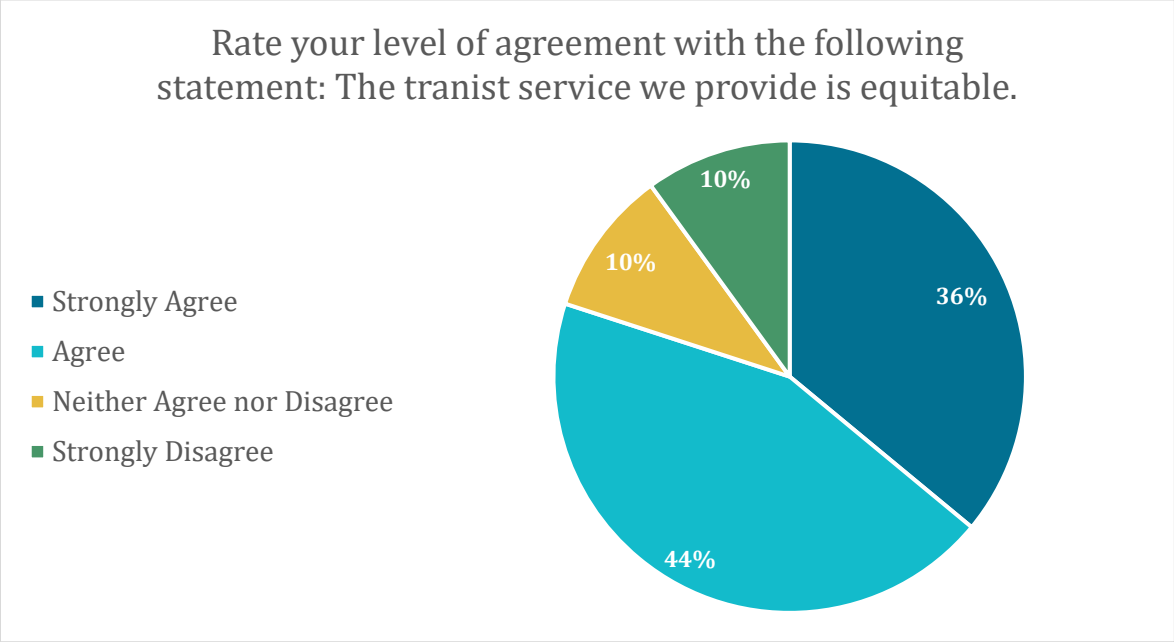


Figure 37. Transit Agency Review of Equity in Transit Service



When reviewing the importance of providing equitable transit service relative to other factors that impact transit service planning, most agencies, 46 percent, reported that equity was higher than most concerns and 44 percent of all surveyed agencies stated that the transit service they provide is equitable, as shown in **Figure 36** and **Figure 37**.

Agencies also were prompted to reflect on inequities perpetuated in historical transit service planning decisions. While the majority of agencies did not identify any previous inequities, other agencies reported previous planning decisions were not evaluated nor designed with an equitable lens and resulted in underfunding that contributed to budgetary decisions that reduced operations and capital quality.

Virginia Transit Agency Interviews

Hampton Roads Transit (HRT)

HRT operates in the southeastern corner of Virginia and provides demand response, fixed-route, and enhanced fixed-route services. HRT completed their FY2021–30 TSP, a 10-year strategy to improve transit services across six cities: Hampton, Chesapeake, Newport News, Norfolk, Portsmouth, and Virginia Beach. The plan included HRT's goals and methodologies for transit propensity and equity evaluation. The TSP outlines a strategic vision that includes overarching agency goals that were updated based on previous planning efforts and also details guiding principles that help to guide the planning, provision, and sustainability of service. These guiding principles were devised through extensive public and stakeholder input through exploration of the public's preferences regarding service tradeoffs and later informed recommended service changes.

HRT's TSP featured a transit propensity index that guided a geospatial market analysis on population and density to identify the demand for transit service throughout the current service area. The indices were classified as trip producers (transit-oriented populations or commuters) and trip attractors (workplaces or non-work destinations including jobs located in restaurants, healthcare, government, social assistance, and

education). Using demographic and employment statistics weighted based on their relative effect on transit ridership in the region, HRT was able to discern the locations with the highest transit propensity.

The agency also performed an equity evaluation, an impact analysis on where service reductions would have disparate effects on minority and low-income communities.

The agency was interviewed to provide further details on their efforts in achieving equitable transit service based on what was outlined in their TSP, other measures they are considering beyond Title VI, and barriers to achieving their equity goals. Key takeaways from the discussion include:

- Fiscal policies that operate with a direct relationship between contribution and received service can skew transit service toward wealthier cities or those with more transit-focused officials, which can have negative effects on equity
- Policy documents such as TSPs that focus on long-range planning efforts are valuable to outline equity goals, recommendations, and approaches to implementation
- Coordination with land use and zoning policy as well as adequate multimodal infrastructure is crucial in supporting equitable transit efforts

HRT described opportunities, barriers, and previous efforts to improving transit service for their riders. The agency offers 73 routes within their service area and, prior to the COVID-19 pandemic, 20 local routes carried 70 percent of their riders. The pandemic has negatively impacted the procurement and analysis of baseline conditions for new routes and has interfered with efforts in gauging the routes' success in providing service aligned with the agency's equity goals.

HRT operates on a cost allocation agreement between the six cities that often results in budgetary constraints and can serve as a barrier to distributing equal service to the jurisdictions. Following the conditions of the cost allocation agreement, the City of Norfolk's contribution exceeds other jurisdictions and results in the municipality receiving the most transit service.

The agency's TSP serves as valuable document for equitable long-range planning goals, but discussions on providing service based on transit propensity analyses are vulnerable to being overlooked during the budget process. HRT described the missing symbiosis between transit service and city processes as a challenge in improving their service. Service gaps that are perpetuated by challenging characteristics such as zoning and land use—including neighborhoods and subdivisions, gaps in multimodal infrastructure, and geographic obstacles such as water bodies—are more difficult to mitigate when transit is not prioritized nor integrated in the local government.

Internal to HRT, the agency attributes some of the value from their TSP and success in their planning process from intense public outreach that engaged the community on budget tradeoffs in coverage and frequency and enlisting advocacy groups during city council meetings.

Charlottesville Area Transit (CAT)

CAT operates fixed-route service in the Charlottesville metro area and meets rider demands in conjunction with Jaunt and the University of Virginia (UVA) transit. The service provider recently completed their TDP for FY2019–28, which included equity-related goals in advancing their system. The agency also has recently introduced a System Optimization Plan in response to the COVID-19 pandemic to address immediate service needs as the system recovers. The Optimization Plan includes accessibility improvements to routes operating at a 30-minute frequency, addressing service reductions from COVID-19, new service areas, and reducing system

transfers. Following board approval of the recommendations detailed in the plan, the agency will launch an extensive education campaign to inform new and existing riders of the proposed service changes. Key takeaways from the discussion include:

- Coordination with other smaller transit agencies or partnerships with bigger agencies can close service gaps and advance the quality of service and mobility for riders
- Ongoing communication to reach consensus regarding implementation and funding with state and federal stakeholders is essential to ensuring that objectives are met
- Long-range planning and allocating resources to support planning personnel in smaller agencies can help maintain and improve the system's optimal performance

During the interview, CAT staff detailed some of the agency's ongoing objectives and barriers to improve equitable success. The agency operates 12 fixed bus routes and has recently implemented a "Lifeline" service to provide essential life connections to riders in response to a significant drop in ridership during COVID-19. The agency is currently working to communicate with communities with a focus on the needs of affordable housing residents and provide a network of optimal 15-minute performance. CAT is planning to implement a rider survey to gain further insight into riders' origins and destinations to use transit as an equalizer and provide connectivity to housing and activity centers. In the meantime, the agency will be making system enhancements from the System Optimization Plan in January of next year that reflects changes in rider habits from COVID.

The agency also is striving to meet the quick-implementation expectations of the community as efficiently as possible given government processes. Currently, efforts are being made to improve coordination with nearby agencies and organizations, UVA and Jaunt, to avoid gaps in service and provide a cohesive network for Charlottesville and the surrounding area. Funding limitations can continue to create gaps in service despite partnership due to limited funding opportunities for smaller agencies and ridership performance metrics that can pose as a direct challenge to providing equitable service. CAT also detailed the value of advocacy groups such as the local community group focused on climate change that encourages bus ridership.

CAT also has been examining equity internal to the agency to improve hiring processes and enhance system reliability. This internal effort includes addressing the health concerns that arose from temporary employees and during the pandemic by adding more permanent part-time and full-time operators to their employment model.

National Case Studies

Approach

Multiple agencies and organizations have developed and led transit or transportation-oriented efforts centered on equitable planning to improve the quality of life for disadvantaged communities. These agencies researched and examined for previous and ongoing equitable service efforts include Houston Link, King County Metro, Gorge Translink, and moveDC. When reviewed holistically, the efforts made to establish equitable service drafts a toolkit with strategies that can be adopted by agencies with similar contexts.

Key Questions to Consider

- How is need defined?
- How is need prioritized for remedy?
- Which demographic groups are included and how are they included when considering access and need?
- What innovative programs or funding have been used to fill gaps/needs?
- What performance metrics are used to mark progress?

Selection Criteria

National case studies were screened for a variety of geography, agency size, modes of service provided, and equity programs that extend above and beyond Title VI. Transit Service Transects were considered when selecting case studies as the amount of transit service they provide allows for similarities to be drawn to other organizations to aid in strategizing context sensitive opportunities and recommendations.

HOUSTON LINK – TEDI (Houston/Harris County, TX)

Houston LINK's Transportation Equity Demand Index (TEDI) effort to identify areas where safe and affordable transportation is most needed to improve the quality of life. Houston Metro, the primary focus of Houston Link, operates as an Enhanced Fixed Route transect in urban setting with demand response service, fixed route buses, and rail service.

The fifteen indicators that devise the matrix for areas of interest were based on **fundamental demographic need**, areas of a **likely higher transit use** based on demand and propensity, and **built environment conditions**:

- Poverty (Low-income households)
- Single Parent Female Headed Households with Children Under 18
- Population with a Disability
- Homes of Workers with Jobs Paying Less than $15,000 Annually
- Work Sites of Workers with Jobs Paying Less than $15,000 Annually
- Minority Population
- Zero Vehicle Available Households
- Workers Commuting by Transit
- Homes of Workers with High School Education or Less
- Work Sites of Workers with High School Education or Less
- Population Density
- Household Density
- Street intersection Density
- Average Block Perimeter (in feet)
- Compact Neighborhood Score

Recommendations for transit were housed under four thematic best practices to improve equity, the quality of service and life across the Houston area. The themes, transit frequency, availability, reliability and accessibility, and their respective recommended operational changes include:

Frequency

- Update local routes so that the frequent network operates at a 15-minute frequency
- Expand the network by converting selected 30-minute routes to 15-minute routes
- Make local routes come at least every 30 minutes and eliminate 60-minute wait times
- Increase all after 9pm, night-time rail line frequency to 15-minute frequency

Availability

- Extend span of service on select local routes to connected under-resourced communities to extended-hour services (e.g., airports, higher education institutions, medical centers)

Reliability

- Increase on-time performance from 75 to 90 percent for local bus trips
- Eliminate schedules for routes that are operating at or above 8 minutes
- Provide real-time next arrival and departure at all centers, heavily used stops, and transfer points

Accessibility

- Fulfill commitments to universal accessibility so that stops are accessible regardless of age, size, or ability
- Prioritize the construction of capital bus stop amenities (e.g., shelter, seating, lighting, etc.) where off-peak service frequency is 30 minutes or longer

The findings of the study supported the development and implementation of regional policy initiatives across the State of Texas. Following the 2018 TEDI Plan, the City of Houston released Vision Zero Houston, the Climate Action Plan, and Resilient Houston to commit to alternative transportation investments and address environmental concerns. Similar to Houston, Harris County recently implemented a Vision Zero plan and is developing an Equity in Transportation plan to guide equitable investments in all modes of transportation infrastructure. TEDI helped to inspire TDOT's proposed vision to expand I-45 and increase transit service to communities neighboring the interstate.

MetroNEXT followed the 2018 plan to improve frequency on local, high-ridership routes through the BOOST network planned to improve access, amenities, and reliability on seventeen high ridership routes.

King County Metro (Seattle/King County, WA)

King County Metro established an Equity Cabinet of representatives of Community Based Organizations with ties to traditionally underserved populations in King County, to assess existing Metro service delivery and provide a framework for updating Metro's Strategic Plan, Long Range Plan, and Service Guidelines. Metro used this framework to develop policy change recommendations resulting in an overhaul of these three policies to center equity and climate throughout. One of the largest changes was re-organizing the scoring index used to assign service priority. Originally this index scored new service based first on how well it connected county activity centers, then by land use (housing, park and ride stalls, and jobs) and finally by Equity (Low-Income and Minority Populations). The updated index scores new service first by Equity (now Low-Income, Minority, Disabled populations, LEP populations, and foreign-born populations), then by land use (now jobs, and, park and ride stalls, housing, and a bonus score for areas with concentrations of low-income jobs), then by how well the service connects activity centers. As King County Metro operates on-demand service, fixed route, and rail service, the diversity and quantity of service enables the agency to be classified under the Enhanced Fixed Route transect umbrella.

King County Metro uses performance metrics identified in the Service Guidelines that pertain to potential service improvements through multiple criteria relating to service quality and service growth. Metrics include on-time performance, crowding, new service hour scoring index, and an Equity Impact Review process that accompanies all changes that require council action. The measures include quantitative and qualitative approaches to measuring service improvement in King County. Additionally, as part of the Metro Strategic Plan, quantitative measures included measuring the percentage of service in high equity areas in on-demand service (high equity areas are identified as areas with a high proportion of people of color, people with low- and- no income, people with disabilities, people who do not speak English in the home, and foreign-born people that also have low midday and night service options), the number of reduced-fare trips, commute times, and scheduled travel times, and proximity to transit. Qualitative measures included customer safety satisfaction and overall customer satisfaction with emphasis on demographics and the priority population to provide a holistic review of the current transit service.

Gorge Translink (Columbia Gorge, OR)

Gorge Translink is an alliance of five rural transit providers, human service organizations, and public planning agencies implemented the Gorge Regional Transit Strategy using heavy and diverse community involvement and engagement. The Gorgelink transit service providers offer a mix of demand-responsive paratransit and fixed route bus service, but overall can be identified as operating under the Fixed Route transect frame. Stakeholders from local, state, and federal government agencies and private sector participants formed a working group to advance transit services in the area. Tribal organizations and other partners representing a variety of interests were included in the robust engagement strategy. The Working Group and Gorge Translink are continuing their effort of developing the Gorge Regional Transit Strategy to serve as the roadmap for future transit service planning in the Columbia Gorge area. The intentional community engagement is a strategic approach to understand and address the current needs of the rural area while also serving as a tool to mitigate future challenges in providing equitable service associated with growth and development.

The recently completed Phase I of the strategy established a partnership unique to the region and created a foundation for the ongoing effort to plan for equitable transit service by prioritizing underserved and diverse communities. The objectives of Phase I included strengthening partnership of agencies and organizations throughout the region synthesizing the existing goals and policies of agencies in the region to create a high-level regional vision. The collective vision informed through multiple perspectives resulted in goals such as supporting local and regional economies, protecting the environment, mitigating traffic congestion, and achieving financial sustainability that will steer the Phase II implementation of the strategy.

moveDC (Washington, DC)

The District Department of Transportation (DDOT) has invested in moveDC to establish the policy and strategy to address the future long-term multimodal needs of the region. The moveDC 2021 update has centered equity as its key consideration for future transportation decisions and service improvements. Due to the amount and type of transit service provided in the District of Columbia, moveDC's efforts in improving the quality of service can be applied to similar agencies operating as an enhanced fixed route transect. The plan reviews the existing conditions of the transportation network to identify areas of greatest need.

moveDC developed the Transportation Needs Map for the District to measure need across the area and identify communities where transit investments should be prioritized. The district utilized three indicators: proximity to frequent transit, safety risks, and low access to jobs and destinations to identify areas of greatest need. Transportation Needs Map visualizes the geographic distribution of transportation of disparate transportation

systems that most frequently impact the historically marginalized communities of the area. This represents a shift from the approach of developing the need based on the presence of certain individuals but instead defining need based on conditions in the transportation network, and then understanding which populations may be impacted by the disparities of need. It also intentionally did not develop an index of certain demographic groups in efforts to not conflate the needs of differing populations as similar.

Summary of National Case Study Review Findings

The findings captured from the review of the four national case studies revealed similarities in approach to establishing equitable services as well as differences brought about from differences in characteristic related to service area size, geography, and agency transects. **Table 16** records the key findings from the review of Houston Link, King County Metro, Gorge Translink, and moveDC, these findings are summarized below:

- Multiple groups organizations consider demographic information as priorities when defining need and reviewing gaps in service.
- Organizations approach equitable service planning through a holistic lens that value a variety of indicators that define equity and need.
- Equitable, just, and restorative planning was centered in the majority of the organizations goals and policies for future improvements.

Table 16: Key Findings from National Case Studies

PLANNING EVALUATION IMPLEMENTATION		Houston Link – TEDI	King County Metro	Gorge TransLink	moveDC
Defining Equity and Need		Block group areas chosen based on high scores of 15 indicators related to the demographic and economic status of the population and the built environment conditions.	Areas with of high density and notable proportions of people belonging to marginalized demographics, limited English, and areas with existing low service.	Gaps and needs in local service were identified by a working group made up of local, public, private sector agencies and organizations.	Areas where there is low proximity to frequent transit, low access to jobs and destinations, and notable safety risks.
Demographic Groups Considered	**Low-Income**	✓	✓		✓
	People of Color	✓	✓	✓	✓
	People with Disabilities	✓	✓		✓
	Limited English Proficiency		✓		✓
	People with a High School Education or Less	✓			
	Female-Identifying Single Parents	✓			
Prioritizing Improvement		Projects in areas were prioritized after being identified as statistically concentrated areas as it related to the 15 indicators.	New service hours are prioritized on an equity score to address unmet needs. Bus crowding and reliability improvements are now prioritized based on an equity score.	Projects to be prioritized in Phase II implementation are guided by Phase I goals and based on their ability to create a high-quality, reliable, seamless, efficient, and well-coordinated and regional transit service.	Projects were prioritized based on equity to reduce disparities in geographic areas with low performances in access, quality of service, and notable safety risk.
Innovative Policy and Fiscal Investment		Supported regional policy initiatives such as: Vision Zero in Harris County and Houston; T-DOT's vision of expanding I-45 and increasing transit service in neighboring community; MetroNext/BOOST network to improve access, amenities, and reliability on high ridership routes; accessibility prioritization in Metro's agency funds with additional funding from the Houston-Galveston Area Council.	Metro centered equity in its policy and budget process and created equitable service guidelines. The Service Guidelines prioritize new service hours in areas of high need. New service hours are identified in the biennial budget process. The Metro Equity Cabinet was included in the creation of the framework that guided the policy updates and had review of the budget priorities.	Gorge Regional Transit Strategy Phase I and beyond approaches equitable transit service improvements through heavy and diverse community engagement and involvement between local agencies, public government, and private sector stakeholders.	moveDC drafted 40 strategies and grouped within 18 policies. Each strategy features a timeline, similar or replated project, the relevance to DDOT's equity statement, and the anticipated outcomes.
Measuring Outcomes		Measures primarily focused on improving frequency, availability, and reliability. Accessibility improvements were held to compliance with ADA standards.	Measures in the Strategic Plan were specified to incorporate equity in on-demand service, customer safety satisfaction, reduced fare, commute times, accessibility, and proximity to transit, customers satisfaction, and ORCA transfers.	Phase I outlined goals to implement projects that support the local and regional economies, protect the environment, mitigate traffic congestion, and are economically viable.	Equitable outcomes that indicate just distribution such as changes to DDOT's investment pest prioritization and utilizing a transportation disparities assessment to set targets to increase the minimum service level and the range of impacts.

Review of Existing Research

MWCOG Transit Equity White Paper

The Metropolitan Washington Council of Governments (MWCOG) performed an assessment of bus transit service within the region to gauge the impact of the COVID-19 pandemic on transit service for historically disadvantaged and marginalized populations. The inputs for the review are criteria for agencies to consider when recovering from the pandemic and restoring service to pre-pandemic operations and a framework for improvements to exceed previous service. COG developed three indexes to analyze the current distribution of transit service and its ability to provide access to employment opportunity, the Transit Need Equity Index, the Level of Service Index, and the Gap Analysis Index. The combination of these tools generate a comparative overview of pre- and post-pandemic service with inputs from route coverage, frequency, time of day, and span of service to people of color, low income households, and non-native speakers. COG's response to the pandemic resulted in an interactive map as a resource for equitable transit planning post pandemic.

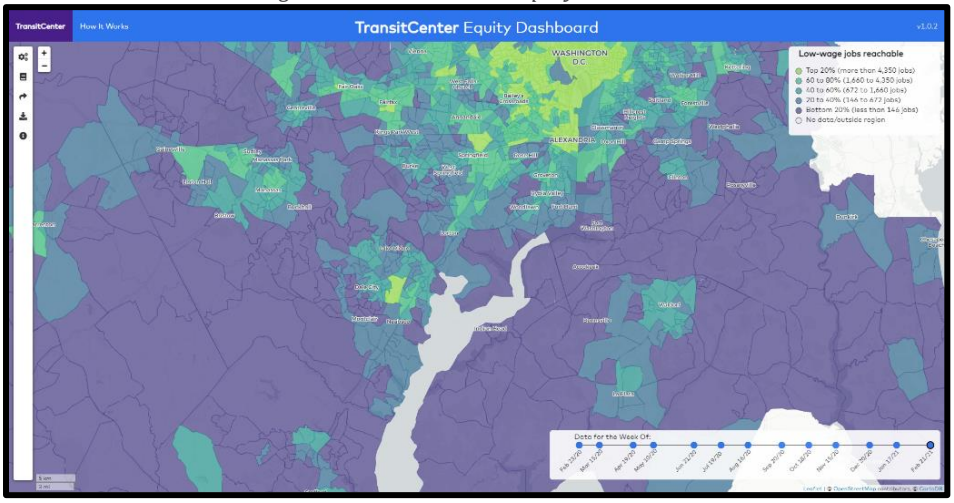
Greenlining Institute

The Greenlining Institute connects community leaders with policymakers, researchers, and private sector leaders. They design and support policies designed to open doors to opportunity, recognizing that America's racial wealth gap was created by deliberate policy choices and it will take deliberate, race-conscious choices to end it. A primary tenet of Greenlining's approach is to separate interactions framing Equity as a zero-sum game in which one side must win and the other must lose. Instead, they reach for win-win solutions that expand opportunity for all Americans. The Greenlining Institute provides a vast array of policy recommendations and research available on their website. Example policy recommendations report includes a Mobility Equity Framework that includes metrics for overall transportation planning efforts to focus on to prioritize the needs of people and their communities.

TransitCenter Equity Dashboard

TransitCenter works to improve transit in order to make cities more just and environmentally sustainable. Using data from seven major urban areas in the United States, TransitCenter assembled a dashboard analyzing how well the transit agencies connect marginalized populations to jobs, services, and amenities they need to thrive as show in **Figure 38**. The dashboard looks at metrics like the number jobs people can reach within a limited timeframe or budget, travel times to hospitals and grocery stores, and service frequency, and tracks how these measures have changed in each region. The dashboard illuminates existing disparities and tracks progress toward equity by measuring transit outcomes for Black people, other people of color, people living in poverty, and single mothers. The TransitCenter Dashboard provides a resource for potential performance indicators as well as a window into how other metro areas perform in equitable service offerings and outcomes.

Figure 38: TransitCenter Equity Dashboard



TCRP: Equity Analysis in Regional Transportation Planning Processes

The Transportation Research Board (TRB) report, *Equity Analysis in Regional Transportation Planning Processes*, details strategies to aid Metropolitan Planning Organizations (MPOs) in advancing their approach to equitable transportation investments. The report serves as a guide outlining a five-step framework to perform an equity analysis for regional policy. In prelude to the five steps, the report emphasizes the importance of laying an inclusive and meaningful public engagement strategy that is tailored to capture the diverse and critical input from underserved communities to inform decision making processes.

1. Identify populations for analysis using geospatial strategies that illustrate population density
2. Identify needs and concerns through stakeholder input, assessing environmental and safety conditions, assessing gaps, and validating the findings through stakeholder engagement
3. Conduct an analysis that measures the impact of the proposed agency activity with guidance on selecting impact indicators
4. Determine whether the impacts are disparate
5. Develop strategies to avoid or mitigate inequities.

Agencies can utilize the findings of this study to conduct a robust analysis and strategy to guide equitable transit improvements. The pilot implantation of the guide case studies includes lessons learned that stress the importance of performing an assessment of impacts and communicating the findings in a meaningful, understandable, and transparent way. Agencies also reported on the importance of involving local stakeholders early in the planning process to leverage their availability that may be limited. Case studies also recommend that network data should be compared and grounded with on-the ground conditions and engaging the local population provides vital insight into refining findings.

TCRP: Redesigning Transit Networks for the New Mobility Future

The TRB report, *Redesigning Transit Networks for the New Mobility Future*, researches and presents case studies and toolkits to examine transit strategies to redesign bus networks to be resilient and maintain efficiency in changes to demography, land use, economics, technology, and mobility options. In two sections, the report describes its findings on bus network redesigns and new mobility and case studies of four transit agencies redesigns and toolkits to support the design endeavors of other agencies. The report discusses key themes and trends in conducting bus network redesigns such as complete overhauls or less intensive system modifications. Equity is described as a key component to system redesign and several new mobility initiatives have sought to serve the needs of historically underserved populations and focus on equity beyond Title IV. The report also describes the necessary internal and external collaboration within the agency and the greater community necessary to successfully plan for redesign.

Adequacy of Infrastructure

Overview and Definition

This section summarizes the findings of a planning-level review of available and accessible data to better understand the baseline conditions or current state of transit infrastructure across the Commonwealth of Virginia. The intent of this review is not to develop a detailed infrastructure audit or asset inventory, but rather to identify general trends in the condition and availability of transit infrastructure operated and/or maintained by transit agencies across the Commonwealth. The baseline conditions are used to help identify high-level areas of opportunities or possible improvements that could lead the Commonwealth of Virginia to provide more adequate and equitable transit infrastructure to residents throughout the Commonwealth.

For the purposes of this study and the topic area, transit infrastructure includes fleet (i.e., revenue vehicles), passenger facilities (e.g., stations and large transfer centers), maintenance and administrative facilities, bus stops and corresponding passenger amenities, dedicated guideway or bus lanes, and multimodal connection supporting infrastructure such as sidewalks and bicycle facilities.

Similarly, under this topic area, the adequacy of infrastructure evaluates the state of good repair (SGR), reliability, and American with Disabilities Act (ADA)-compliant accessibility of the transit infrastructure. Additional details on the elements used to evaluate adequacy are presented under the Methodology section of this technical memorandum.

Baseline Conditions

The baseline conditions review and opportunities assessment generally explores key issues of interest around the existing quality and adequacy of transit infrastructure (including vehicles, bus stops, and facilities) owned by transit agencies, policy or implementation barriers in the provision of basic amenities including ADA-compliant amenities for transit users, the availability of infrastructure that supports multimodal connectivity to these transit infrastructure, and how equity is considered by the transit agencies when planning for transit infrastructure.

A few assumptions and limitations should be noted regarding the analysis. Although the study evaluates equity in a more holistic manner, for the purposes of the analysis under this topic area, the focus on equity becomes much narrower due to the limitations in data that can be used to consider equity factors around infrastructure at a statewide level. As such, under the analysis of this topic area, equity will be reviewed by observing the availability and distribution of adequate infrastructure overlayed on areas of low income or of persistent poverty across the state and evaluated as to whether there are any discernable trends.

Furthermore, although the study provides a statewide review of transit infrastructure, many of the issues and concerns surrounding some of the transit infrastructure (e.g., dedicated guideways or bus lanes) and most of the infrastructure supporting multimodal connections (e.g., sidewalks, ADA-accessible ramps, bicycle lanes) are funded by or fall under the purview of local jurisdictions or of non-transit agencies such as the Virginia Department of Transportation (VDOT). As such, there are limitations to the sphere of influence that Virginia Department of Rail and Public Transportation (DRPT) has and, as such, what transit agencies can do to provide more adequate infrastructure.

Methodology

The general framework guiding the baseline conditions analysis is to identify opportunities and develop findings that are based on and driven by data; however, due to limitations in the quality and availability of transit infrastructure data, it became necessary to use more qualitative or anecdotal information to delineate general context and trends around the information presented by the available data to better understand the current state or adequacy of the Commonwealth's transit infrastructure.

Data Sources

Broadly, the approach to data collection and review process used for the baseline conditions analysis, and relevant data sources, can be outlined as:

1. Collected and reviewed transit infrastructure data from national, state, local (including transit agencies), and open- and crowdsourced data sources including:
    - **National Transit Database (NTD)**: Used the latest (FY2019) data for the vehicles, facilities, and bus and rail guideway analyses.

- **DRPT TransAM**: Used the latest data in conjunction with NTD data for vehicles analysis.
- **DRPT Support for Evaluation of Facilities – Detailed Facility Assessment**: Used latest data to supplement NTD data for the facilities analysis.
- **Open-source state, local, and agency Geographic Information System (GIS)**: Collected and downloaded available open-source GIS data for bus stops, bus amenities (e.g., shelters), sidewalks, bicycle facilities (e.g., bike lanes), and ADA-compliant ramps.
- **Crowdsourced data – OpenStreetMap**: Reviewed data for sidewalk and bicycle facilities (e.g., bike lanes) but review indicated data was incomplete and decided not to use this data source.

2. Reviewed and evaluated collected data for completeness and requested additional data to transit agencies via GIS data request and survey.

   - Requested GIS data from transit agencies for the following transit infrastructure elements: bus stops, bus amenities (e.g., shelters and/or benches), sidewalks, and bicycle facilities (e.g., bike lanes).
   - Requested data and feedback using a **survey** to transit agencies regarding infrastructure-related topics including:

     - Fleet (revenue vehicle) reliability performance measure
     - Administrative and maintenance facilities capacity
     - Passenger facilities capacity and ADA compliance
     - Bus stop amenities, multimodal connection, and ADA compliance
     - Agency decision-making on transit infrastructure investments

3. Reviewed current plans and open-text survey responses to fill gaps or build context around information generated by the available data. Plans reviewed to get additional context on current-state and future trends relevant to fleet, facilities, bus stops, bus lanes or rail lines, and multimodal connections to transit include:

   - Transit development plans (TDPs) of transit agencies in the Commonwealth
   - Transit strategic plans (TSPs) of transit agencies in the Commonwealth
   - Long-range transportation plans (LRTPs) of metropolitan planning organizations (MPOs) in the Commonwealth
   - Virginia planning district commission (PDC) plans

Analysis Approach

The data collected was analyzed to help develop a better understanding of the current state of adequacy and equitable distribution of transit infrastructure across the Commonwealth.

Transit Agency Transects

There are 39 transit agencies in the Commonwealth considered for evaluation in the study (not including the Washington Metropolitan Area Transit Authority [WMATA]).

It also should be noted that out of the 39 transit agencies in Virginia, not all were evaluated for bus stops. Of the 39 transit agencies, two operate demand response-only services. There also are four agencies who utilize fixed-route flag stop services. For flag stops, riders must hail the bus along the route and operators must determine if it is safe to stop at those locations. All agencies utilizing flag stops also utilize bus stops on their routes, though flag stop locations are not considered as infrastructure in this analysis.

Agency	Transect	Service
Lake Country Area Agency on Aging	Demand Response	Demand Response
Mountain Empire Older Citizens	Demand Response	Demand Response
Alexandria Transit Company (DASH)	Enhanced Fixed Route	Fixed Route Bus, Demand Response - Taxi, (interface with rail)
Arlington County Transit	Enhanced Fixed Route	Fixed Route Bus, Demand Response, Demand Response - Taxi, (interface with rail)
City of Fairfax (CUE)/Fairfax City University Energy Saver	Enhanced Fixed Route	Fixed Route Bus, (interface with rail)
Fairfax County (Fairfax Connector)	Enhanced Fixed Route	Fixed Route Bus, (interface with rail)
Fredericksburg Regional Transit (FRED)	Enhanced Fixed Route	Fixed Route Bus, (interface with rail)
Greater Richmond Transit Company (GRTC)	Enhanced Fixed Route	Fixed Route Bus, Bus Rapid Transit, Demand Response, Vanpool
Hampton Roads Transit	Enhanced Fixed Route	Fixed Route Bus, Light Rail, Ferryboat, Demand Response, Demand Response - Taxi, Vanpool
Potomac and Rappahannock Transportation Commission (PRTC, Omniride)	Enhanced Fixed Route	Fixed Route Bus, Commuter Bus, Vanpool, (interface with rail)
Virginia Railway Express	Enhanced Fixed Route	Rail only provider
Altavista Community Transit System	Fixed Route	Fixed Route Bus, Flag Stops
Bay Transit	Fixed Route	Fixed Route Bus, Demand Response
Blacksburg Transit	Fixed Route	Fixed Route Bus, Demand Response
Blackstone Area Bus System	Fixed Route	Fixed Route Bus, Flag Stops
Bristol Virginia Transit	Fixed Route	Fixed Route Bus, Demand Response, Flag Stops
Central Shenandoah Planning District Commission (BRITE)	Fixed Route	Fixed Route Bus, Demand Response
Charlottesville Area Transit	Fixed Route	Fixed Route Bus
Chincoteague Pony Express/PONY EXPRESS	Fixed Route	Fixed Route Bus, Flag Stops
Danville Transit	Fixed Route	Fixed Route Bus, Demand Response
District Three Public Transit (Mountain Lynx)	Fixed Route	Fixed Route Bus, Demand Response, (Fixed, Flexible - Trillium addition)

Agency	Transect	Service
Farmville Area Bus	Fixed Route	Fixed Route Bus, Demand Response
Four County Transit	Fixed Route	Fixed Route Bus
Graham Transit	Fixed Route	Fixed Route Bus, Demand Response
Greater Lynchburg Transit Company	Fixed Route	Fixed Route Bus, Demand Response
Greater Roanoke Transit Company (Valley Metro)	Fixed Route	Fixed Route Bus, Demand Response
Greensville-Emporia Transit	Fixed Route	Fixed Route Bus
Harrisonburg Department of Public Transportation	Fixed Route	Fixed Route Bus, Demand Response
Jaunt	Fixed Route	Commuter Bus, Demand Response
Loudoun County Transit	Fixed Route	Fixed Route Bus, Commuter Bus, Demand Response
Petersburg Area Transit	Fixed Route	Fixed Route Bus, Demand Response
Pulaski Area Transit	Fixed Route	Fixed Route Bus, Demand Response
RADAR	Fixed Route	Fixed Route Bus, Demand Response
Radford Transit	Fixed Route	Fixed Route Bus
STAR Transit	Fixed Route	Fixed Route Bus, Demand Response
Suffolk Transit	Fixed Route	Fixed Route Bus, Demand Response
Virginia Regional Transit	Fixed Route	Fixed Route Bus, Demand Response
Williamsburg Area Transit	Fixed Route	Fixed Route Bus, Demand Response
Winchester (WinTran)	Fixed Route	Fixed Route Bus, Demand Response

	= Rural reporter agencies (less than 50,000 population)
	= Small systems reporter agencies (30 or fewer vehicles)

Adequacy Measures

Under the baseline conditions analysis for transit infrastructure, adequacy is generally evaluated by measuring the infrastructure's SGR condition, reliability, and ADA-compliant access. **Table 17** summarizes the approach and/or relevant metrics used to evaluate the adequacy factors for each of the transit infrastructure types of interest.

Table 17: Evaluation Methods for Adequacy of Transit Infrastructure Types

Transit Infrastructure Type	SGR Condition	Reliability	ADA-Compliant Access
Vehicles	Percent of vehicles at or beyond useful life benchmark (ULB)*	No consistent measure used across all transit agencies in the Commonwealth. Some agencies use on-time performance (OTP), mean distance between failure (MDBF), mean distance between delay (MDBD), and/or other measures	Vehicle ADA compliance as reported to NTD*
Administrative and Maintenance Facilities	Percent of facilities below a condition score of 3.0*	No current federal or statewide definition or measure	Facility ADA compliance as reported to NTD and the Commonwealth**
Passenger Facilities (i.e., Stations and Transfer Centers)	Percent of facilities below a condition score of 3.0*	No current federal or statewide definition or measure	Facility ADA compliance as reported to NTD and the Commonwealth**
Bus and Rail Lines	Rail: Percent of track mileage classified as slow zone* Bus: No current federal definition or measure	No current federal or statewide definition or measure	N/A
Bus Stops and Amenities	No current federal or statewide definition or measure	No current federal or statewide definition or measure	Bus stop placement and layout of amenities should comply with federal ADA standards (if data is available)

**Based on NTD FY2019 data*
***Based on NTD FY2019 and DRPT Facilities Assessment 2020*

For bus stops, the baseline analysis also reviewed the presence of supporting infrastructure that provide ADA-compliant multimodal connection. Based on the availability of data, the analysis evaluated for the presence of sidewalks and/or bicycle facilities (e.g., bike lanes) and ADA compliance of these infrastructure (e.g., ADA-compliant sidewalks and curb ramps).

Vulnerable Populations Index (VPI)

Agency-level VPI scores are only used for analysis of fleet and facilities, where the impacts of these assets are systemic across the agency's service area.

By overlaying the adequacy data for facilities, bus stops and amenities, and bus and rail lines over the VPI map, the baseline analysis evaluated whether there is any trend or significant correlation between the areas where capital investments for transit infrastructure are present (or lack thereof) and the location of underserved or vulnerable communities. Furthermore, by overlaying available data for sidewalks, bicycle facilities (e.g., bike lanes), and/or ADA ramps, the analysis also evaluated any significant correlation between the availability of infrastructure providing multimodal connection and the location of underserved or vulnerable communities.

Best Practices

In addition to the data review and analyses conducted to evaluate the current state of adequacy and equitable distribution of transit infrastructure across the Commonwealth, this baseline analysis also reviewed relevant best practices. The best practice literature review focused on planning processes and analyses within Virginia and across the US used to improve transit infrastructure and social equity outcomes. These best practices are presented throughout this technical memorandum as another resource to help identify opportunities to improve current processes and practices.

Benchmarking of Virginia data against other states or national averages is only limited to the SGR measures for fleet and facilities.

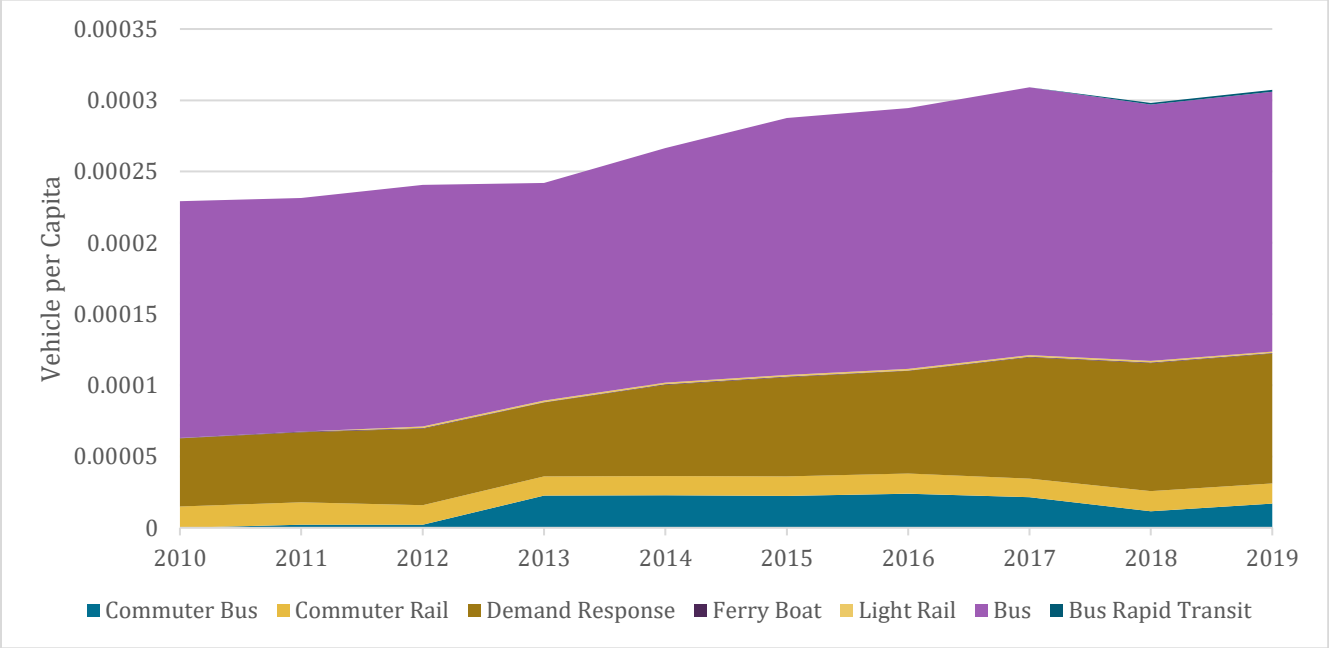
Analysis Results

Vehicles

The statewide transit fleet has grown during the course of the past decade rising by more than 1,500 vehicles from 2009 to 2019. Accounting for the growth in population in the state, the number of vehicles per capita also has increased. As shown in **Figure 39,** The bulk of this growth occurred from 2014 to 2016, when the transit vehicles per capital in the Commonwealth also increased. In 2010, there was one transit vehicle to every 4,300 people; by 2019, this number had improved to 3,200 people per vehicle.

Overall, more transit vehicles and more transit service are being provided in Virginia than at any time in the past decade.

Figure 39: Transit Vehicle Growth per Capita in Virginia



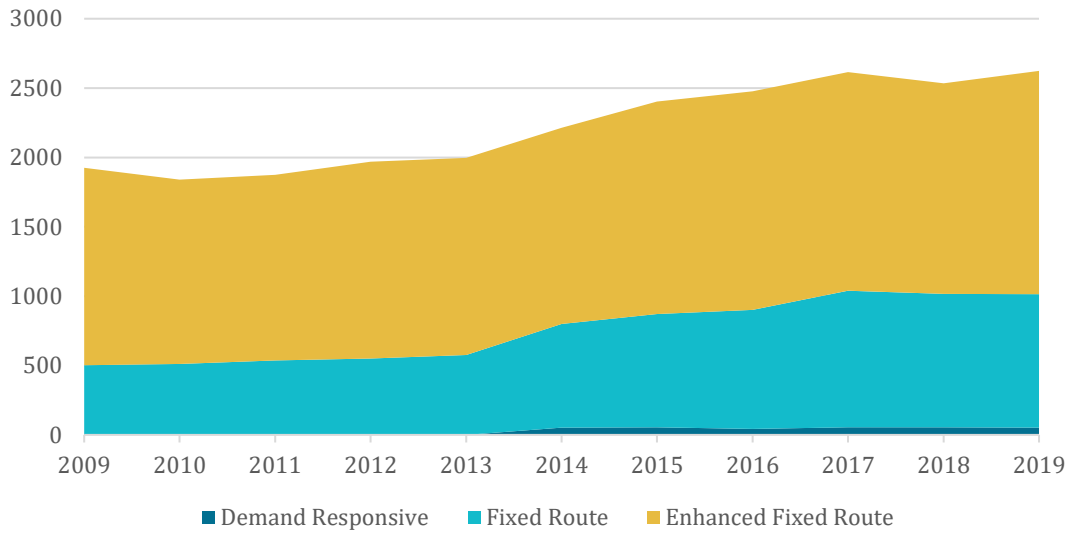
Growth in the fleet is driven predominantly by an increase in buses, either serving fixed or commuter routes. Additional growth in the fleet also comes from demand response vehicles being consistently added each year starting in 2013. No mode included in the analysis has seen their fleet size decrease and most have increased by a significant amount. There has been a 21 percent increase in bus vehicles from 2010 to 2019 and an 11 percent increase in commuter rail vehicles. The number of demand response vehicles has increased by 69 percent in the same period. In 2012, the first light rail vehicles were added to the state fleet.

By transect, most of the growth in the state fleet is a result of the expansion of agencies classified as fixed route (**Table 18**). Since 2009, the fixed-route fleets have expanded by 92 percent, adding twice as many vehicles as enhanced fixed-route operators. Enhanced fixed-route agencies also have grown, but at a slower rate than fixed-route operators. Rural fixed-route agencies grew as much as urban fixed-route agencies, each adding around 300 vehicles, while small, fixed-route agencies added just under 100 vehicles.

Table 18: Change in Vehicles by Mode by Transect 2009-2019

Mode	Transects		
	Demand Response	Fixed Route	Enhanced Fixed Route
Commuter Bus	0	82	64
Commuter Rail	0	0	12
Demand Response	52	242	-13
Demand Taxi	0	0	92
Ferryboat	0	0	1
Light Rail	0	0	9
Bus	0	137	34
Bus Rapid Transit	0	0	13
Total	**52**	**461**	**199**

Figure 40: Total Growth in Fleet Size by Transect, excluding vanpool



The largest growth in the transit fleet has occurred in communities with an average VPI of 3 or 4, as seen in **Figure 41**. Though much of the fleet growth has occurred in these less-vulnerable areas, it should be noted that in 2009 there were no vehicles serving areas with an average VPI of 6 and 7. This suggests that more recent transit provision is expanding in areas with more vulnerable populations.

Figure 41: Total Growth in Fleet Size, 2009-2019, by VPI, excluding vanpool

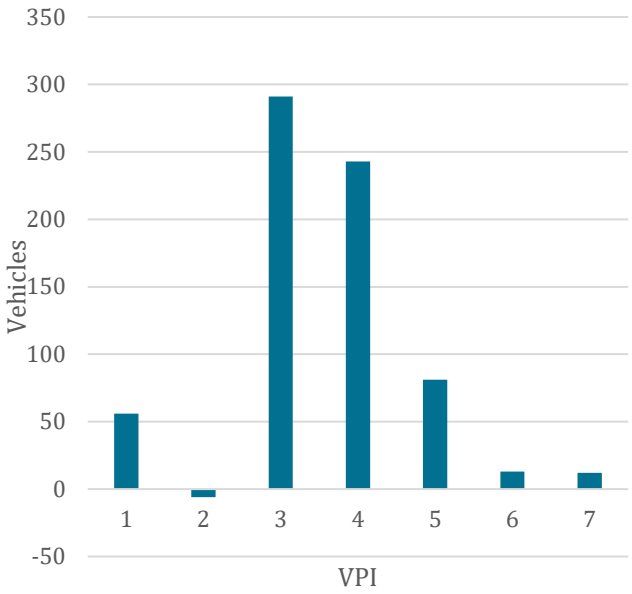
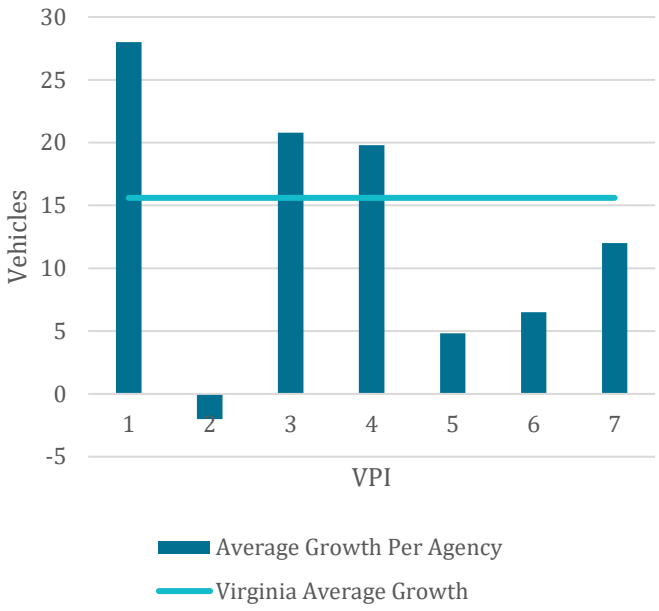


Figure 42: Average Growth in Fleet Size per Agency, 2009-2019, by VPI, excluding vanpool



In addition, the growth of fleet per agency is highest at agencies serving less-vulnerable communities—namely, those with a VPI of 1, 3, and 4 are above the statewide average for growth (**Figure 42)**. While the majority of agencies fall in these categories, the growth across the state is not proportional. Several agencies serve areas with an average VPI of 5 but there was little fleet growth. This means, on average, each agency added only 5 vehicles, while agencies serving areas with an average VPI of 1 increased their fleets, on average, by 28 vehicles. Growth of the fleet in agencies with a VPI of 2 and 5 are significantly below what they should be, proportionally.

ADA Compliance

The ADA requires transit agencies to utilize vehicles that do not restrict access, are usable, provide allocated space and/or priority seating for individuals who use wheelchairs, and that the space or seating is able to be accessed using lifts or ramps. As shown in **Figure 43,** 98.5 percent of all bus vehicles nationwide were ADA-compliant in FY2019.[14] Comparatively, 94 percent of buses in the Commonwealth were ADA-compliant (this goes up to 96 percent if commuter buses are excluded).[15] Virginia's transit fleet is less ADA-compliant than the national average.

Figure 43: FY2019 Nationwide ADA Bus Fleet

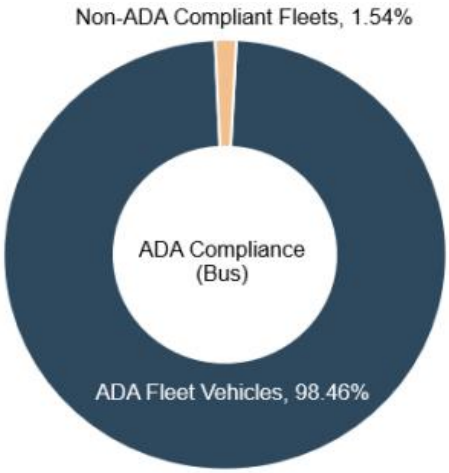
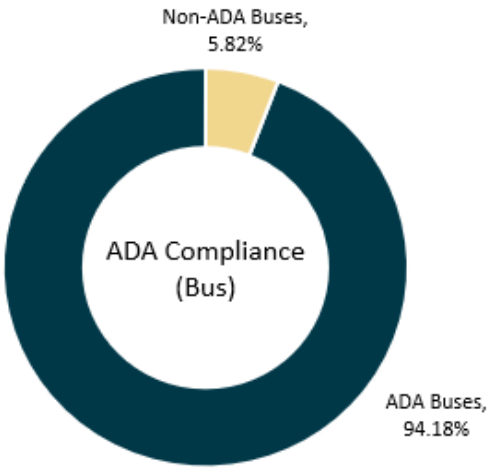


Figure 44: FY2019 Virginia ADA Bus Fleet



It should be noted that NTD data used for this analysis is not always accurate. There are some instances where agencies have misreported vehicles as not being ADA-compliant. Large discrepancies that stand out in the data can be checked with agencies and corrected, but smaller errors may go unnoticed and misrepresent the actual proportion of the fleet that is ADA-compliant. In addition, TransAM does not include a clear definition of ADA compliance for vehicles that aligns with FTA reporting, with lifts and ramps tracked as separate items in TransAM. Therefore, detailed analysis of ADA compliance is not appropriate and only rough order of magnitude (ROM) conclusions can be drawn.

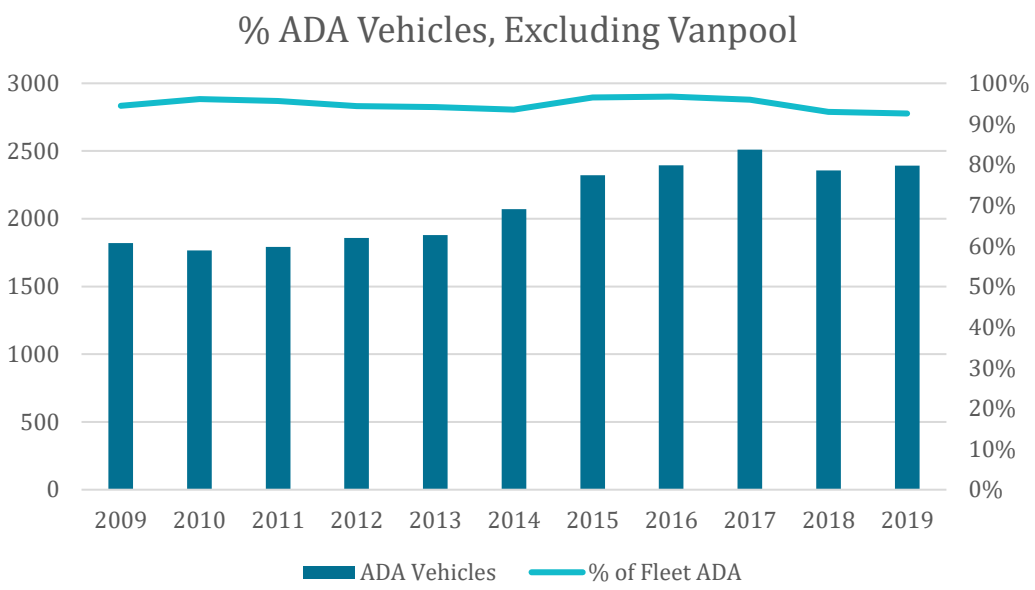
These data quality issues are an opportunity for DRPT to provide technical guidance and support to agencies in their reporting of data to the NTD. This will lead to more accurate data that will better support future studies into accessibility and equity of the transit fleet.

Including rail and demand response fleets, the proportion of the Virginia transit fleet that is made up of ADA vehicles has been relatively stable and high, varying slightly over the course of the past decade between 93 and 97 percent. The number of ADA vehicles also has increased, mainly in 2014 and 2015, coinciding with the increases in the total fleet. This, and the stability of the percentage of the fleet that is ADA-compliant, shows that expansion of the fleet has been driven predominantly through the acquisition of ADA vehicles.

[14] 2019 National Transit Summaries and Trends (NTST). https://www.transit.dot.gov/ntd/2019-national-transit-summaries-and-trends-ntst

[15] FY19 NTD data was adjusted to correct reporting of ADA compliant fleet for one Virginia agency.

Figure 45: Percentage of ADA Compliant Transit Vehicles in Virginia, excluding vanpool



The ADA vehicles by transect reveals that growth in agencies classed as fixed route has been at a similar rate as for the total fleet (95 percent vs. 92 percent, respectively). For enhanced fixed-route agencies, their fleet growth in ADA vehicles has been slower than their total fleet growth (7 percent vs. 13 percent, respectively).

Table 19: FY19 percentage of ADA Compliant Transit Vehicles in Virginia by VPI, excluding vanpool

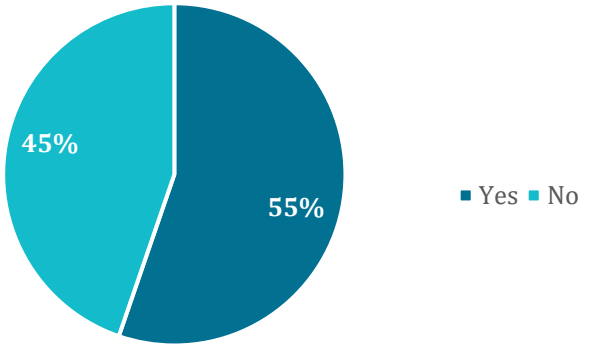
VPI	1	2	3	4	5	6	7
ADA Compliant Vehicles	99%	99%	96%	89%	89%	100%	100%

ADA compliance across the state's agencies is high, but non-ADA compliant vehicles are concentrated in agencies serving areas with VPIs of 4 or 5. As noted above, the newest transit vehicles in the fleet, all purchased after 2009, are serving the agencies with VPIs of 6 or 7.

Reliability

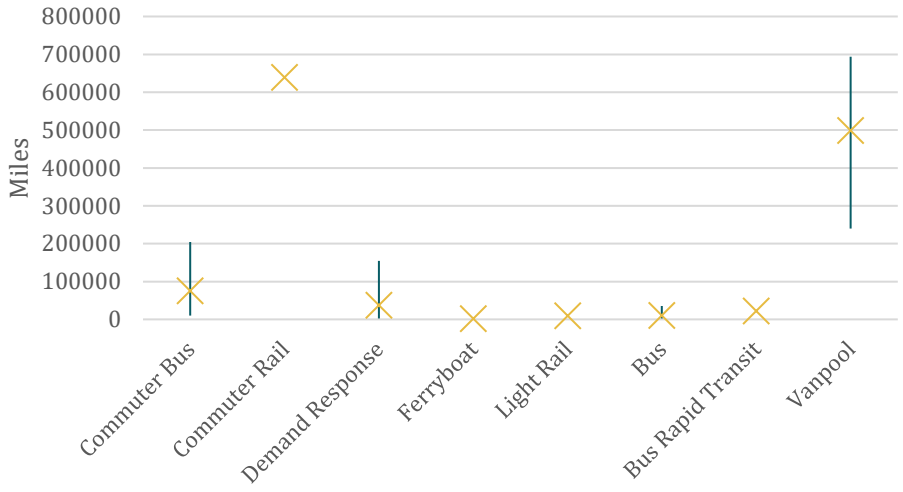
In the survey of transit agencies, more than half of the 39 respondents indicated that their agency tracks fleet reliability (**Figure 46**). Of those that responded that they track fleet reliability, most indicated they use mean distance between failure (MDBF) as a metric, while few indicated that they use MDBF and/or other metrics such as mean distance between delay (MDBD), mean time between failure (MTBF), or similar metrics (e.g., miles between service interruptions [MBSI]). Out of the agencies that responded that they do not track reliability of their fleet, most stated that they track fleet performance by tracking mileage, monitoring operations and route logs, or monitoring maintenance logs or reports.

Figure 46: Response to Survey Question to Transit Agencies "Does your agency track fleet reliability as a performance measure?"



From FY2019 NTD data, only 15 Virginia agencies report their fleet mechanical failures to FTA. Using this data, the MDBF can be calculated by mode, with the caveat that the agencies are not representative of smaller or rural reporters. **Figure 47** illustrates the maximum (top of the line), minimum (bottom of the line), and mean (represented by X) measures for agencies by mode. Commuter rail is not included, as the distance between failures for that mode is well outside of the range of other modes, at 638,787 MDBF. For Commuter Bus and Demand Response the range of reported MDBF may indicate differing definitions of "failure" for reporting purposes. Some agencies only include mechanical failures if they cause a significant delay or offloading of passengers, while others will report any road calls as failures. Therefore, the wide range of MDBF may not represent actual range of fleet performance nor customer experience of the service.

Figure 47: FY19 Mean Distance Between Failure by Mode



Similar to the reporting of ADA compliance, the accounting for reliability is an opportunity for DRPT to provide technical guidance and potentially generate statewide standards.

Figure 48: FY19 Mean Distance Between Failure by VPI for Commuter Bus, Bus and Demand Response

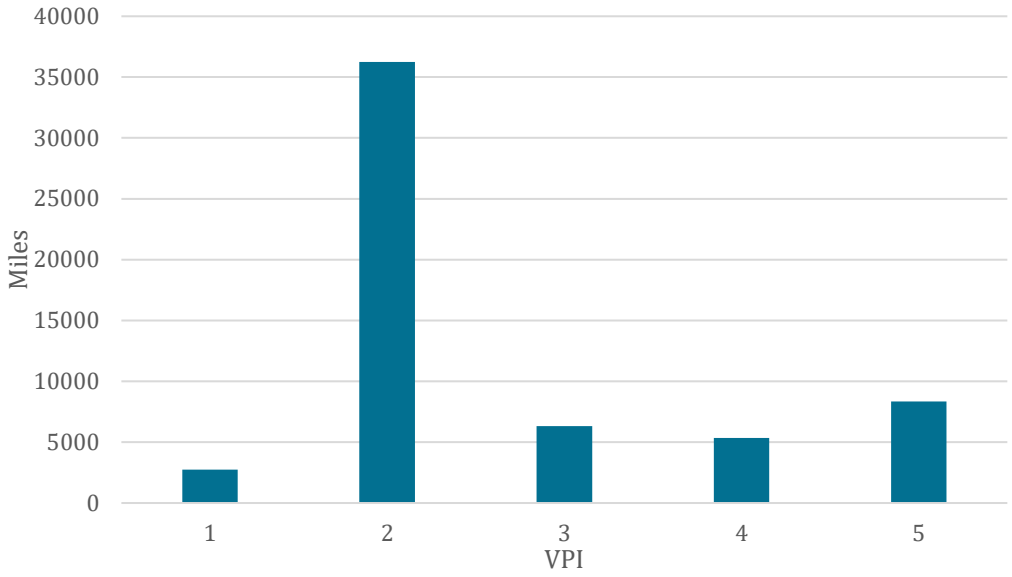


Table 20 shows agencies' on-time performance (OTP) targets and definitions, with agencies being represented by their respective transect. Each agency has its own target and definition of OTP, whether they run fixed routes, enhanced fixed routes, or have demand responsive service. Target rates range from 70 to 100 percent with most agencies noting that if a vehicle arrives later than 5 minutes then that vehicle is considered "late." For demand response agencies and those using flag stops, which are not set bus stop locations but rather a fixed route where riders can hail the bus anywhere along the route, OTP calculations are necessarily different than other fixed-route systems.

Standardizing metrics and definitions of OTP would enhance the analysis of agencies' services and DRPT's understanding of system performance in vulnerable or underserved areas.

Table 20: On-Time Performance Targets and Definitions

Agency	Transect	Target OTP	Definition of OTP
Arlington County Transit	Enhanced Fixed Route	95%	0 to 6 minutes late with no trips leaving early
Blacksburg Transit	Fixed Route	85%	Not provided
Central Shenandoah Planning District Commission (BRITE)	Fixed Route	90%	No more than 1 minute early or 5 minutes late
Charlottesville Area Transit	Fixed Route	90%	0 to 5 minutes late with no trips leaving early
Chincoteague Pony Express	Fixed Route	80%	0-5 minutes late
City of Fairfax (CUE)	Enhanced Fixed Route	90%	Not provided
Danville Transit	Fixed Route	90%	No more than 1 minute early or 5 minutes late
District Three Public Transit (Mountain Lynx)	Fixed Route	95%	0-5 minutes late
Fairfax County (Fairfax Connector)	Enhanced Fixed Route	96%	0 to 5 minutes late with no trips leaving early
Farmville Area Bus	Fixed Route	100%	5 to 10 minutes late
Four County Transit	Fixed Route	95%	0-5 minutes late
Fredericksburg Regional Transit (FRED)	Enhanced Fixed Route	90%	0-10 minutes late

Graham Transit	Fixed Route	95%	0 to 5 minutes late with no trips leaving early
Greater Lynchburg Transit Company	Fixed Route	95%	0-3 minutes late
Greater Richmond Transit Company	Enhanced Fixed Route	80%	0-5 minutes late
Greater Roanoke Transit Company (Valley Metro)	Fixed Route	93%	0-5 minutes late
Greensville-Emporia Transit	Fixed Route	95%	0 to 5 minutes late with no trips leaving early
Hampton Roads Transit	Enhanced Fixed Route	85%	0-5 minutes late
Harrisonburg Department of Public Transportation	Fixed Route	90%	10 minutes late, more than 10% of the time
Jaunt	Fixed Route	85%	Not provided
Loudoun County	Fixed Route	Not Provided	No more than 1 minute early or 5 minutes late
Mountain Empire Older Citizens	Demand Responsive	90%	Not provided
Petersburg Area Transit	Fixed Route	95%	0 to 5 minutes late with no trips leaving early
Pulaski Area Transit	Fixed Route	90%	Not provided
RADAR	Fixed Route	Not Provided	No more than 10 minutes late
Radford Transit	Fixed Route	90%	0 to 5 minutes late with no trips leaving early
STAR Transit	Fixed Route	95%	0 to 5 minutes late with no trips leaving early
Suffolk Transit	Fixed Route	70%	0 to 5 minutes late with no trips leaving early
Virginia Regional Transit	Fixed Route	90%	No more than 1 minute early or 5 minutes late
Winchester	Fixed Route	95%	0 to 5 minutes late with no trips leaving early
Williamsburg Area Transit	Fixed Route	90%	0 to 5 minutes late with no trips leaving early

Few agencies report OTP results publicly. With few agencies reporting OTP, statistically significant analysis of results against equity communities is not possible; however, at a high level, there does not appear to be a correlation between equity areas and lower OTP. A more complete dataset of all agencies with fixed-route services, and standard definitions for OTP, would allow DRPT to understand if there is a service reliability issue that is inequitable across the state.

SGR

For vehicles, FTA measures SGR performance based on the percentage of active fleet that is at or beyond its useful life benchmark (ULB). Transit agencies are intended to set a ULB in consideration of the type of vehicle, type of service, maintenance plans, and operating environment. As such, an agency's ULB allows for a more accurate assessment of the useful lives of vehicles based on operational realities than the grant minimum useful lives established for tracking federal financial interest in assets.

BEST PRACTICE EXAMPLE: SETTING ULBS

Following a condition assessment of their bus fleet, **TriMet** set a 16-year ULB for their 40-foot buses as the wear and tear indicated a longer optimal service life. In contrast, **LYNX** in Orlando operates buses in one of the largest service areas in the country and set a ULB of 10 years for their 40-foot bus fleet based on the mileages accrued each year and the increased maintenance costs of keeping buses longer.

As of FY2019 reporting, 19 percent of the Commonwealth's transit fleet is at or beyond its ULB. This is roughly in line with the rest of the country, where 20 percent of vehicles were reported as at or beyond ULB. Anecdotally, the review of the regional LRTPs and agency TDPs or TSPs suggest that the number of vehicles at or beyond ULB across the Commonwealth should continue to be low as investment made by transit agencies focus heavily on replacing their vehicles.

Figure 49: FY19 Nationwide Vehicles at or beyond ULB

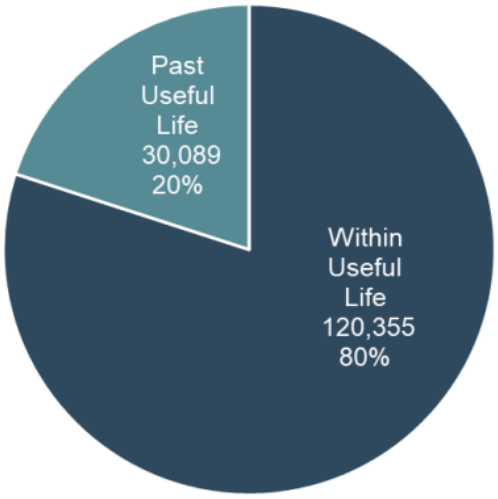
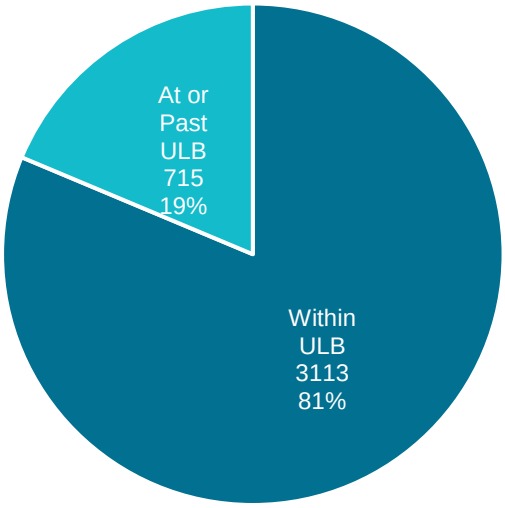
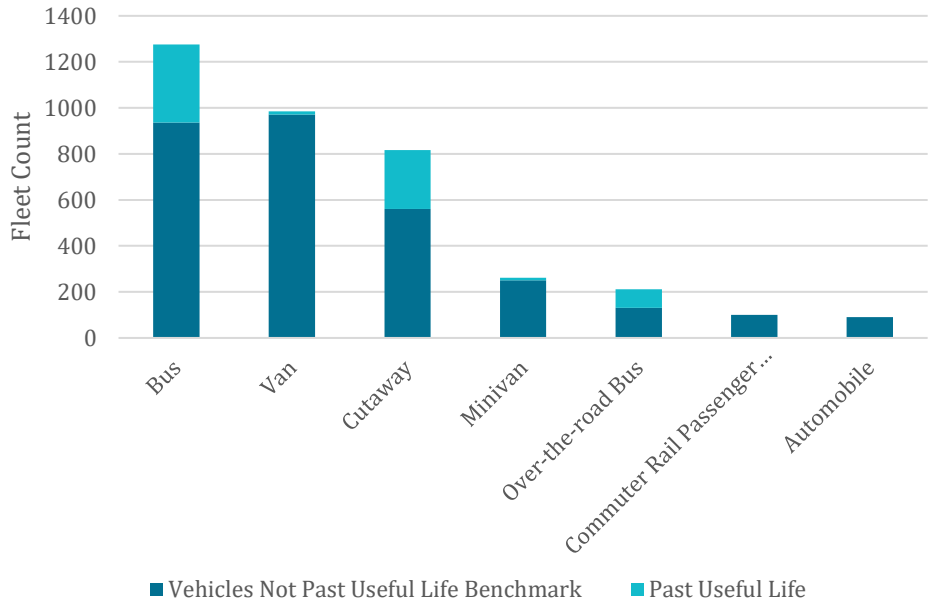


Figure 50: FY19 Virginia Vehicles at or beyond ULB



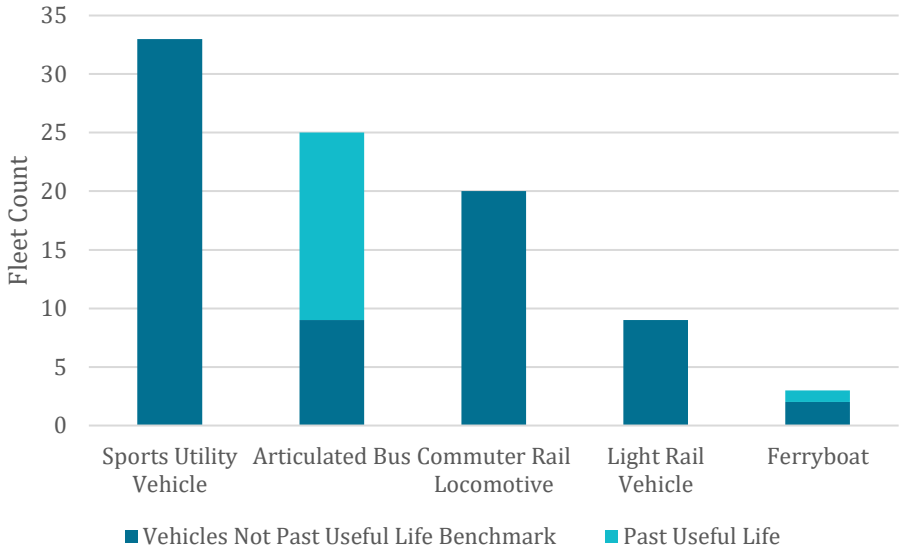
Most of those vehicles at or beyond ULB (54 percent) are operated by enhanced fixed-route agencies, which aligns with the fact that most vehicles in Virginia are operated by these agencies. Fixed-route agencies account for 38 percent of vehicles at or beyond their ULB but operate only 22 percent of all transit vehicles, showing a disproportionately high percentage of vehicles not in SGR. Small, fixed-route agencies have a much larger proportion of vehicles beyond their ULB (57 percent) then rural and urban fixed route agencies. Rural agencies have only 8 percent of vehicles beyond their ULB, while urban fixed-route agencies have 17 percent of vehicles past their ULB.

Figure 51: FY19 Virginia Vehicles at or beyond ULB by vehicles type (1 of 2)



Please note the size of fleets between **Figure 51** and **Figure 52** are significantly different. Articulated buses are the only vehicle type with a majority of the fleet at or beyond ULB. This is due to a relatively small fleet and one agency reporting 14 articulated buses as beyond ULB.

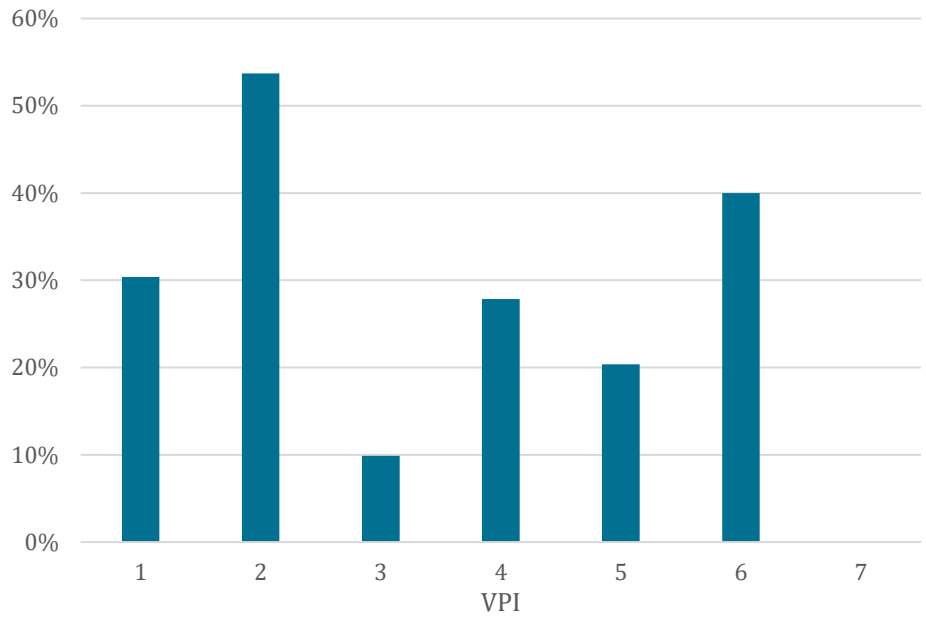
Figure 52: FY19 Virginia Vehicles at or beyond ULB by vehicles type (2 of 2)



Significantly, a third of all fixed-route agency vehicles are at or beyond their useful life benchmark. For these agencies, the bulk of the vehicles beyond their useful life are buses or minivans. This trend is replicated across all vehicles beyond their useful life, which are predominately the different types of buses.

The MERIT – Capital Assistance program (described in detail in the Statewide Planning for Infrastructure section), introduced in FY 2020, prioritizes the allocation of state capital funding to State of Good Repair needs before system enhancements or expansions. State of good repair projects, including the replacement of revenue vehicles, are prioritized based on the age and mileage of vehicles compared to their Useful Life. Under this program, transit agencies throughout the state have been allocated funds to replace their oldest and highest mileage fleet vehicles first.

Figure 53: FY19 Vehicles Past Useful Life Benchmark by VPI



There is a moderate negative correlation (r = -0.46) between the percentage of vehicles past useful life and VPI. Agencies with a higher VPI, or more vulnerable populations, are likely to have a smaller proportion of vehicles beyond their ULB. This suggests that that there is an equitable emphasis on getting vehicles within their useful life to agencies representing more vulnerable populations.

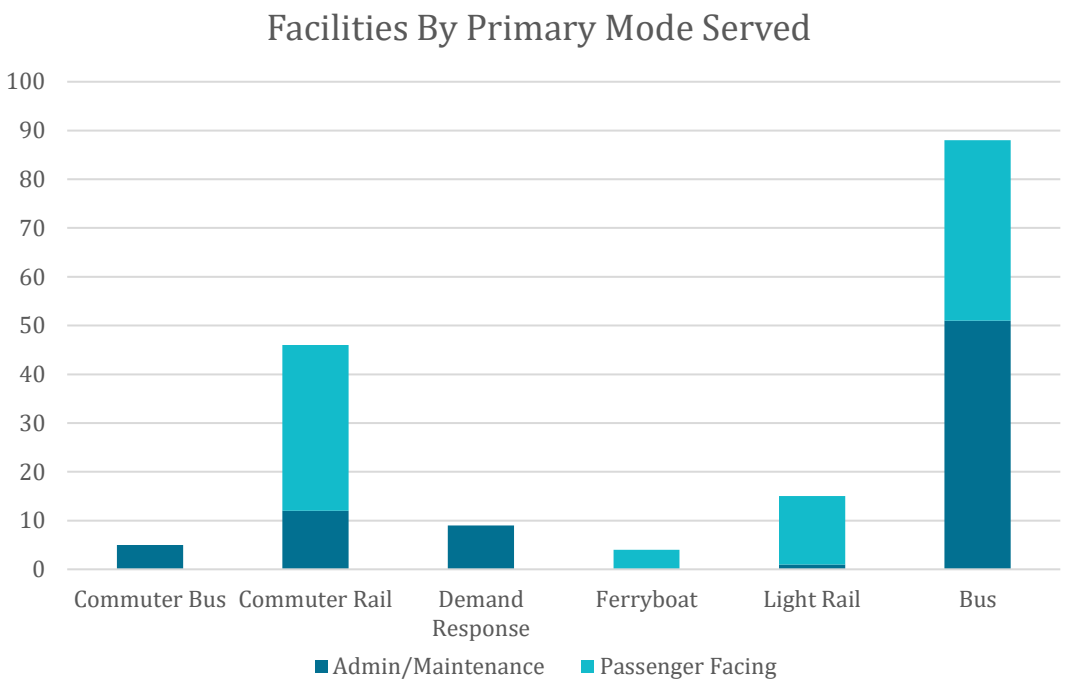
Facilities (including Stations)

Transit facilities include all passenger stations and facilities including stations on right-of-way (ROW), bus terminals, and transfer stations and all maintenance and administrative buildings. In addition, passenger parking lots and structures are included as passenger facilities for reporting. Individual bus stops and associated amenities are not considered transit facilities. See the following section for bus stop analysis.

Under the FTA definition of a facility, each individual building should be inventoried by agencies. For example, if a bus garage has four separate buildings on the site, that would be inventoried and reported as four facilities. All passenger facilities must be inventoried regardless of who owns or maintains the site; however, support facilities should only be reported if the agency has direct capital responsibility for the buildings. Direct capital responsibility entails owning the building or having responsibility for capital maintenance. Third-party facilities that service vehicles but are not owned or maintained by the agency are not reported.

Facilities are classified by their primary function: passenger station or administrative/maintenance facility.

Figure 54: Total Transit Facilities in Virginia by Primary Mode and Function



The proportion of facilities that are passenger facing or used for administrative or maintenance is roughly equal across the state. The majority of passenger facilities are either rail stations or bus transfer stations—these facilities account for more than a third of reported facilities. Dedicated maintenance facilities account for 16 percent of reported facilities, with a further 15 percent of facilities being maintenance combined with administrative offices. Ten percent of reported facilities are purely administrative offices. There are eight parking facilities reported by agencies, seven of which are surface lots.

Growth

The number of transit facilities in the state has grown for all modes since 2012; however, the scale of growth cannot be accurately determined using NTD data. For example, NTD data from 2012 to 2019 shows the number of bus facilities increasing by more than 350 percent, the number of facilities reported by demand response agencies tripling in the same period, and commuter rail adding more than 40 facilities. These increases are based on changes in the reporting requirements and definitions of facilities due to Moving Ahead for Progress in the 21st Century (MAP-21) rulemaking for NTD and transit asset management (TAM). The structure of NTD reporting of facilities changed significantly between 2014 and 2017. Reporting of some inventory data was made optional in 2017 as the new rule became effective in the 2018 reporting cycle. This explains the large drop in facilities reported in 2017, though the overall trend picking back up in 2018 is increasing.

Based on the survey conducted for this study, 27 out of 39 responding transit agencies stated that their administrative and maintenance facilities have enough capacity to support current service levels. Similarly, 17 out of 21 transit agencies that own passenger facilities stated that their passenger facilities have enough capacity to support current service levels. Out of those agencies that stated their passenger facilities have enough capacity to support current service levels, four agencies responded that existing and planned facilities will not be able to support future service levels.

Understanding the growth and locations of transit facilities may be improved through use of Virginia's TransAM system (see section below) if historical records are kept and timeseries are produced.

Accessibility

Based on the survey conducted for this study, more than 70 percent of transit agency respondents that own passenger facilities stated that all their passenger facilities are ADA-compliant. However, there are no statewide or national database that collects and tracks the ADA compliance of facilities (passenger and administrative/maintenance) to validate the survey responses. The NTD does not collect information on the accessibility of facilities or whether they are ADA-compliant. This is an opportunity to use the fact that agencies have to report facility information annually (either through condition assessments of facilities or TransAM) to also encourage them to report information on the ADA compliance and accessibility of their facilities, particularly passenger-facing facilities. This will enable more accurate analysis of accessibility in the transit system and how well it serves vulnerable populations.

SGR/Reliability

FTA defines the SGR of a facility based on the 5-point condition rating scale shown in **Table 21.** Facilities below a 3 are not in SGR as they have critical maintenance needs and multiple components beyond useful life. Facilities must be inspected and scored on this scale once every 4 years as part of the TAM requirements. To qualify for reporting, a facility must be more than 100 square feet and the agency must have direct capital responsibility for the facility.

Table 21: FTA Condition Rating Scale

Condition	FTA Rating	Description
Excellent	5	• New asset • No visible defects
Good	4	• Good condition but no longer new • Asset showing minimal signs of wear but is functional
Adequate	3	• Moderately defective or deteriorated components(s) • Has not reached useful life
Marginal	2	• Defective or deteriorated in need of replacement • Exceeded useful life
Worn	1	• Critically damaged or in need of immediate repair • Well past useful life

Facilities are assessed based on multiple components, including the:

- Substructure
- Shell
- Interiors
- Conveyance
- Plumbing
- Heating, Ventilation, and Air Conditioning (HVAC)
- Fire Protection
- Electrical
- Equipment
- Site

Equipment valued at more than $50,000 should be inventoried and assessed separately from the facility itself, whereas equipment valued at less than $10,000 should not be assessed as part of the facility equipment. Generally speaking, the FTA requirement does not include assessing the performance or reliability of equipment as part of the inspection process; however, it is best practice to include either a functional test or historical maintenance issues (pain points) related to critical equipment such as fare gates, bus lifts, bus wash, etc. in the inspection process. While DRPT may not have a reliability metric for facilities inspections, the reporting done should include any major reliability issues at a site.

Combining NTD data with the most recent DRPT facility condition assessments, 4 percent of facilities have a condition below a 3. This is significantly better than the nationwide proportion of facilities scoring below a 3 at 12 percent of all facilities.

Figure 55: FY19 Nationwide Facility SGR Measure

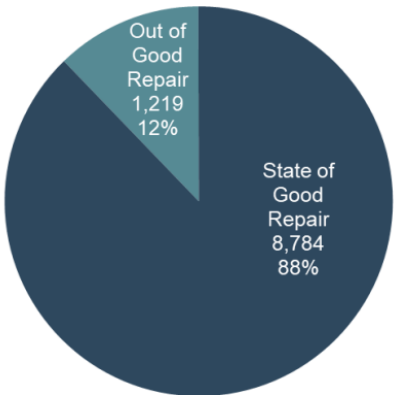
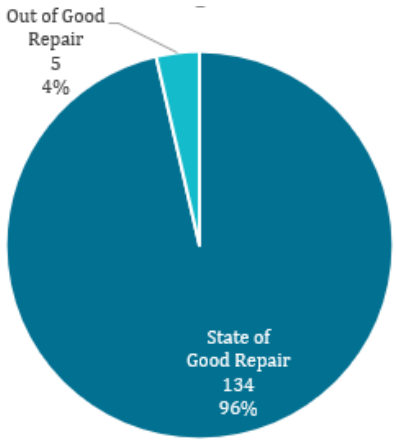


Figure 56: FY19 Virginia Facility SGR Measure



The condition of the Commonwealth's transit facilities is well above the national average, with few SGR issues and most agencies reporting sufficient capacity at existing facilities.

Figure 57: FY19 Facility Condition by Mode

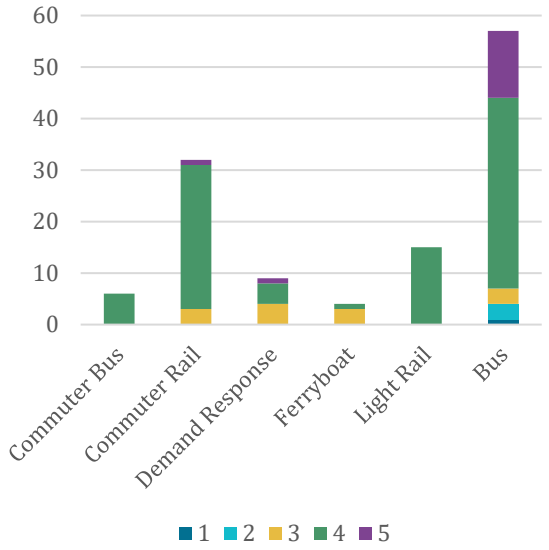
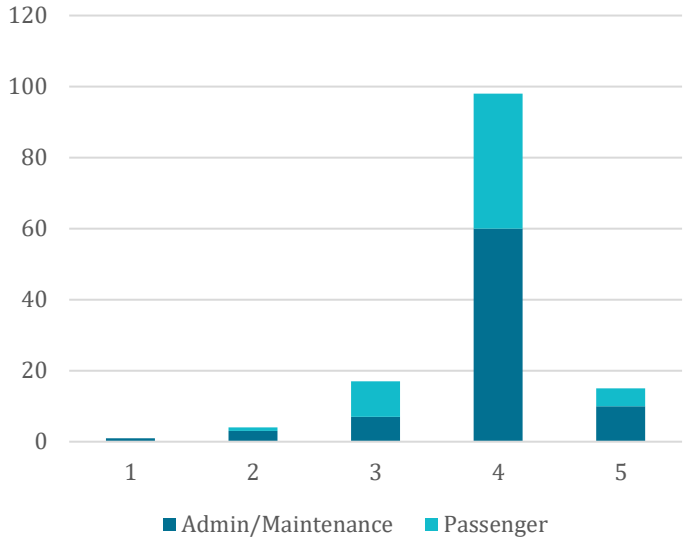


Figure 58: FY19 Facility Condition by Use



By mode, only bus has facilities with a condition below a 3, while commuter bus and light rail have all facilities above 3. There is no significant difference in the assessed conditions of facilities that are passenger-facing or used for administrative or maintenance purposes, with similar proportions of each being assessed at each condition level. By transect, the only facilities assessed with a condition below 3 serve fixed-route agencies.

Table 22: Facilities reported with condition below 3 based on NTD FY2019 Reporting

Transect	Mode	Use	Facilities with Condition Below 3
Fixed Route	Bus	Admin/Maintenance	3
Fixed Route	Bus	Passenger	1
Enhanced Fixed Route	Bus	Admin/Maintenance	1

The facilities being reported as having a condition below 3 in data from the NTD are listed above. All five of the facilities serve bus services and three are administrative or maintenance buildings. While only five facilities are not in SGR, these facilities tend to be in agencies serving communities with higher average VPI, or more vulnerable populations. Four of the facilities are from agencies with an average VPI higher than the average for Virginia agencies.

Bus Lanes and Rail Lines

Table 23 and **Table 24** summarize NTD data reported in FY2019 for bus and rail guideway operated by transit agencies in Virginia (excluding those operated by WMATA). Based on the NTD data on bus guideway, the City of Alexandria and GRTC are reporting the operation of BRT-type bus services, while Fairfax County, Hampton Roads Transit (HRT), and the Potomac and Rappahannock Transportation Commission (PRTC) operate their fixed-route and/or commuter bus services on high-occupancy toll (HOT) lanes on the interstate highway

system. The lane miles of bus guideway reported to NTD since 2017 have remained unchanged across most agencies; only GRTC has added bus guideway since 2017, with the opening of the Pulse BRT service in 2018.

Table 23: Bus Guideways in Virginia based on NTD FY2019 Reporting

Agency Name	Element	Mode(s)	Lane Miles
City of Alexandria	Controlled Access High Intensity Busway	MB	3.7
Fairfax County	Controlled Access High Intensity Busway – Non-BRT	MB	34.8
GRTC	Controlled Access High Intensity Busway	RB	7.6
HRT	Controlled Access High Intensity Busway – Non-BRT	CB, MB	72.8
PRTC	Controlled Access High Intensity Busway – Non-BRT	CB, MB	74.7

Anecdotally, there is a growing interest in implementation of enhanced bus infrastructure to provide BRT-type service across the Commonwealth. However, many of the roadways that these systems are proposing would not be owned or maintained by transit agencies, which could lead to limited reporting to the NTD and DRPT's TransAM system. The lack of consistent capture of information on bus lanes or high-intensity busways would make tracking of bus and rail guideway information challenging, should agencies continue pursuing expansion of enhanced service infrastructure.

Consequently, there is an opportunity for DRPT to establish processes or practices to capture more data consistently and understand trends in implementation and performance of bus or rail guideways if there is a desire to support their use or development statewide.

In terms of rail guideways, the rail infrastructure for HRT light rail and Virginia Railway Express (VRE) commuter rail systems have been reported to the NTD. It should be noted that the rail guideway that VRE operates on is currently owned by a third party. HRT's light rail began service in 2011 and is the only growth in rail guideway across the Commonwealth in recent years. Although no other significant expansion in the Commonwealth's rail system has occurred in the recent past, the Commonwealth is currently implementing Transforming Rail in Virginia as a major intercity program that will benefit VRE with increased state-owned rail infrastructure that should improve reliability and speed of service.

Table 24: Rail Guideways in Virginia based on NTD FY2019 Reporting

Agency Name	Element	Mode(s)	Track Miles
HRT	Revenue Track	LR	14.5
VRE	Revenue Track – No Capital Replacement Responsibility	CR	189.4

SGR/Reliability

FTA defines the measure of SGR for infrastructure as the percentage of directional route miles (DRM) under speed restriction or slow order as of 9:00 a.m. on the first Wednesday of each month, averaged over 12 months of the year. Speed restrictions do impact the reliability of rail systems, among other factors contribute to overall system performance. This measure is necessarily narrow in terms of the timing of measurement, as speed restrictions change regularly on a rail line, so pinning down a consistent way to average the impact of them is difficult.

VRE and HRT both reported 0 DRM under speed restriction for FY19. Given that VRE's track is reported as all being built before 1930 and HRT's track was all built after 2010, it's unlikely that the SGR is equivalent between the systems. The HRT system has yet to go through significant renewal, while VRE's segments of track are undergoing capital maintenance on a regular basis through CSX, NS, and Amtrak.

This measure is not collected for bus guideway, as slow zones are not applicable to bus lanes. There is no standard measure for the performance or SGR of bus guideway, other than reporting on the condition or age of the pavement compared to the useful life. There also is no standard measure for the reliability of bus lanes, though improved reliability of bus service that utilize them can be calculated.

Given that TransAM (see section below) does not collect data on the condition, age, or expected useful life of bus lanes or rail lines, it is difficult to determine the SGR for these assets across the state. Since wear and tear on linear assets can vary significantly based on the total load carried over time, it may be difficult to set expected useful lives consistently; however, planning for system renewal is generally based on a useful life for tangent and curved sections and inspections for wear to validate the need.

BEST PRACTICE EXAMPLE: BUS GUIDEWAY RELIABILITY

As part of an FTA requirement, the **Maryland Department of Transportation Maryland Transit Administration (MDOT MTA)** determined the efficacy of new bus lanes by conducting a before-and-after study of bus movements. This was performed by using automatic vehicle location (AVL) data that tracks the arrival time of each bus at every stop along its route. Travel times between stops was compared before and after the installation of the red bus lanes as well as considerations for increased ridership and travel time distribution to better understand reliability and consistency of the buses traveling through the dedicated bus lane corridors in Baltimore. This study proved a more reliable bus service and better rider experience. Baltimore plans to install more bus lanes in the future.

There is an opportunity for DRPT to gather more data and standardize methods for planning SGR renewal or replacement of linear assets.

Bus Stop and Amenities

Growth

Table 25 summarizes the number of transit agencies in the Commonwealth that fall under each transect and the number of transit agencies under each transect that operate bus stops. The total number of transit agencies assumed to operate bus stops under this analysis is 36, which excludes agencies that fall under the demand response transect and VRE (operates rail only).

Table 25: Number of Virginia Agencies in each Transect and with Bus Stops

Transect	# of Applicable Transit Agencies*	# of Applicable Transit Agencies with Bus Stops
Enhanced Fixed Route	9	8
Fixed Route	28	28
Demand Response	2	0

**Does not include WMATA*

As bus stops are not reported to FTA, nor are they uploaded in DRPT's TransAM system, there is no historical data source for determining growth over time; but, given the increase in fleet and dedicated bus lanes during the past decade, it is reasonable to assume that there are more bus stops in Virginia today than 10 years ago.

However, based on the most recent LRTPs across the Commonwealth, 11 of 15 MPOs explicitly referenced needing to increase bus stops and/or amenities at bus stops (i.e., shelters and benches).

For the five enhanced fixed-route transit agencies where bus stops and amenities (with focus on shelters and benches) data were available, the data review also revealed some inconsistencies. In particular, there seems to be significant discrepancies in the bus stop numbers between the General Transit Feed Specification (GTFS) and the GIS sources for some agencies evaluated in **Table 26.** Understanding the source of these discrepancies and verifying the correct datasets for analysis will be critical to any future analysis of equitable distribution of stops and amenities.

Even with the noted discrepancies, the available data indicates that there is a consistently low percentage of stops with amenities (**Table 27**). It must be noted that only enhanced fixed-route transect data is available for this analysis, so this result may not be representative of other transects.

Table 26: Bus Stops and Amenities for 5 Agencies with Available Data

	GTFS Data	GIS Data			Other Data Sources*		
Agency	Bus Stops	Bus Stops	Shelters	Benches	Bus Stops	Shelters	Benches
Agency A	621	629	111	58	769	138	204
Agency B	501	1120	283	332	1120	301	251
Agency C	1644	4128	259	423	1620	93	343
Agency D	2710	2810	238	NA	2800	169	169
Agency E	544	547	47	31	NA	87	NA

**Combination of information from TDP/TSP and other data received from agencies*

Table 27: Percentage of Shelters and Benches Relative to Bus Stops for 5 Agencies with Available Data

	GIS Data			Other Data Sources*		
Agency	Bus Stops	Shelters	Benches	Bus Stops	Shelters	Benches
Agency A	629	18%	9%	785	18%	27%
Agency B	1120	25%	30%	1120	27%	22%
Agency C	4128	6%	10%	1620	6%	21%
Agency D	2810	8%	NA	2800	6%	6%
Agency E	547	9%	6%	NA	NA	NA

**Combination of information from TDP/TSP and other data received from agencies*

Accessibility

Of the 36 agencies with bus stops, few agencies can provide comprehensive data to assess the adequacy of their stops in terms of amenities provided, sidewalk or bike lane access, or ADA accessibility. Following the search for publicly available data sources and direct requests for data from agencies, only five agencies had sufficient data available to support analysis of how amenities and sidewalk access are distributed.

Table 28 illustrates how many datasets are available by transect. The data currently available to assess bus stops is not representative of the distribution of agencies across the Commonwealth, as enhanced fixed-route systems are overrepresented and fixed-route systems are significantly underrepresented. The scarcity of data for analyzing the location of amenities, adjacent sidewalks, bike lanes and ADA-features (curb cuts, ramps) at bus stops limits the ability of the Study to draw conclusions about statewide adequacy of infrastructure and equitable distribution for bus stops.

Also note that none of the datasets had clearly defined and understandable ADA data surrounding bus stops.

Table 28: Bus Stop Data Availability by Transect

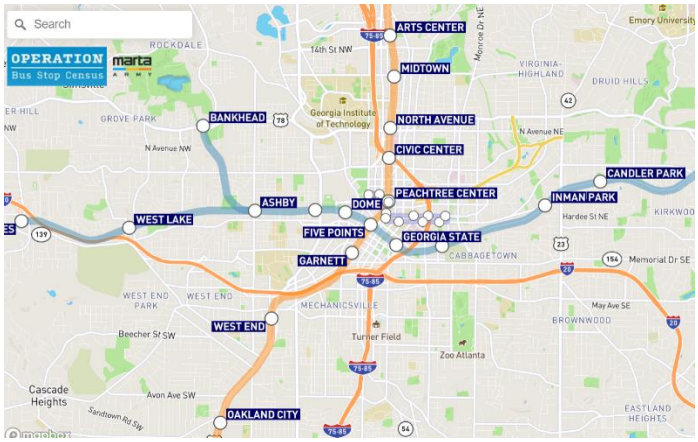
			Agencies with GIS Data Availability				
Transects	NTD Reporter Status	Total Agencies*	Bus Stops	Bench	Shelter	Sidewalk	Bike Lane
Fixed Route	Rural Reporter	13	13	0	1	1	1
Fixed Route	Small Systems Reporter	8	8	0	0	1	1
Fixed Route	Full Reporter	7	7	0	0	2	1
Enhanced Fixed Route	Small Systems Reporter	1	1	0	0	1	1
Enhanced Fixed Route	Full Reporter	8	8	4	5	6	4

** Does not include transit agencies identified under the demand responsive transect and VRE*

Given the importance of bus stop accessibility and amenities to riders, there is a significant opportunity to increase collection and provision of data on bus stop conditions for decision-making purposes. Crowdsourced data collection is one option for tracking stop conditions while maintenance management systems with mobile applications support agency staff data collection.

Best Practices: Bus Stop Data Collection

The **MARTA Army** is a bus advocacy non-profit in Atlanta, GA. This group has coordinated an initiative to crowdsource reporting of bus stop status through a mobile application. The Bus Stop Census application shows stops that have been assessed versus those that still require a survey. Survey questions include whether there is a bench, shelter, trash can, wayfinding, lighting, obstacles to access, and sidewalk access. More than 3,000 bus stops have been surveyed, with incentives like prizes for participation. A local advocate in **Richmond, VA**, also has referenced this approach in "The Bus Stops Here" as a best practice for completing a similar census of GRTC stops, though it was noted that 13 percent of Richmond residents do not have smartphones, so a non-mobile solution may be needed for full coverage. The MARTA Army uses paper surveys as a backup for riders without smartphones.



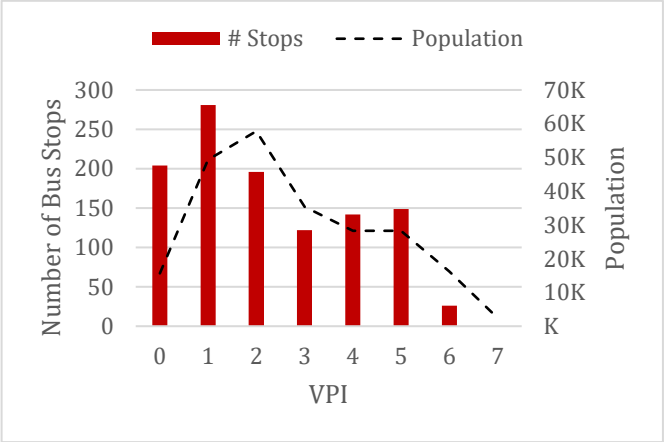
Due to the limitations in the available data, the study team used a couple of agencies where there was sufficient data to run sample analyses to help evaluate equity in access to transit infrastructure across the Commonwealth. The analysis that follows is only an example of understanding two local datasets. To produce a statewide analysis of bus stop conditions, a more representative dataset with consistent attributes is required.

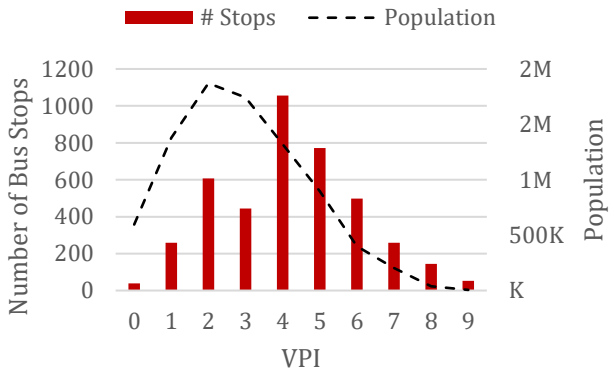
These analyses reviewed the following measures:

- Bus stops (number and location)
- Availability of amenities at these stops (as the example the analysis focused on shelter availability)
- The bus stop's proximity (within 25 feet) to sidewalk
- The robustness of the sidewalk network around the stop (i.e., sidewalk availability)

These data were mapped on the VPI at a US Census Tract Block Group level to evaluate if there are any significant correlations between the availability of infrastructure and vulnerable populations. It is important to note that these are linear correlations and not multivariate regression results, which would provide more robust analysis of how the different variables are related to each other and which are significant. Multivariate regression may be warranted when a more comprehensive dataset is available for the Commonwealth.

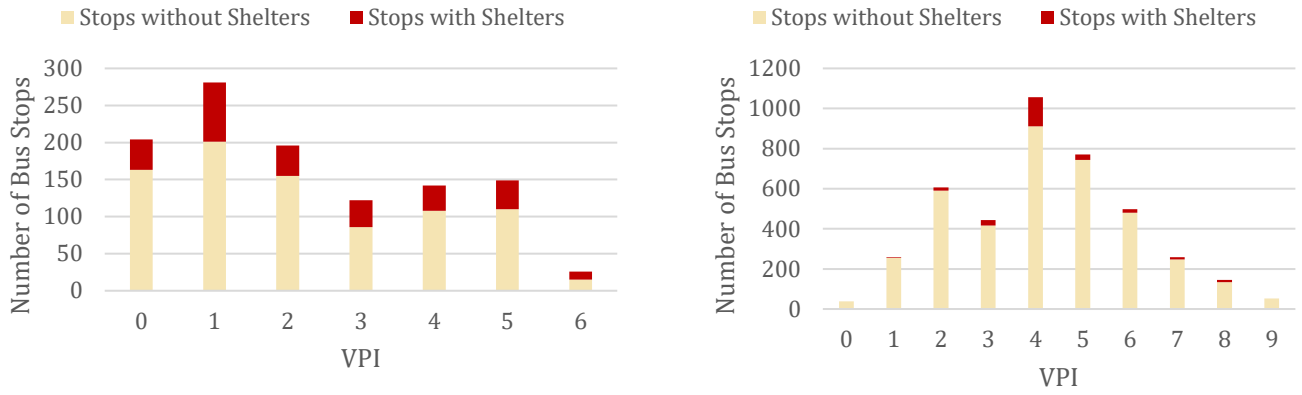
Figure 59: Sample Analysis of Stop Locations by VPI for Two Enhanced Fixed Route Agencies





In terms of the number of stops related to US Census Tract Block Groups, the strongest correlation in the data is between the number of stops and the population of the Block Group. Stops increase as population increases in both examples (r = 0.73 and 0.55, respectively). In both areas there also is a moderate-to-strong negative correlation between population and VPI, with lower population numbers in more vulnerable areas (r = -0.56 and -0.72, respectively). Please note, for the agency on the left, there are no bus stops in the Block Group with a VPI score of 7, though there is a very small population there.

Figure 60: Sample Analysis of Stops with Shelters by VPI for Two Enhanced Fixed Route Agencies



In terms of the distribution of shelters at bus stops, the agency on the left displays a strong positive correlation between the percentage of shelters available at bus stop and VPI (r = 0.67). This indicates a greater relative distribution of shelters in more vulnerable areas. The agency on the right has almost no correlation between the percentage of shelters and VPI (r = 0.15). It is unclear how the policies of these two agencies affect these results, but it is important to note that the agency on the left has a higher overall percentage of stops with shelters than the agency on the left, while the agency on the left is serving a broader range of VPI scores in their service area.

In any case, the results of amenities analysis are distinctly different for the two agencies even though they are both enhanced fixed-route operators, illustrating that local policies, partnerships, and funding likely have a large impact on these results. For statewide analysis, a comprehensive dataset must be available which allows for controlling external variables to determine what is driving distribution of amenities.

Based on feedback from transit agencies on a survey, only about a quarter of the agencies seem to provide ADA-compliant, basic amenities at all of their bus stops. Anecdotally, based on survey responses and review of the LRTPs and TDPs/TSPs, the lack of consistent or standardized policy and/or guidance on bus stop designs, the lack of ownership of or access to right-of-way, and lack of funds seem to be the major inhibitors to a greater number of ADA-compliant bus stops with adequate amenities.

Some of the transit agencies in the Commonwealth do have bus stop design guidelines or ADA policies but many do not. There is no federal guidance on bus stop design for ADA. Furthermore, among those with existing guidance, there are differences in standards across agencies in terms of minimum or basic requirements for bus stop amenities and ADA-compliant design elements, and when or where certain amenities should be used at certain bus stops. For instance, ridership (e.g., daily boardings or alightings) seems to be a common way to measure if bus stops require certain amenities for many design guidance; however, what amenities or design elements are required for different levels of ridership differs among agencies. Anecdotally, some transit agencies also have questioned whether ridership should be the metric used to determine basic amenities present at a bus stop or if agencies should involve safety and security considerations (e.g., lighting in an area) more as part of the standard process to include amenities at bus stops.

Best Practice Example: Bus Stop Amenities and ADA-Compliant Design

WMATA developed and uses the ***Guidelines for the Design and Placement of Transit Stops*** to provide WMATA and its jurisdictional partners specific physical design criteria to be integrated with local comprehensive plan policies, land use ordinances, pedestrian plans, and street design guidelines. Design criteria and requirements are provided for elements including bus stop signs and signposts, information or map cases, lighting, ADA-compliant landing pad or passenger waiting areas, benches, shelters, and trash receptacles.

WMATA also developed the ***Bus Stop Amenity Reference Guide*** to further provide guidance for agencies, jurisdictions, developers, and property owners regarding amenities provided at bus stops served by WMATA Metrobus to improve the bus customer experience at bus stops, which are for the most part not owned and managed by WMATA.

Similarly, although there is a federal ADA design guidance that agencies should comply with in theory, there is some room for interpretation in terms of minimal design requirements for bus stop elements (i.e., landing area, clear paths, signage height, and/or curb or platform height) and guidance or requirements in the retrofit of older infrastructure that make implementation of ADA-compliant transit infrastructure across an area difficult or inconsistent.

Furthermore, some agencies provided feedback that even though they have policies or guidelines requiring specific amenities or design elements for certain types of bus stops, the jurisdiction that owns the property or right-of-way where the bus stop is located (e.g., city, county, VDOT, or private developers) may not have policies or requirements for transit design. With transit agencies not being able to enforce their design guidelines, the actual implementation of standards for bus stops become difficult or inconsistent.

There is an opportunity for DRPT to expand or supplement their Multimodal System Design Guidelines to include more detailed policy or guidance on bus stop design or development that transit agencies can use as a basis to develop their own guidelines (including specific and standardized minimum design requirements) and provide guidance on best practices to coordinate or form partnerships with right-of-way owners to allow actual implementation of the guidelines.

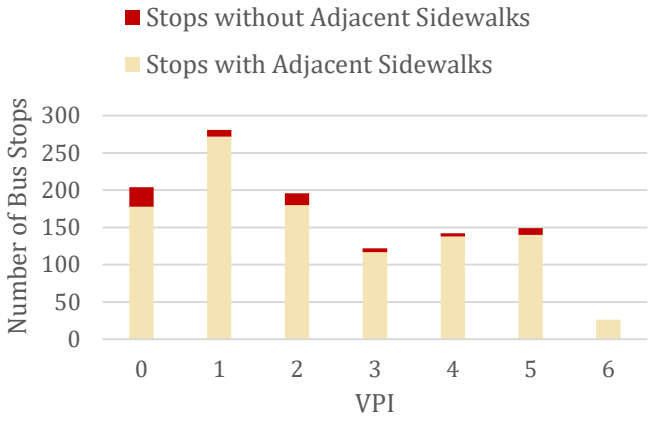
Multimodal Connections to Bus Stops

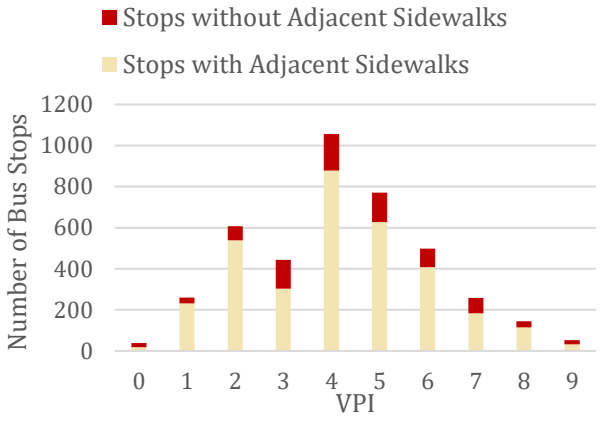
Based on the survey feedback from transit agencies, only 21 percent of Virginia agencies stated that their bus stops are well connected to pedestrian and bicycle infrastructure. Out of those agencies that responded that bus stops were connected to pedestrian infrastructure, approximately half (about 13 agencies) stated that only about 50 percent of their stops are located adjacent to sidewalks. Out of the agencies that responded that their stops are connected to bicycle infrastructure, 15 out of 19 agencies stated that less than 30 percent of their stops are adjacent to bicycle lanes or trails. These responses illustrate that even those agencies that view their bus stops as well connected do not have multimodal access to a majority of their stops.

In terms of sidewalk access to bus stops, for the two example agencies below there is a much higher proportion of stops with adjacent sidewalks than those with shelters. In fact, a majority of stops have a sidewalk within 25 feet of the stop location for these two agencies, indicating that they may not be representative of most of the Commonwealth's transit agencies.

Approximately 21 percent of Virginia transit agencies responded that their bus stops are well connected to pedestrian and bicycle infrastructure.

Figure 61: Sample Analysis of Stops Adjacent (within 25') to Sidewalks by VPI for Two Enhanced Fixed Route Agencies



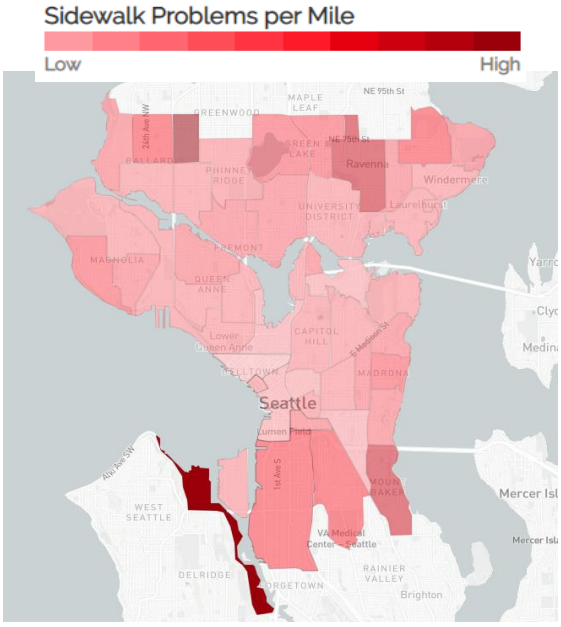


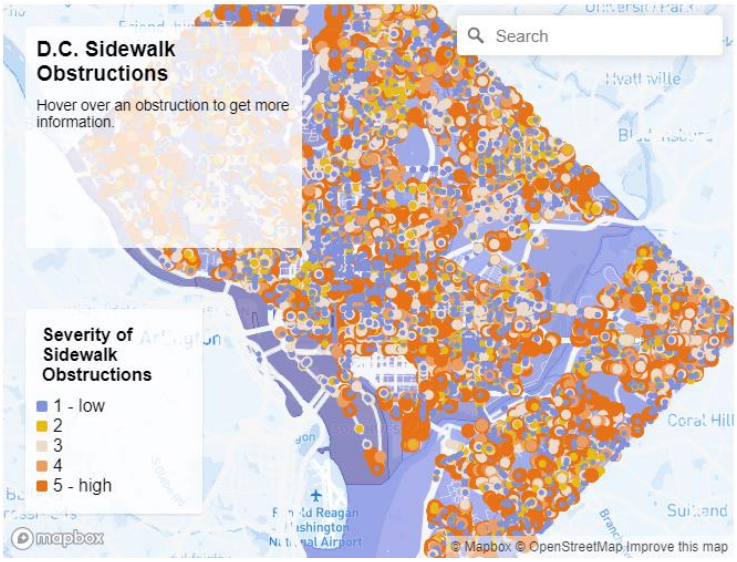
Again, the agency on the left shows a strong positive relationship between the percentage of bus stops with sidewalk access and VPI scores, with greater access in more vulnerable areas (r = 0.70). The agency on the right shows no relationship between sidewalk access at stops and VPI.

As noted above, the different results for these agencies indicates a need for broader analysis of factors and also more agency data to create a representative dataset for the Commonwealth.

Best Practice Example: Sidewalk Data Collection

Project Sidewalk, run by the University of Washington, is a *crowdsourced data collection website* and tool that allows people to remotely label pedestrian-related accessibility problems by virtually walking through city streets in Google Street View. Users can label missing ramps, obstacles, poor surfaces, and missing sidewalks and rate severity on a 1-to-5 scale. The pilot was deployed in Washington, DC, and is now active in multiple cities, including Seattle, Columbus, and Mexico City. All of Seattle's 987+ miles of streets have been mapped, with results showing the areas where pedestrian accessibility is a significant problem.



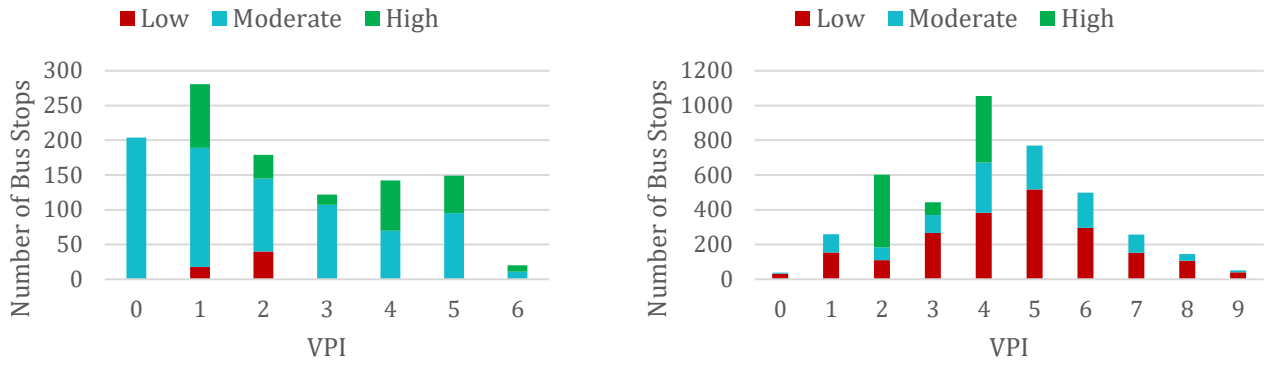


Anecdotally, the review of LRTPs generally reveals that sidewalks and bicycle infrastructure are generally concentrated around denser central business district (CBD) areas, older residential neighborhoods, and near schools or downtowns of rural areas; however, outside these denser areas, small percentages of roadways are generally equipped with sidewalks or bicycle infrastructure.

Even in areas where there are proactive efforts to increase sidewalk and bicycle infrastructure through new development rules, the overall area or regional network (i.e., outside development) generally have major gaps and lacks a consistent framework where infrastructure is built in locations with limited practical use. As such, both sidewalks and bicycle infrastructure networks tend to be more fragmented outside these denser areas and there is a real challenge connecting communities by walking or cycling.

Furthermore, the LRTP review suggest that there are major room for improvement for both sidewalks and bicycle infrastructure across the Commonwealth of Virginia; generally, there are very little investments in bicycle infrastructure along roadways, especially when considering that much of the existing bicycle infrastructure are present in form of sharrows, which have been acknowledged by several MPOs as not the safest or most comfortable facility for cyclists. Supporting this lack of investment in bicycle facilities, an example from Central Virginia presented that for approximately for every mile of sidewalk there are about 7.5 miles of roadway but for every mile of designated bicycle lanes there are more than 99 miles of roadway.

Figure 62: Sample Analysis of Stop Location Relative to Sidewalk Availability by VPI for Two Enhanced Fixed Route Agencies



The general availability of sidewalks also was assessed, as many agencies and MPOs in the Commonwealth have noted the pedestrian networks are often disconnected. This measure, in **Figure 62,** compares the distance of sidewalks to the distance of roadways surrounding bus stops to determine how well connected the pedestrian network is. The sidewalk availability measure was calculated by measuring the distance of roadway centerline available within a US Census Tract Block Group and if that length of roadway had sidewalks on both sides through the entire length, the sidewalk availability measure was calculated to be 100 percent.

For this measure of sidewalk availability, both agencies were grouped into low (0 to 33 percent), medium (33 to 67 percent), and high (+67 percent) groups. As shown above, the agency on the right only has *high* sidewalk availability or connectedness in three VPI areas at the lower end of the vulnerability spectrum (2, 3, and 4); however, the correlation between sidewalk availability and VPI across all Block Groups is weak (r=-0.31). For the agency on the left, the opposite relationship exists with a weak positive correlation (r = 0.32) between sidewalk availability and VPI, indicating more sidewalk coverage in more vulnerable areas.

Many transit agencies indicated that lack of funding is a major barrier to implementing plans to improve multimodal connection to bus stops. However, survey feedback also indicates that even if there is additional funding to improve multimodal connections to bus stops, lack of access to the right-of-way where bus stops are often placed and lack of general policy framework or guidance that agencies can use to facilitate coordination with jurisdictional partners are still challenges to implementing plans to improve multimodal connection.

BEST PRACTICE EXAMPLE: MULTIMODAL INVESTMENTS

The **Federal Highway Administration's** *Strategies for Accelerating Multimodal Project Delivery* advocates for implementing a project scoring process that includes criteria specific to bicycle and pedestrian projects or that weighs infrastructure projects that include multimodal elements differently than those that do not.

In **Memphis, TN**, the criteria for awarding funding through the region's Surface Transportation Program explicitly awards points for infrastructure projects that include a shared-use path or cycle track.

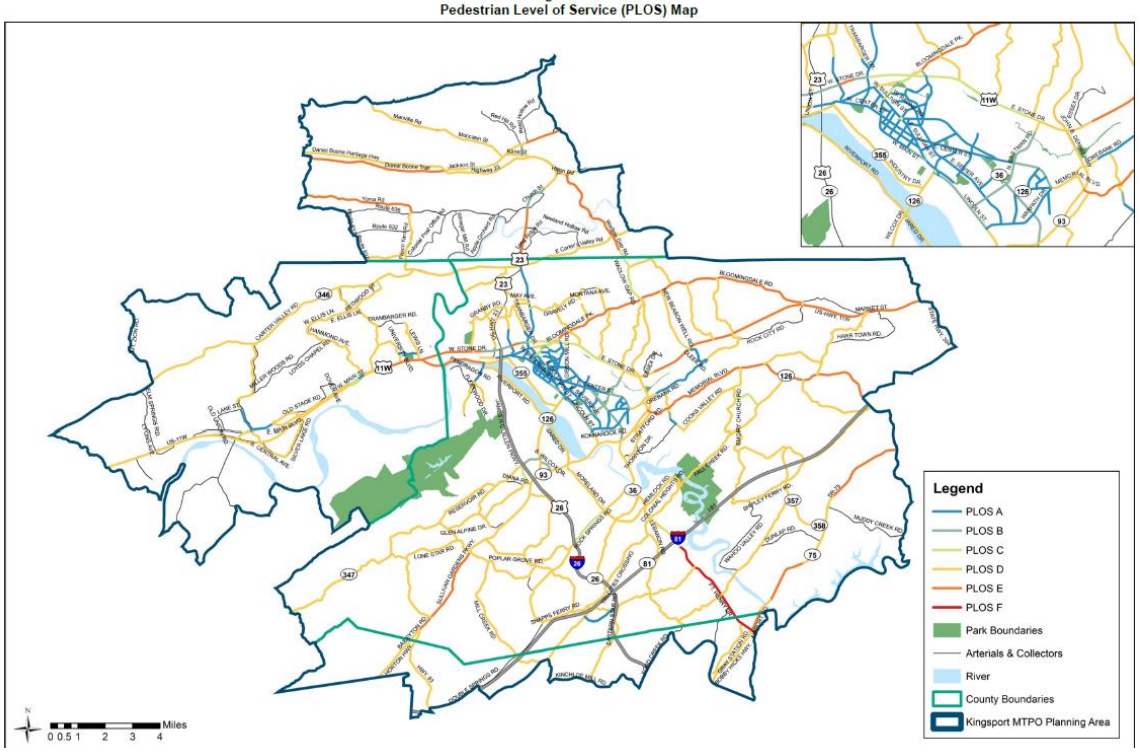
SGR/Reliability

As bus stops are not reported as facilities to FTA, there is no publicly available data on bus stop conditions. Condition can be collected as part of maintenance staff or crowdsourced efforts, though cleanliness is more often recorded than actual condition. Many agencies have customer reporting portals that allow riders to log issues at stops, such as broken benches or missing trash cans. That data often is used to send out maintenance crews and identify areas with persistent issues.

Best Practice Example: Understanding Bike/Ped Levels of Service

Kingsport MPO provides an analysis for pedestrian and bicycle level of service (LOS) in their LRTP. These maps are compared to levels of demand for nonmotorized trips to determine where there are priority gaps in the network of sidewalks and bicycle facilities.

Figure 4-16
Pedestrian Level of Service (PLOS) Map



Best Practice Example: Bus Stop Conditions

HRT collects bus stop condition data using an in-house-developed mobile application. The app allows staff to record the following data points in the field:

- Stop number
- Route number(s)
- Stop description
- Cleanliness
- Condition (using FTA's 1-to-5 scale)
- Accessibility (on a 1-to-3 scale)
- Amenities
- Location details (lat/long, city, etc.)
- Date of assessment

This database then allows HRT to look at the conditions of all bus stops over time, as they are reassessed periodically.

Statewide Planning for Infrastructure

TransAM

In 2012 US Congress passed the Moving Ahead for Progress in the 21st Century Act, MAP-21, which is a funding and authorization bill to govern federal surface transportation spending. As part of MAP-21, the FTA developed the TAM rule that applies to all transit providers that are recipients or subrecipients of Federal financial assistance under 49 U.S.C. Chapter 53 and own, operate, or manage transit capital assets used in the provision of public transportation. The final rule came into effect in 2017 with initial reporting requirements in place in 2018. The rule request that all Tier I transit providers, those that operate rail, or have more than 100 vehicles operated at maximum service (VOMS) across all fixed route modes or one non-fixed route mode, develop a TAM Plan with 9 elements (shown at right). All Tier II operators, which includes 5311 subrecipients and agencies with fewer than 101 VOMS across all fixed route or within on non-fixed route mode, must participate in a group TAM Plan which includes the first 4 TAM Plan elements.

In addition to TAM Plan requirements, the National Transit Database (NTD) reporting requirements were updated to reflect additional inventory and condition reporting of assets. The NTD inventory reporting requirements include all revenue and non-revenue vehicles, all facilities and stations, and all guideway and associated systems (train control and electrification). It is notable that the requirements for inventory in a TAM Plan are higher than the requirements for reporting to NTD. Asset Inventory in a TAM Plan should include all assets used in the provision of public transit, including assets that are owned by a third party or shared resources (except for equipment). The inventory must include all non-revenue vehicles, and any other equipment assets over $50,000 in acquisition value. Agencies only need to include condition assessment for assets for which they have direct capital responsibility. Facilities must be visually inspected every 4 years to report conditions to NTD, while other assets require a “condition assessment” for the TAM Plan with no specific guidance on methodology.

In addition, asset performance measures are reported to NTD on an annual basis with performance targets set for the next fiscal year. For a group TAM plan these targets are calculated on the aggregate for all transit agency participants. The following table shows the distinction between what assets must be included in asset inventories and the assets for which transit providers must measure performance.

Asset Class	Types of Assets (Reporting Category)	Asset Inventory Characteristics	Performance Measure	Performance Target
Rolling Stock	Revenue vehicles	Detailed count of vehicles by type, capacity, age; useful life benchmark (ULB) by vehicle type	Percentage of vehicles that have met or exceeded their ULB	One target per vehicle type
Equipment	Service vehicles			
Facility	Passenger stations, parking, administrative and maintenance facilities	Type, location, square footage, and condition rating by individual facility	Percentage of facilities rated below 3 on the TERM scale	One target per facility group
Infrastructure	Rail track	Mileage by type and count of special elements (ex: crossovers, turnouts)	Percentage of track segments, signal, and systems with performance restrictions	One target per mode
	Fixed guideway	Guideway by construction type		
	Substations	# of Structures		
	Signals & power (third rail/catenary)	Note if present		

DRPT, in conjunction with the Pennsylvania Department of Transportation (PennDOT), developed the TransAM system for reporting and tracking transit assets at the state level in 2014. The purpose of TransAM is to provide state agencies the asset data required to support capital reinvestment decision-making and development of group TAM Plans (for Tier II operators). The asset data currently is used to determine when replacement assets should be funded, as well as to forecast SGR needs of the transit providers. Agencies are required to report the following asset categories to TransAM:

- All revenue vehicles purchased or to be replaced with state funding (midlife overhauls that increase the useful life of the asset by 50 percent are to be tracked as well)
- All facilities for which the agency has partial or direct capital responsibility
- Non-revenue vehicles and large equipment worth more than $50,000

TransAM also provides an Infrastructure category for linear assets such as bus guideway, bridges, tunnels, trackwork, and associated rail systems for signaling and power; however, DRPT does not require reporting of infrastructure.

There is no reporting requirement for reporting bus stop amenities or technical support systems, such as fare collection, computer-aided dispatch (CAD)/AVL, closed-circuit television (CCTV), etc. While the components of these support systems may not meet the $50,000 requirement for equipment, the system could be considered in its entirety to be above that threshold.

TransAM allows users to enter critical information for capital needs assessment, such as the service status, expected service life (ESL) or useful life and lifecycle events for assets. Fleet mileage and age are tracked against minimum replacement thresholds set by the state. Other lifecycle policies can include rehabilitation or overhaul which can be set by asset type and subtype.

While users can enter conditions and purchase prices, the condition and cost fields do not appear to be consistently utilized or validated. Some agency self-reported conditions conflict with conditions provided by the group TAM Plan inspection process. In addition, purchase prices for vehicles often conflict with the replacement costs by vehicle type provided by TransAM. The conflict could be caused by changing of technology or the vehicle market itself, though it is not immediately clear which data source is more accurate for a novice user. Discrepancies in purchase price and replacement cost were previously identified by DRPT and updates have been made in FY2021 to how replacement cost is calculated (to represent inflated purchase price). However, there is still no quality control performed on agency-entered purchase prices.

Best Practice Example: Statewide Asset Data Reporting and Prioritization

All 56 transit grantees in downstate Illinois submit asset inventory annually to the Capital Needs Assessment (CNA). Reporting of all vehicles, facilities, major facility components, intelligent transportation systems (ITS)/systems, infrastructure, and equipment more than $3,500 is required along with agency determined useful lives. Agency plans for replacement and rehabilitation of assets is included in the model, along with needs predicted based purely on age, mileage, and useful life/mileage thresholds for replacement. Double counting of needs is eliminated by comparing agency plans to the modelled forecast. The CNA model prioritizes SGR needs for submitted assets based on asset condition, safety impact, service reliability impact, and operations and maintenance (O&M) cost impact. The SGR score calculated through the CNA is directly included in the **Illinois Department of Transportation (IDOT)** grant application process. In addition, IDOT incentivizes reporting of assets to the CNA by including a "planning criterion" in scoring where agencies receive 2 additional points for needs submitted through the CNA process prior to grant submittal.

Finally, TransAM has the functionality to collect key data points for supporting further equity analysis. Latitude and longitude are collected for facilities but also could be applied to other asset categories to allow DRPT to map transit assets to their communities. The field for ADA compliance for vehicles and facilities also would help DRPT understand what areas require additional support/investment to make transit more accessible. This field should be required for all relevant asset types. Finally, the use of lifecycle policy tables could be applied to more asset types within the tool to help DRPT predict capital needs for a larger set of transit assets. Currently, only fleet policies are applied to determine replacement needs based on the state-standard ESLs. More asset types can have ESLs applied to give DRPT a ballpark for the level of unconstrained capital funding necessary to keep transit assets in SGR.

Collecting data on infrastructure, bus stop amenities, and critical transit support systems could improve reinvestment decisions related to the MERIT process described in the following section, in conjunction with completing/validating key data fields for existing data or improving audit processes.

MERIT – Captial Assistance Program

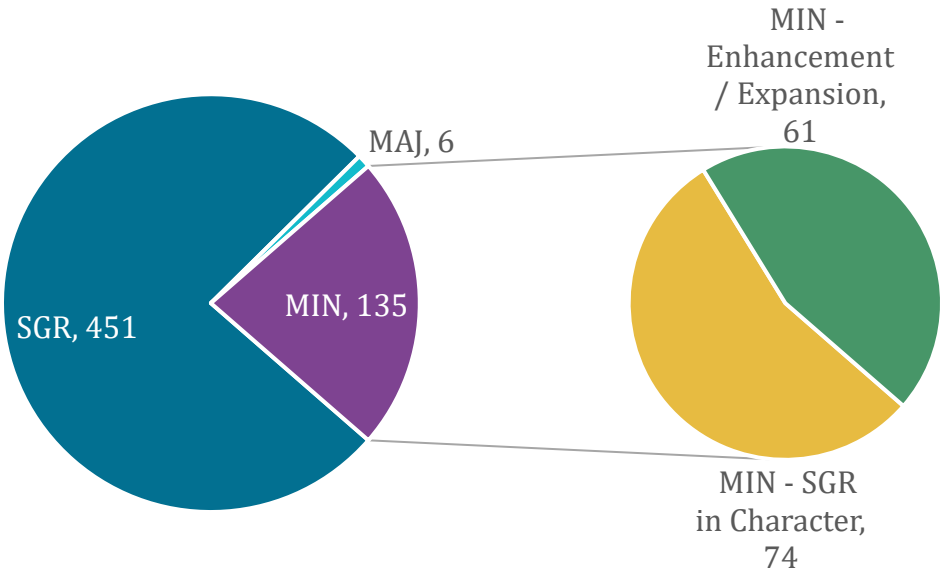
The MERIT (Making Efficient + Responsible Investments in Transit) - Capital Assistance Program provides a process for prioritizing the allocation of DRPT Capital Assistance funds. The MERIT process was implemented by DRPT in Fiscal Year 2020 to standardize allocation decisions and, in part, to address the issues noted above regarding consistent data and reporting from transit agencies. As the process has evolved and matured it has helped transit agencies improve the data available and DRPT's understanding of transit infrastructure needs. The MERIT process is DRPT's primary mechanism for influencing investments in transit infrastructure in the Commonwealth.

There are three categories for capital needs submissions:

1. State of Good Repair (SGR): Projects or programs to replace or rehabilitate an existing asse
2. Minor Enhancement (MIN): Projects or programs to add capacity, new technology, or a customer facility and meet the following criteria:
    a. Total project cost: less than $2 million; or
    b. Vehicle expansion of no more than five vehicles or 5 percent of the existing fleet size, whichever is greater
    c. Note: Increases in paratransit fleets to meet increasing service demands will be evaluated in the same manner as Minor Enhancements
3. Major Expansion (MAJ): Projects or programs to add, expand, or improve service with a cost exceeding $2 million or, for expansion vehicles, an increase of greater than five vehicles or 5 percent of fleet size, whichever is greater

Most projects submitted to the process are evaluated as either SGR or MIN. Existing transit infrastructure is submitted as SGR, though many projects submitted as SGR end up being assessed as MIN due to a lack of data on the existing asset, as shown in **Figure 63**. If an existing asset record is not available, with an age and ESL, the project cannot be scored as SGR and is moved into the MIN scoring process. Asset records in TransAM support this process, but as infrastructure, bus stop amenities, and support systems are not required reporting, the data submitted on these needs tends to be incomplete.

Figure 63: FY22 MERIT Evaluated Projects



As shown below, 60 out of 100 points for an SGR project are associated with the Age of the asset (as percent of useful life) and Mileage (for vehicles only). Under this scoring approach, assets that have surpassed their state approved ESL are prioritized, with the furthest beyond ESL given highest priority.

For MIN projects, the only scoring criteria is Service Impact with a total of 40 points. There are four sub-criteria under Service Impact that can each receive up to 10 points:

- Service Frequency, Travel Time, and Reliability
- Efficiency
- Service Accessibility and/or Customer Experience
- Safety and Security

Figure 64: SGR Project Scoring

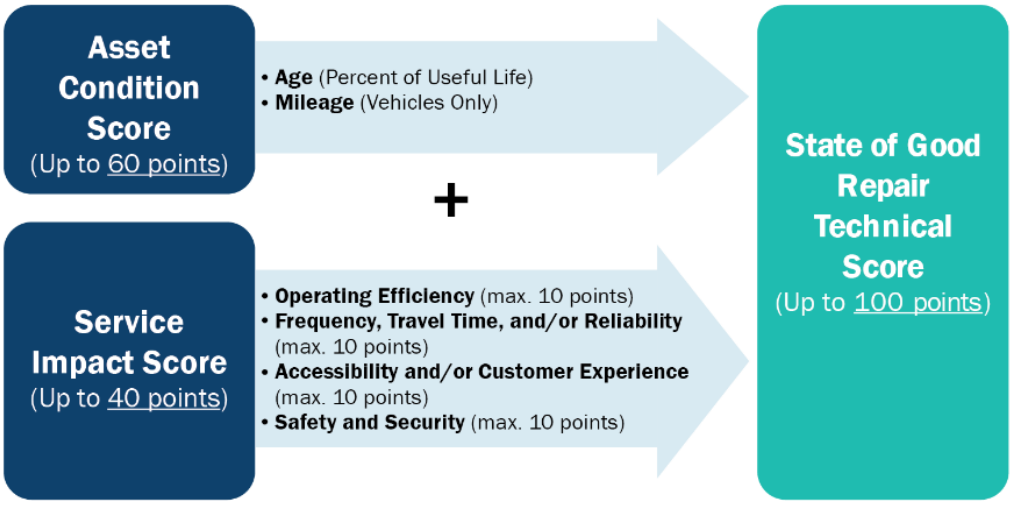
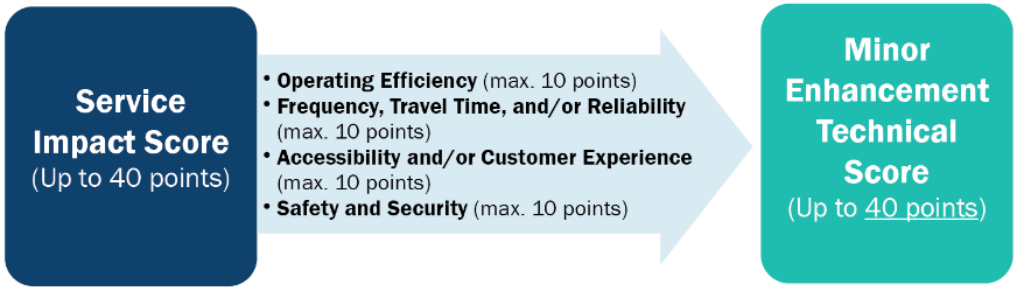


Figure 65: MIN Project Scoring



Given that many SGR projects do not have the asset data required to be scored on Asset Condition, it is critical to understand the Service Impact scoring for directing funds to transit infrastructure that may not be adequate. Points are assigned to projects based on their project type (or asset type) shown in **Figure 66** with points initially assigned based on the default rating for each criterion:

- High = 8
- Medium = 5
- Low = 2
- No Impact = 0

The scoring for Service Impact is assigned by very high-level asset categories, only 12 options, which may not illustrate the differing importance of underlying asset types. For example, there is one category called "Maintenance/ Administrative Facilities - All", which assigns a baseline score to any project related to a maintenance or administrative facility. In reality, a maintenance facility may have a larger impact on reliability and customer experience than an administrative facility—particularly if that administrative facility does not include customer-facing services. Similarly, the category of System Infrastructure could include a wide variety of systems (signals or power) and linear infrastructure with a high impact on Safety and Security outcomes.

DRPT can improve the existing MERIT scoring process to account for the variable impacts of asset types on these criteria. The Transit Service Delivery Advisory Committee (TSDAC) was created under VA Code § 33.2-214.4 (2020) to advise DRPT on the process for the distribution of capital and operating funds, with formal representation from the Virginia Transit Association, the Community Transportation Association of Virginia, the Virginia Municipal League, the Virginia Association of Counties, and three members appointed by the Director of DRPT. TSDAC should be engaged in the improvements to MERIT criteria to ensure buy-in from transit agencies and local government representation.

Figure 66: Baseline Service Impact Scoring by Project Type

Primary Project Types	Secondary Project Types	Operating Efficiency	Frequency, Travel Time and/or Reliability	Accessibility and/or Customer Experience	Safety and Security
Admin/Maintenance Facilities	All	Medium Impact	Medium Impact	Low Impact	Medium Impact
Customer Facilities	Bus Stop/ Shelter Improvements	Low Impact	No Impact	High Impact	Medium Impact
Customer Facilities	Transit Centers/Stations	Medium Impact	Medium Impact	High Impact	Medium Impact
Maintenance Equipment & Parts	All	Medium Impact	Medium Impact	Medium Impact	High Impact
System Infrastructure	All	High Impact	Medium Impact	Medium Impact	Medium Impact
Technology/Equipment	Administrative	Low Impact	Low Impact	Low Impact	Low Impact
Technology/Equipment	Operations Support	Medium Impact	Medium Impact	Medium Impact	Medium Impact
Technology/Equipment	Onboard Systems—ITS/Communications	Medium Impact	Medium Impact	High Impact	Medium Impact
Technology/Equipment	Onboard Systems—Safety	No Impact	No Impact	Medium Impact	High Impact
Vehicles	Revenue Vehicles	High Impact	High Impact	High Impact	High Impact
Vehicles	Support Vehicles	Medium Impact	Medium Impact	Low Impact	Low Impact
Vehicles	Overhaul/Engine Replacement	High Impact	High Impact	Medium Impact	High Impact

The maximum score available from the baseline approach is 32 points. The remaining 8 points to reach the maximum of 40 come from Additional Scoring criteria. Additional criteria are shown below in **Figure 67.**

Figure 67: Service Impact Additional Scoring Considerations

Criteria	Additional Considerations Added to Default Score (Not to Exceed 10 points for Any Criterion)
Operating Efficiency	• Add 1 point for LEED-certified buildings or facilities (reduced facility operating costs). • Add 1 point for Electric or Hybrid Technology vehicles • Add 1 point for expansion buses if the agency spare ratio is below 15%
Service Frequency, Travel Time and Reliability[1]	• Add 1 point if the agency fixed-route on-time performance (OTP) is greater than 80% • Add 1 point if the agency Vehicle Mean Distance between Failures > 10,000 miles
Service Accessibility and Customer Experience	• Add 1 point for investments that add new stops or expand service coverage • Add 1 point for software/hardware to provide real-time arrival information
Safety and Security	• Add 1 point for onboard technology to enhance passenger safety • Add 1 point for improved lighting or other crime prevention features • Add 1 point for pedestrian safety improvements

[1] Measures used for demand responsive service may differ from those used for fixed route, for example, percentage of missed trips could be used in place of on-time performance.

These 8 "additional points" only marginally influence scoring compared to the 32-point baseline from the project type alone. For example, in terms of modernizing existing infrastructure-only LEED certification, electric or hybrid vehicles, and real-time information systems receive credit here and each will receive only 1 additional point.

As environmental, rider comfort, and cost-saving concerns begin to rise, agencies are beginning to think of transitioning to zero-emission buses (ZEBs). Within the agency survey, it was found that three agencies (Blacksburg Transit, DASH, and HRT) currently operate zero-emission transit buses or paratransit vehicles. Other agencies have immediate concerns about this transition, relating to lack of funding, operation impacts, understanding of ZEBs and electrification, and training.

Accessibility to transit infrastructure, including ADA improvements or sidewalk connections, are not explicitly included in the bonus point considerations—though projects can receive 1 additional point for pedestrian safety improvements like the FHWA recommendation noted previously of providing credit to multimodal projects. However, scoring a project with 1 additional point for pedestrian safety may not overcome the baseline scoring of projects where bus stop improvements only receive 15 points on default criteria compared to the 32 points for revenue vehicles.

Equity or a proxy for equity is not currently included in the MERIT scoring considerations, neither in the baseline or the additional criteria.

MERIT scoring is a major opportunity for DRPT to align grant making with the goals of equity and modernization of infrastructure.

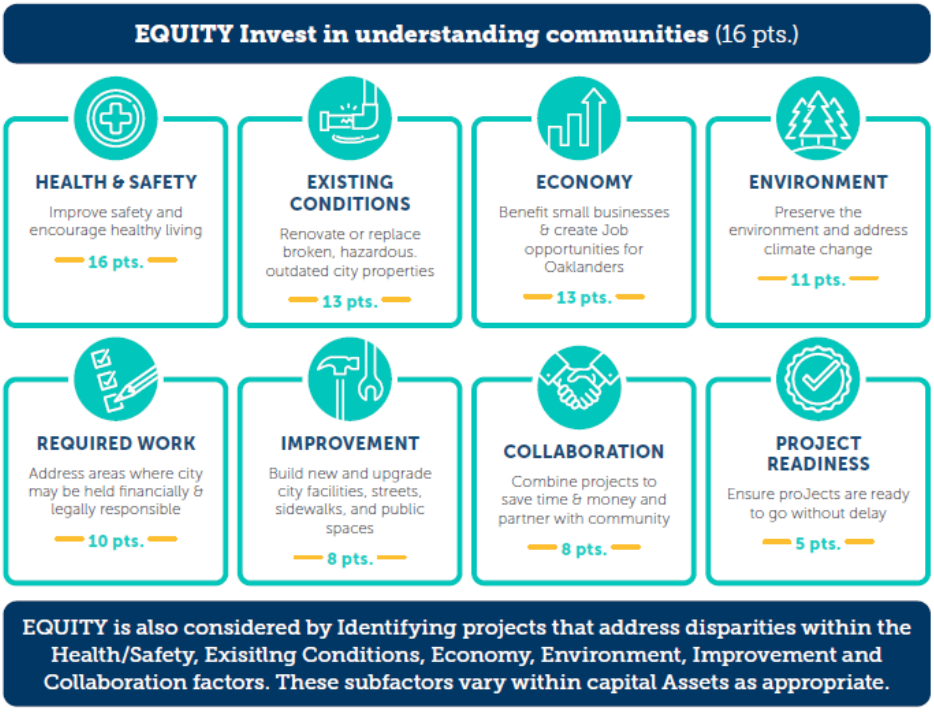
Best Practice Example: Equity in Investment Decision Making

Howard County, MD, has started to use a system based on the Baltimore Metropolitan Council's Vulnerable Population Index (VPI) to track whether certain capital investments are being made in an equitable manner. The VPI is based on seven populations determined to be vulnerable based on federal requirements and regional demographics: Poverty, Non-Hispanic/Non-White, Hispanic, Limited English Proficiency (LEP), Disabled, Elderly, and Carless. Census tracts are compared to the regional mean for each individual population group and scores are aggregated based on how far above the mean they are.

Howard County's Complete Streets Policy includes tracking the percentage of new roadway projects or roadway repairs in priority communities as identified by the VPI. The number of projects or repairs located in vulnerable census tracts are divided by the total number of projects and repairs completed countywide to produce a percentage figure.

Best Practice Examples: Equity in Prioritization Criteria

In 2018, the **City of Oakland**, **CA**, overhauled its capital improvement program (CIP) prioritization process to help ensure community values are reflected in its 2-year CIP. The new, citywide prioritization factors and weighting center on equity, as shown below. Not only are projects scored specifically on whether it is located in an underserved community, but equity is a consideration in other prioritization measures as well. In addition to using equity-centered prioritization criteria, Oakland's Department of Race and Equity is consulted regularly throughout the CIP development process to help ensure the CIP incorporates equity in a manner that is meaningful and aligns with Oakland's objectives.



Similar to Oakland, the **Boston Region MPO** recently updated its Transportation Improvement Program (TIP) criteria to center on equity more explicitly. Under the new scoring criteria, projects receive progressively more points based on the share of equity populations in the project area and the expected impacts of the project. An equity multiplier is applied to each project to help ensure that projects are spread fairly across all areas of the region.

Lawrence, KS, also incorporates equity as a prioritization factor in its CIP. In Lawrence, a project's score in the equity category is based on the following questions: 1) does the proposed project positively impact populations of different incomes, races, education levels, language skills, ages, physical or mental abilities, or other vulnerable population and 2) is the proposed project in a low- or moderate-income area as outlined by the U.S. Department of Housing and Urban Development?

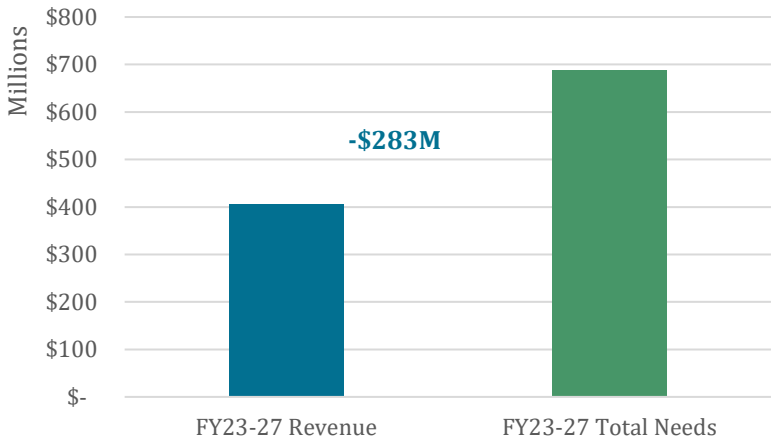
Capital Needs Assessment

From the survey of transit agencies, the top three ways agencies determine where and when transit infrastructure investments are needed include:

- Public input
- Jurisdictional priorities
- Asset lifecycles

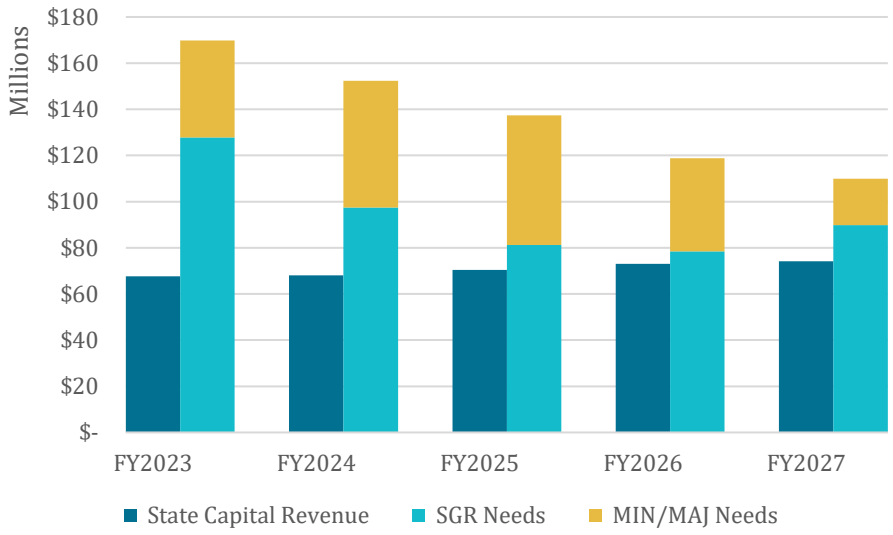
DRPT's FY2022 Six-Year Improvement Program (SYIP) included analysis of all submitted capital needs for FY2022 and the next 5-year budget (FY2023 to FY2027). The capital needs assessment illustrated that there is a gap between capital needs and projected state revenue to support planned projects in the 6-year window of analysis under the current state match rates. Comparing the projected revenues to projected needs, DRPT anticipates a $283 million shortfall in State Capital and State Controlled Federal revenues to fund all projects during the 5 fiscal years included in this analysis.

Figure 68: Projected Funding Gap for Virginia Transit Investment Needs



This funding gap persists if you limit the agency needs to SGR only (including both SGR and MIN projects that are SGR in nature), meaning even reinvesting in existing transit infrastructure will not keep pace with emerging needs. If DRPT were only to consider SGR needs, however, the projected funding gap does shrink to $69.3 million. As seen in **Figure 69**, revenues are much closer to being able to meet SGR needs. Though, the large needs in FY2023 and gap in funding available do indicate an SGR backlog of deferred capital reinvestment needs. If SGR backlogs are not addressed over time, the condition and reliability of transit infrastructure will decline and impact customer experience.

Figure 69: FY2022 SYIP Capital Needs Assessment versus State Capital Revenue



It must be noted that this analysis did not include the contribution of local or federal funding to submitted projects but also did not include projects where agencies may only utilize local funding sources.

The SYIP analysis also is based on needs submitted through the MERIT program, which involves agencies "pre-prioritizing" submissions—meaning this is not an entirely unconstrained needs assessment, as agencies may be submitting only their highest-priority needs to DRPT for funding. A truly unconstrained analysis would consider all transit infrastructure and assets in terms of their lifecycle needs and build the value from upcoming replacements, rehabilitations, and enhancements. The unconstrained needs value, particularly for SGR, is likely higher than what is submitted via MERIT, meaning the funding gap to maintain transit infrastructure and assets in Virginia is likely greater than what is stated here.

Building up unconstrained needs from asset lifecycles for SGR can be accomplished with a more complete statewide inventory and lifecycle policies in TransAM.

It is not currently possible to assess the level of funding gap by agency, to determine if there are any equity concerns related to the funding or submitting of SGR needs. The data required to understanding funding gaps by agency or by VPI is not currently available as it requires individual agency needs compared to agency-level revenue forecasts.

Best Practice Examples: Unconstrained Capital Needs

The **San Francisco Municipal Transportation Agency** (SFMTA) develops an unconstrained 20-Year Capital Plan based on asset management data, which serves as an assessment of SFMTA's expected capital needs during the coming 20 years. This document is used as a guide for developing SFMTA's fiscally constrained CIP annually. While the 20-Year Capital Plan is not updated every year, it serves as a clearing house for all potential capital projects for SFMTA, allowing the agency to keep track of projects that may not have been funded in the CIP.

To track unfunded projects, **New Jersey Transit** publishes an unconstrained financial summary as part of its CIP. For New Jersey Transit, this unconstrained summary is used to help prioritize capital projects in future constrained plans or as additional funding becomes available and is seen as an aspirational document.

Emerging Technologies

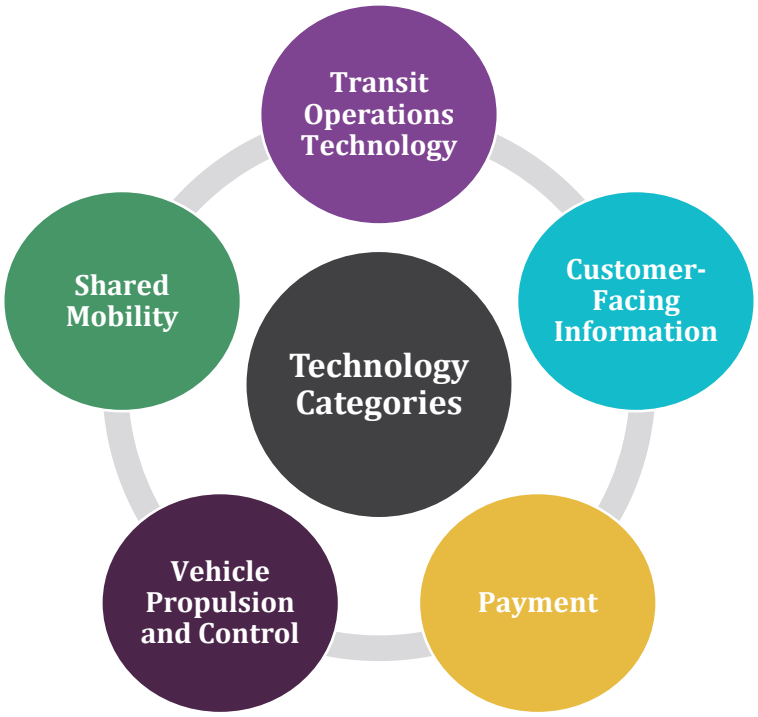
Overview and Definition

The Implementation of Emerging Technology technical area considers innovative technology and technology-enabled services that are or could be deployed by transit agencies in the Commonwealth. Technologies are at various stages of adoption within the transit industry—some are more established and widely used while others are emerging. Given that transit agencies of different sizes or experience with technology implementation may view "emerging" as a relative term, the following definitions are provided based on a technology's maturity and adoption across the transit industry at large:

- **Established Technology**: Refers to proven systems and applications that have been widely implemented by public transportation agencies and are in full use by transit riders
- **Emerging Technology**: Refers to innovative and promising technologies applicable to transit service that are either under conceptual development or limited deployments and are expected to be widely deployed within the next few years

Five main technology categories are identified in **Figure 70.** Each category consists of a variety of technologies—both established and emerging—which are defined and explored in more detail.

Figure 70: Technology Categories



Implementation of Emerging Technology relates to the other technical areas of the study including:

- **Transit Accessibility**: Technology may enhance accessibility, for example through the use of real-time customer-facing information or shared mobility services to expand access. It also can create barriers if reliant on personal technology that is not widely available to customers. Payment technologies are a component of determining fare policies as well.
- **Adequacy of Infrastructure**: Technology systems are transit assets that require continual management and maintenance, similar to physical infrastructure like fleet vehicles and facilities.

- **Electrification**: Electric-drive propulsion systems and associated charging or fueling systems are emerging technologies included in the Vehicle Propulsion and Control technology category.
- **Transit Safety**: Technologies such as cameras, automated customer alerts, and emerging air filtration methods are important tools for transit safety and security.
- **System Engagement and Governance**: Transit agency engagement with the general public can help determine priorities of implementing technology and ensure plans are grounded not only in transit agency needs but also customer needs. Technology adoption in common culture often dictates expectations for transit customers. For example, GPS phone technology enables customers to see transit options in proximity to their current location.

Baseline Conditions

Introduction

The objective of the baseline conditions and opportunities assessment for emerging technology is to answer the following questions:

- What are established and emerging transit technologies?
- What are equity considerations for emerging technologies?
- What are the common and uncommon technologies currently used by transit agencies in Virginia?
- How do agencies in the Commonwealth compare to agencies nationwide with regards to deploying emerging technologies?
- What are the common needs and barriers to implementing emerging technologies?
- What role does the Commonwealth play with testing and deploying emerging technologies?
- What are opportunities to modernize and enhance equitable service delivery with technology?

Methodology

The objective questions above were answered or will be further defined through the course of the study through the following activities paired with input received through the Public Participation Program (e.g., transit agency survey, technical working group [TWG], etc.):

- **Summary of Emerging Transit Technologies:** Develop definitions of established and emerging technologies, organize into five main technology categories, identify key equity considerations, and define the typical deployment status of technologies of agencies nationwide
- **Virginia Deployment Analysis:** Compile an inventory of technologies deployed by transit agencies in Virginia using recently published plans
- **Barriers to Implementation:** Survey transit agencies on common barriers to implementation, supplement with input from TWG (to be done later in study)
- **Available Products and Options:** Develop a list of available and soon-to-be-available technology products (to be done later in study)
- **Opportunity Assessment:** Compare Virginia deployment status with typical nationwide deployment status, survey transit agencies on their interest and needs for technologies, identify potential roles for the Commonwealth (to be refined throughout study)

The following **Analysis Results** section is organized around the five main technology categories. Each subsection contains:

1. Definitions for established and emerging technologies. Established technology definitions are provided in summary tables while more detail and examples are provided for emerging technology definitions.
2. Key equity considerations.

3. A high-level industry assessment to identify the typical deployment status.

   For established technologies, this was done by both transect and service type (fixed route or demand response, as not all technologies are applicable to both). The fixed route transect was segmented by rural reporter and non-rural reporter to provide greater granularity. Adoption of a particular technology in transit agencies depends on the existing infrastructure, funding, and agency resources. As a part of the study, the project team reached out to subject matter experts and assessed adoption of technology in different agencies based on their service area and types. High-level research on vendors and their clients also was conducted to assess the level of adoption amongst various agency types. Industry deployment status was estimated according to the following levels:

   - **Low**: Approximately less than 50 percent of agencies use the technology
   - **Medium**: Approximately 50 to 75 percent of agencies use the technology
   - **High**: Approximately more than 75 percent of agencies use the technology

   For emerging technologies, this was done by service type according to the following levels:

   - **Concept Development**: This category includes technology that is currently being developed by vendors or transit agencies. It includes technology currently in the early stages of their development, which includes demonstrations and proof of concept.
   - **Limited Deployment**: Technology currently in the pilot phase or in live deployment for a short duration (between 12 to 24 months) in a limited number of agencies.
   - **Full/In-Service**: Technology currently in service for more than 24 months; widely used by agencies and their customers but not mainstream adoption.

4. A Virginia deployment analysis was conducted, comparing the technologies used by Virginia transit agencies to the typical industry deployment status by transect and service type. Existing Virginia deployments were identified from a variety of sources including the Statewide Integrated Mobility Plan (Virginia Department of Rail and Public Transportation, 2019), latest available transit development plans or transit strategic plans, or transit agency websites. While comparison to the industry is a valuable baseline, it is still important for transit agencies to consider their unique needs when making decisions on technology implementation.

Finally, summaries of common barriers to implementing technology and areas of needed support are included at the end of the analysis based on input received from Virginia transit agencies via the survey.

Key takeaways from the analysis are then presented in the **Preliminary Findings and Opportunities** section.

Analysis Results

Transit Operations Technology

Definition

Transit operations technologies include a wide range of systems and applications for daily operations. Public transportation providers utilize these technologies to manage operators and vehicles, maintain transit infrastructure, and plan for schedule improvements. While a small number of agencies continue using pen and paper for daily operations tasks, a majority of US agencies have implemented and deployed the established technologies listed in **Table 29**.

Table 29: Established Technologies—Transit Operations Technology

Established Technology	Description
Automatic passenger counter (APC)	Systems that automatically count and report on boarding and alighting passengers
Basic data management processes	Lifecycle of acquisition, management, and utilization of data produced by each technology
Computer-aided dispatch/automated vehicle location (CAD/AVL)	Vehicle tracking and service monitoring enabled by vehicle, central and wireless communications systems
Maintenance management software	System for tracking vehicle health, maintenance inspections, and repairs
Mobile data terminals/tablets (MDT)	Onboard devices for operator data input/text communication often with real-time location tracking capabilities
Scheduling software and optimization	Software for trip building, run cutting, vehicle assignments, operator assignment, optimization, etc. For demand response service, software for tracking trip reservations and run scheduling.
Surveillance/cameras	Video monitoring or recording of activity at transit facilities or onboard transit vehicles
Transit signal priority (TSP)	Provides transit vehicles with expedited treatment at intersections by communicating with the traffic signal or central system

Emerging Technologies

- **Advanced Analytics and Business Intelligence**: With a plethora of data generated from various established and emerging transit technologies, advanced analytics and in-depth business intelligence using a combination of data sources and tools are much easier than in the past. Advanced analytics allow transit agencies to gain information on system performance and the increasingly granular data that detail the nuances of operational performance. These systems also provide customer-centered measurements to allow planners to understand service from the customer's perspective and allow for transparency and accountability. This helps agencies understand how their riders are interacting with the various transportation systems and how to encourage customers to take public transit more. Business intelligence also can release inefficiency bottlenecks by refining business processes and automating routine tasks. The efficiency and productivity gains can be considerable, including more responsive customer service, closer monitoring of project implementation, and better use of agency's staff time.

- **Air Filtration**: Since the onset of the COVID-19 pandemic, transit agencies have strengthened cleaning protocols, boarding practices, and social distancing rules to control the spread of the virus at transit facilities and onboard transit vehicles. While agencies are beginning to use more powerful air filters with higher Minimum Efficiency Reporting Value (MERV) rating, emerging technologies in air filtration such as UV-C (Ultraviolet-C) air purifiers and the use of plasma as an advanced oxidation solution are potential solutions to improve air quality and reduce

COVID-19 spread during revenue service.

- **Bus Lane Enforcement:** Bus lane enforcement technology uses dedicated cameras installed on the roadside or onboard the bus to automatically capture parking violations along the bus lane to discourage regular traffic from using bus-exclusive lanes. When a non-permissible vehicle enters the bus lane, the camera captures a photo of the vehicle's license plate. In some systems, the cameras also include a short video that captures before and after the photo was taken. The license plate, location, and timestamp information are sent in real time to a back-end server that processes them. Photos and videos can be sent either in real time via cellular connection or through Wi-Fi at the garage at the end of the day.

- **Center-to-Center (C2C) Communications (Regional Data Sharing)**: C2C communications involve the exchange of data between computers and networks physically located in different transportation management center facilities (AASHTO/ITE, 2020). C2C communications enable direct interactions between transit management centers and other regional agencies such as public safety, traffic management centers, incident management centers, etc. Technologies such as TSP can benefit from permanent C2C communications with direct data communication and exchange of information from roadside infrastructure including traffic signals and detection sensors.

- **Machine Learning (ML) for Fleet Management, Operations, and Maintenance**: ML is an application of artificial intelligence (AI) for designing and training algorithms to learn from and act on the data on its own to develop meaningful insights. Examples of emerging applications of AI/ML in the transit industry include:

  - In fleet maintenance, AI/ML can collect and analyze historical health data from vehicle components and electronic pre-trip driver vehicle inspection reports to predict failures and improve preventive maintenance.
  - In passenger counting, AI/ML enabled people counting sensors can be utilized on-board transit vehicles and at passenger facilities to improve counting accuracy, manage queues, and enable real-time occupancy sharing.In operations management, agencies can utilize various historical variables (e.g., dwell time, weather, traffic) to improve the accuracy of vehicle arrival predictions. Also, agencies can utilize historical occupancy data to predict crowding and determine service management strategies in advance.
  - In TSP, agencies can eliminate the need to install additional communications hardware on-board of transit vehicles by utilizing roadside traffic detection sensors with C2C communications and AI/ML algorithms to identify transit vehicles and activate TSP.

- **Operations Data Standards**: Operations data standards aim to standardize data from a variety of systems including CAD/AVL, automatic fare collection (AFC), and APC systems. Operational data standards are still relatively new for North American public transit agencies and there are currently no standards with significant adoption. Some existing North American standards with limited adoption include the Transit Communications Interface Profiles (TCIP) by the American Public Transit Association (APTA), and GTFS-ride aiming to build a standard for ridership data collection, sharing, reporting, and analysis using the General Transit Feed Specification (GTFS) standard. Recently, a number of standardization processes are underway including a Transit Cooperative Research Program (TCRP) G-18 Study – Improving Access and Management of Transit ITS Data that aims to develop a data standard for AVL, APC, and AFC data. The California Integrated Travel Project (Cal-ITP) – Operational Data Standard working group also is working to standardize common interfaces, starting with the interface between scheduling and CAD/AVL data.

- **Operations Data Quality**: Data quality is a measure of condition of data based on factors such as accuracy, completeness, reliability, relevance, and timeliness. Public transportation agencies generate large amounts of data in daily operations, including AVL, AFC, APC, and GTFS. High-quality and trustworthy data in transit operations

increases accuracy of applications, analysis, and reporting, which can lead to better decision-making, improve internal business processes, and avoid errors in reporting. Periodic, recurring data validation ensures data collected from various operations technologies falls within the acceptable range of values. Data verification as an ongoing process plays an important role in eliminating duplicate data and ensuring data between applications and interfaces is transferred correctly from one source to another.

- **Real-Time Detour Management**: Real-time detour management refers to tools and strategies to timely inform operators on upcoming detours and alerting both onboard and potential downstream riders of the service change.

- **Transfer Connection Protection**: Transfer connection protection refers to technologies and tools that transit operators use to improve the reliability of transfers between transit services for passengers who rely on multiple transit modes/services for their complete trip (US Department of Transportation, 2021). Transfer connection protection technologies rely on a mix of both human-initiated aspects, such as customer- or operator-initiated transfer requests, as well as automatically generated real-time data such as estimates of arrival times and schedule delays, to identify mechanisms to "protect" or improve the chances of customers making their desired transfers. The most common mechanism in use is the transmission of a hold message to a downstream vehicle operator in the case of a delay to an upstream service carrying passengers interested in transferring at a stop served by both. Connection protection can be performed within a single agency, across multiple agencies, and across multiple modes.

- **Advanced Wireless Communication and Voice Over Internet Protocol (VoIP)**: Advanced wireless communication refers to technologies that use modern broadband-based infrastructure for voice and data communications for vehicle-to-central communications. Examples are mission-critical push-to-talk (MCPTT) or voice over LTE (VoLTE); VoIP; or FirstNet, a public safety broadband. VoIP, which has been deployed by several agencies in the past 5 years, allows users to make voice calls using an Internet connection instead of a traditional radio system-based voice infrastructure. VoIP allows agencies to avoid investments in expensive radio-based infrastructure while providing typical capabilities needed to manage voice communications between vehicles and the central system in a closed-mic configuration.

- **Yard Management Software (YMS)**: YMS is a technology used by agencies to improve garage operations by allowing users to better locate and manage vehicles that are in the garage or yard and communicate this information to other users or systems. Typically, the in-yard vehicle location tracking is visually depicted on a digitized map replicating the yard/garage layout. The vehicle location can be adjusted manually by garage staff if needed. Beyond vehicle location, the system can be integrated with other data and systems to provide additional information to garage dispatchers, such as driver/vehicle assignment, fueling status and maintenance status.

Equity Considerations

The main purpose of the operations-focused emerging technologies is to help an agency deliver services to its riders in a more efficient and cost-effective manner. Transit operations technologies have direct impacts on the quality of service provided to a community. The main goal of implementing these emerging transit operations technologies should focus on minimizing service disruptions and improving on-time performance that benefits all transit riders. With riders returning to their travel patterns similar to pre-pandemic levels, safety and health technology implementations that match or exceed that of single-occupancy vehicles would help regain confidence and trust of both first-time and seasoned transit riders.

State of Industry

The typical state of deployment of transit operations technologies for US transit agencies is summarized in for established technologies **Table 30** and **Table 31** for emerging technologies. The next section includes a comparison to Virginia.

Table 30: State of Industry – Established Transit Operations Technology

Category	Established Technologies	Industry Deployment Status (by Transect)		
		Demand Responsive or Fixed Route (Rural Reporter)	Fixed Route (Non-Rural Reporter)	Enhanced Fixed Route
Transit Operations Technology	**FIXED ROUTE SERVICE TECHNOLOGIES**			
	Automatic passenger counters (APC)	**Low**	**Low**	**High**
	Basic data management processes	**Low**	**Medium**	**High**
	Computer-aided dispatch/automated vehicle location (CAD/AVL)	**Medium** ⌄	**Medium** ⌃	**High**
	Maintenance management software	**Low**	**Medium** ⌃	**High**
	Mobile data terminals (MDT)/tablets	**Low**	**Medium**	**High** ⌄
	Scheduling software and optimization	**Low**	**Medium** ⌄	**High**
	Surveillance/cameras	**Low** ⌃	**Medium** ⌃	**High**
	Transit signal priority (TSP)	**Low**	**Low**	**Medium** ⌄
	DEMAND RESPONSE SERVICE TECHNOLOGIES			
	Basic data management processes	**Low** ⌃	**Low** ⌃	**Medium** ⌃
	Computer-aided dispatch/automated vehicle location (CAD/AVL)	**Low**	**Medium**	**High**
	Maintenance management software	**Low**	**Medium** ⌃	**High**
	Mobile data terminals (MDT)/tablets	**Low**	**Medium**	**High**
	Reservations and scheduling software	**Low**	**Medium** ⌃	**High**
	Surveillance/cameras	**Low** ⌃	**Low** ⌃	**High**

Low = Approximately less than 50 percent of agencies use the technology; Medium = Approximately 50 to 75 percent of agencies use the technology; High = Approximately more than 75 percent of agencies use the technology

Comparison to Virginia:

⌃ applicable Virginia agencies have a **higher** level of deployment compared to industry

⌄ applicable Virginia agencies have a **lower** level of deployment compared to industry

Table 31: State of Industry – Emerging Transit Operations Technology

Category	Emerging Technologies	Industry Deployment Status		
		Concept Development	Limited Deployment	Full/In-Service
Transit Operations Technology	Advanced Analytics and Business Intelligence		**FR, DR**	
	Air Filtration	**FR, DR**		
	Bus lane enforcement		**FR**	
	Center-to-center (C2C) communications (regional data sharing)		**FR**	
	Machine learning for fleet management, operations, and maintenance	**FR, DR**		
	Operations data standards	**FR, DR**		
	Operations data quality		**FR, DR**	
	Real-time detour management			**FR, DR**
	Transfer connection protection			**FR**
	Advanced wireless communication (VoIP)		**FR, DR**	
	Yard management software		**DR**	**FR**

FR = Fixed Route, DR = Demand Response

Virginia Deployment Analysis

Established Technologies

Table 30 contains icons that indicate whether Virginia has higher, lower, or similar (not marked) levels of deployment for transit operations technologies across the transects compared to the industry. In general, Virginia is in line with the industry or has higher levels of development for several technologies. Areas in which Virginia has lower levels of deployment compared to the industry include:

- Fixed-route CAD/AVL for the fixed-route (rural reporter) transect
- Fixed-route scheduling software for the fixed-route (non-rural reporter) transect
- Fixed-route MDT/tablets for the enhanced fixed-route transect
- Fixed-route TSP for the enhanced fixed-route transect

Emerging Technologies

There are very few deployments of emerging transit operations technologies in Virginia. Multiple agencies (fixed-route and enhanced fixed-route transects) are interested in implementing YMS. At least one transit agency in the enhanced fixed route transect has installed advanced wireless communication and expressed interest in implementing real-time detour management.

Customer-Facing Information

Definition

In the past, transit agencies provided static schedule information to riders through paper schedules and timetables at transit stops, with the dissemination of limited real-time information on rail platforms. Once web and mobile communications became more affordable, existing systems were repurposed to also provide customers with real-time information through multiple dissemination channels such as customer service centers, websites, mobile apps, and digital signage. **Table 32** defines established technologies in the category of customer-facing information. **Table 33** defines the established channels to disseminate information to transit riders.

Table 32: Established Technologies – Customer-Facing Information

Established Technology	Description
Automated stop announcements	Prerecorded audio and visual announcements triggered by an onboard system based on current vehicle location or current time and synced with in-vehicle signage
Electronic information displays	Information displays at stops, stations, or activity centers to provide static or real-time information to customers
Interactive voice response system or short message service (IVR/SMS)	Interactive voice-response system or SMS for providing traveler information via telephone or text message
Real-time schedule and arrivals	Immediate information provided to customers on departure times with trip updates, service alerts, and vehicle positions
Static schedule information (GTFS)	GTFS: public data feed of static transit schedule
Trip planner	Interactive service the provided via internet, mobile device, or kiosk for identifying the best travel route

Table 33: Dissemination Channels – Customer-Facing Information

Dissemination Channel	Description
Customer Service Center (In-Person)	Facility or space with latest paper schedules and/or staffed with transit agency staff to answer questions, usually during regular business hours
Customer Service Center (Phone Call)	Dedicated phone line with automated call system and/or transit agency representative
Short Messaging Service (SMS)	Automated messaging system for customers to receive up-to-date schedule and trip information through one-time request or subscription
Mobile Applications	Program or software developed by transit agency or third-party vendors that runs on a mobile device
Signage (Static)	Signs with word descriptions, direction, and/or diagrams
Signage (Digital)	Electronic signs that display real-time and pre-programmed information
Website	Web pages and content with a domain name accessible on the internet
Social Media	Websites and applications that enable users to create and share content or to participate in social networking

Emerging Technologies

- **ePaper Displays**: ePaper technology is a form of digital information that mimics the appearance at ink on paper. ePaper displays are typically deployed at bus stops or transit stations to inform passengers of the estimated time of departure of upcoming vehicles, stop times, delays, and other information, which allows customers to be informed during their trips. They can be remotely managed and updated 24/7. Many of these signs can feature an Americans with Disabilities Act (ADA)-compliant spoken information service and translated content. These signs also can feature information useful to customers such as time, weather, and news updates.

- **Infotainment**: Public transportation infotainment systems are used by transit agencies to provide customers with information such as next-stop announcements, transfer information, connection times, and rider alerts as well as additional entertainment or advertising material. Infotainment systems primarily utilize LCD/LED multimedia display screens (rather than single- or multiline LED display signs) and are installed onboard transit vehicles or at major stations or stops. Educational videos about new transit technologies, system changes, or other information also can be displayed for rider consumption.

- **Multimodal Traveler Information (One-Stop Location for All Modes)**: With the increased popularity of ridesharing and micromobility options complementing public transportation services, transit agencies and private businesses are partnering to broadcast multimodal traveler information at major transit stations and popular locations such as airports, hotels, and entertainment venues. Through large displays, real-time arrivals and traveler information for buses, trains, light rail, micromobility, ridesharing, etc. are all shown on one screen, allowing riders to compare the best option for their trips.

- **Open Data Standards (GTFS, GTFS-Realtime, GTFS-Flex, etc.)**: During the past decade, North American and international transit agencies have increasingly started sharing data based on "open data standards." These refer to publicly available, nonproprietary data shared in a documented, standardized format. Since the late 2000s, and starting with the advent of the GTFS schedule data standard initially developed by Google, these commonly consist of various standards maintained by a public community of contributors. The most notable standards are:
    - GTFS: Static schedule information including stop time, stop locations, and route locations
    - GTFS-Realtime: Real-time information with service alerts, trip updates, and vehicle positioning

  As needs for standardized data for demand-responsive services increase, GTFS-Flex has been proposed to become an extension to GTFS. GTFS-Flex adds the capability to model various demand-responsive services to GTFS, which currently only models fixed-route services.

- **Real-Time Vehicle Occupancy**: Crowding information has become vital for riders as the COVID-19 pandemic heightened and transit agencies set occupancy limits on buses. With existing APCs, data communication platforms, and data standards, real-time vehicle occupancy data can be published through various customer-facing information channels. As COVID-19 began to impact transit operations and ridership, public transportation agencies started incorporating crowding information through GTFS-Realtime feed.

- **Wayfinding – Indoor and Outdoor**: Traditionally, riders relied on static wayfinding signage within platforms and stations or roadside transit stops to help them navigate to their desired locations. Advanced technologies have made it possible for riders to utilize new tools under the following three categories:
    - **Localization and orientation:** Helping riders determine their current location in an indoor or outdoor environment as part of their trip
    - **Information:** Providing information as required (e.g., locating a bus, locating entrance door)
    - **Step-by-step guidance:** Providing step-by-step guidance for travelers who may need such help in an unfamiliar indoor environment (e.g., locating station platform at a large rail station); this can be provided using text-based guidance or using advanced technologies such as augmented reality

Equity Considerations

While most emerging forms of customer-facing information are available to view on a computer or a personal mobile device, such information may not reach the economically disadvantaged or people with disabilities. As computer or mobile devices come with a user cost, the economically disadvantaged may not be able to afford the device or data plan needed to view real-time information, particularly in rich-text format. People with disabilities may not be able to see the displayed information or have difficulty understanding real-time alerts. With the COVID-19 pandemic affecting ridership and customer confidence in riding transit, agencies may also consider providing additional information and data regarding public health and cleanliness of transit vehicles, such as real-time occupancy, onboard air quality, and the exact time a particular vehicle was last cleaned. Public transportation agencies and mobility providers can develop user interfaces and alternatives for emerging customer-facing information technologies to ensure real-time information is accessible via multiple dissemination channels.

State of Industry

The typical state of deployment of customer-facing information technologies for US transit agencies is summarized in **Table 34** for established technologies and **Table 35** for emerging technologies. The next section includes a comparison to Virginia.

Table 34: State of Industry – Established Customer-Facing Information Technology

Category	Established Technologies	Industry Deployment Status (by Transect)		
		Demand Responsive or Fixed Route (Rural Reporter)	Fixed Route (Non-Rural Reporter)	Enhanced Fixed Route
Customer-Facing Information	**FIXED ROUTE SERVICE TECHNOLOGIES**			
	Automated stop announcements	**Low**	**Medium**	**High**
	Electronic information displays	**Low**	**Low**	**Medium**
	Interactive voice response system or short message service (IVR/SMS)	**Low**	**Low**	**Medium**
	Real-time schedule and arrivals	**Low**	**Medium**	**High**
	Static schedule information (GTFS)	**Medium**	**High**	**High**
	Trip planner	**Low**	**Medium**	**High**
	DEMAND RESPONSE SERVICE TECHNOLOGIES			
	Interactive voice response system or short message service (IVR/SMS)	**Low**	**Medium**	**Medium**
	Real-time schedule and arrivals	**Low**	**Low**	**Medium**
	Trip planner (demand response focused)	**Medium**	**Medium**	**High**

Low = Approximately less than 50 percent of agencies use the technology; Medium = Approximately 50 to 75 percent of agencies use the technology; High = Approximately more than 75 percent of agencies use the technology

Comparison to Virginia:

applicable Virginia agencies have a **higher** level of deployment compared to industry

- applicable Virginia agencies have a **lower** level of deployment compared to industry
-

Table 35: State of Industry – Emerging Customer-Facing Information Technology

Category	Emerging Technologies	Industry Deployment Status		
		Concept Development	Limited Deployment	Full/In-Service
Customer-Facing Information	ePaper displays			**FR**
	Infotainment			**FR**
	Multimodal traveler information (one-stop location for all modes)		**FR, DR**	
	Open data and standards (e.g., GTFS-Realtime, GTFS-Flex)	**DR**		**FR**
	Real-time vehicle occupancy			**FR, DR**
	Wayfinding – indoor and outdoor	**FR, DR**		

FR = Fixed Route, DR = Demand Response

Virginia Deployment Analysis

Established Technologies

Table 34 contains icons that indicate whether Virginia has higher, lower, or similar (not marked) levels of deployment for customer-facing information technologies across the transects compared to the industry. In general, Virginia is in line with the industry but has lower levels of deployment for several demand response technologies. Areas in which Virginia has lower levels of deployment compared to the industry include:

- Fixed-route electronic information displays for the enhanced fixed-route transect
- Demand response IVR/SMS for the fixed route (non-rural reporter) transect
- Demand response real-time schedule and arrivals for the enhanced fixed route transect
- Demand response trip planner for all transects

Emerging Technologies

There is activity and interest in multimodal traveler information, open data and standards, and real-time occupancy in Virginia. Multiple transit agencies in Northern Virginia (enhanced fixed-route transect) feed real-time customer-facing information to multimodal information displays. Approximately 15 percent of transit agencies produce a GTFS-Realtime feed for disseminating real-time arrival information to customers. One transit agency (fixed route transect) provides estimated vehicle occupancy to customers via the Internet using their onboard data collection system. There are few to no deployments of the emerging ePaper displays, infotainment, and wayfinding technologies in Virginia.

Payment

Definition

Payment systems encompass a wide array of technologies for riders to purchase fares. Electronic fareboxes and ticket vending machines (TVM) are widely deployed by many agencies across the US, with cash, magnetic stripe (magstripe) cards, and smartcards being three common ways to pay for fares. Riders may purchase fare media online or over the telephone and have it added directly to their smartcard. This reduces costs associated with printing fare media and dealing with cash transactions, while allowing customers to buy passes from home. However, many smaller agencies continue to use manual fareboxes for cash collection given the cost required to implement electronic fareboxes for a relatively low volume of cash. Some agencies may decide to forgo electronic means of fare collection given a relatively small amount of fares collected to justify the technology investment, or may possibly eliminate fare collection altogether. **Table 36** defines established technologies in the category of payment.

Table 36: Established Technologies— Payment

Established Technology	Description
Cash, magstripe, and smartcard payment	Conventional methods to collect fare required to travel on public transportation
Electronic farebox	Scan and assess the value of fare media presented by boarding passengers and stores information on the transaction
Ticket vending machine (TVM)	Self-serve machine installed at stations, platforms, and transit centers to collect or validate fare
Mobile ticketing – visual validation	System that allows customers to purchase and validate tickets or fare via their smartphone

Emerging Technologies

- **Account-Based Systems and Integrated Payments**: Account-based fare collection technology is an opportunity for enhancing integrated payment options. These systems allow customers to maintain an account that they can fund with a bank card or other methods (e.g., paying by cash in person at retail locations). At the same time, agencies can work with third-party solution providers to build links with shared mobility service provider apps, so customers can pay for their trips when they book or when trips have been completed. Account-based payment also allows agencies to partner with local retailers to sell passes and other fare products through electronic media (e.g., prepaid cards and loading agency smartcards) to customers who may be unbanked. Account-based systems can enable fare capping policies, which "cap" single fares paid by riders when they reach the equivalent cost of a period pass (e.g., daily, weekly or monthly pass).

- **Contactless Open Payments**: Contactless open payments refer to the use of credit or debit bank cards for paying for trips onboard or at an offboard payment terminal—just like customers can do at many retailers. Use of bank cards allows flexibility to customers as they can use the same payment media that they may carry for purchasing other (non-transit) goods and services. The deployment for open payments is predominately occurring in large urban environments but adoption is expected to increase in the next few years as digitization of payments continues to increase.

- **Digital Cash**: Digital cash refers to any electronic system that can store, transfer, and spend money only in digital form. In the context of transit industry, digital cash offers benefits for unbanked and underbanked populations that are not able to utilize the benefits of account- and bankcard-based payment systems that require linking a bank account to a customer account. With the help of digital cash service providers (e.g., PayNearMe, T-CETRA) riders can use a QR code or other method (e.g., a prepaid card) obtained in exchange for cash paid at a partner retail

network location (e.g., pharmacy or grocery store) for transit payments.

- **Mobile Ticketing – Electronic Validation**: While mobile payments and ticketing is an established technology, new forms of validation are emerging. As field communication technologies and mobile phone capabilities improve, riders can self-validate their transit tickets with new validation methods that may include near-field communications (NFC), Bluetooth Low Energy (BLE), or other wireless technologies (e.g., RFID). With NFC, riders can tap their smartphones over contactless readers for validation. For more advanced contactless validation methods (e.g., BLE, RFID), payments are validated without tapping on a payment terminal as riders get on and off a vehicle—also known as be-in-be-out (BIBO).

- **Mobile Wallet Payments**: As an extension to contactless open payment technology, next-generation payment solutions include integrations with mobile wallets, which help riders pay directly through their Apple or Google virtual wallets on their smartphones. Mobile wallets also allow users to create and manage virtual transit cards. A number of transit agencies in the US have introduced mobile apps with virtual card capability. These apps allow users to convert physical transit smartcards to virtual cards.

- **Regional Integration**: Public transportation systems in metropolitan cities and regions typically involves multiple providers and operators with various methods of payment, including different smartcards, trip fare options, connections discounts, etc. With shared mobility initiatives such as transportation network company (TNC) partnerships and first- and last-mile connections, riders may need to use two or more methods of payment during a single trip. Regional integration allows riders to pay for a multimodal trip and connections on a single payment platform. Providers collect their portion of fare after the trip is complete.

Equity Considerations

Most emerging payment technologies require a mobile device or an account and, therefore, riders who lack access to these many not be able to utilize these payment options. In 2021, 97 percent of Americans own a mobile device of some type, with 85 percent owning a smartphone. Notably for specific population groups, seniors (65+) were less likely to have a cell phone (92 percent) or a smartphone (61 percent). Rural residents also were less likely to have a smartphone (65 percent). When considering implementation of new fare payment technologies such as mobile payment or cash reduction, public transportation providers can provide alternative ways to purchase digital fares—for example, at customer service centers, hospitals, supermarkets, or convenience stores. Another implementation consideration is whether the technology can support reduced-fare programs or whether fare technology can be forgone due to eliminated fares altogether. This topic is discussed further in the **Transit Accessibility** technical area.

State of Industry

The typical state of deployment of payment technologies for US transit agencies is summarized in **Table 37** for established technologies and **Table 38** for emerging technologies. The next section includes a comparison to Virginia.

Table 37: State of Industry – Established Payment Technology

Category	Established Technologies	Industry Deployment Status (by Transect)		
		Demand Responsive or Fixed Route (Rural Reporter)	Fixed Route (Non-Rural Reporter)	Enhanced Fixed Route
Payment	**FIXED ROUTE SERVICE TECHNOLOGIES**			
	Cash	**High**	**High**	**High**
	Magstripes	**Medium**	**Medium**	**Low**
	Smartcards	**Low**	**Medium**	**High**
	Electronic fareboxes	**Medium**	**Medium**	**High**
	Fare vending machines	**Low**	**High**	**High**
	Mobile ticketing—visual validation	**Low**	**Medium**	**High**
	DEMAND RESPONSE SERVICE TECHNOLOGIES			
	Cash	**High**	**High**	**High**
	Magstripes	**Low**	**Medium**	**Low**
	Smartcards	**Low**	**Medium**	**High**
	Electronic fareboxes	**Low**	**Medium**	**High**
	Mobile ticketing—visual validation	**Low**	**Low**	**Medium**

Low = Approximately less than 50 percent of agencies use the technology; Medium = Approximately 50 to 75 percent of agencies use the technology; High = Approximately more than 75 percent of agencies use the technology

Comparison to Virginia:

^ applicable Virginia agencies have a **higher** level of deployment compared to industry

v applicable Virginia agencies have a **lower** level of deployment compared to industry

Table 38: State of Industry – Emerging Payment Technology

Category	Emerging Technologies	Industry Deployment Status		
		Concept Development	Limited Deployment	Full/In-Service
Payment	Account-based systems/integrated payments			**FR, DR**
	Contactless open payments		**FR**	
	Digital cash		**FR, DR**	
	Mobile ticketing – electronic validation			**FR, DR**
	Mobile wallet payments		**DR**	**FR**
	Regional integration		**FR, DR**	

FR = Fixed Route, DR = Demand Response

Virginia Deployment Analysis

Established Technologies

Table 37 contains icons that indicate whether Virginia has higher, lower, or similar (not marked) levels of deployment for payment technologies across the transects compared to the industry. This category has the largest number of gaps from the industry and, in general, Virginia has lower levels of deployment. Areas in which Virginia has lower levels of deployment compared to the industry include:

- Fixed-route electronic fareboxes and magstripes for the demand-responsive and fixed-route transects
- Fixed-route smartcards for the fixed-route (non-rural reporter) and enhanced fixed-route transects
- Fixed-route fare vending machines for the fixed-route (non-rural reporter) and enhanced fixed-route transects
- Fixed-route mobile ticketing for fixed-route (non-rural reporter) transect
- Demand response electronic fareboxes and smartcards for the fixed-route (non-rural reporter) and enhanced fixed-route transects
- Demand response mobile ticketing for the enhanced fixed route transect

Emerging Technologies

Contactless (but not open) payments, mobile wallet payments, and regional integration are offered by fixed-route transit services in Northern Virginia that are part of the SmarTrip regional fare collection system managed by the Washington Metropolitan Area Transit Authority (WMATA). Apart from SmarTrip mobile payment in Northern Virginia, the limited number of other transit agencies in Virginia that offer mobile fare payment utilize visual validation as opposed to emerging electronic validation methods. Based on the transit agency survey, 78 percent of transit agencies are interested in contactless payments with 49 percent actively pursuing or planning to pursue it in the next 5 years. Furthermore, 55 percent of transit agencies expressed interest in regional fare payment integration with 32 percent actively pursuing or planning to pursue it in the next 5 years. There are no reported deployments of account-based systems or digital cash; however, WMATA continues to plan upgrades of the SmarTrip system, which could bring these capabilities to Northern Virginia transit providers in the future.

Vehicle Propulsion and Control

Definition

Since the first American gasoline-powered buses began running in New York City in 1905, public transportation agencies have procured and operated gasoline- and diesel-powered vehicles for fixed-route and demand-responsive services. In the late 2000s, as gasoline prices began to rise, an increasing number of transit agencies in the US converted part or most of their fleet to vehicles powered by compressed natural gas (CNG). Around the same time, concerns of environment impacts caused by air pollution led some transit agencies to consider hybrid electric vehicles that use an electric motor or battery with regenerative braking technologies to improve fuel efficiency. In early 2010s, connected and automated vehicle (CAV) concepts began to materialize with large investments in the automotive industry. By late 2010s, the Federal Transit Administration (FTA) initiated research and innovation activities on transit automation to investigate future concepts of public transportation.

Table 39 defines established technologies in the category of vehicle propulsion and control. Emerging technologies associated with electrification are further analyzed in the **Electrification** technical area of the study.

Table 39: Established Technologies – Vehicle Propulsion and Control

Established Technology	Description
Compressed Natural Gas (CNG)	A readily available form of natural gas compressed to less than 1 percent of its volume
Diesel	Liquid fuel obtained by crude oil distillation for use in diesel compression ignition engine
Gasoline	Fuel made from crude oil and other petroleum liquids, with up to 10 percent of ethanol by volume
Hybrid	Vehicles powered by an internal combustion engine and an electric motor or battery

Emerging Technologies

- **Advanced Driver Assistance Systems (ADAS)**: According to SAE International, the term "Advanced Driver Assistance Systems" is commonly used to describe a broad range of features, including those that provide warnings and/or momentary intervention, such as forward collision warning (FCW) systems, lane keeping assistance (LKA) systems, and automatic emergency braking (AEB) systems as well as some convenience features that involve Level 1 (see Driving Automation Systems description) driver support features, such as adaptive cruise control and certain parking assistance features.

- **Battery Electric**: Battery electric vehicles are powered by electric motors rather than internal combustion engines. Internal combustion engines rely on burning fuel to create translational mechanical energy through the action of pistons, which is then converted to rotational energy through the crankshaft. Electric motors are simpler and rely on electrically powered onboard magnets to directly create mechanical rotational energy. Electric vehicles in general have a high energy conversion efficiency, transferring 72 to 94 percent of the input electrical energy into motion, dramatically more than the 12 to 30 percent of gasoline energy converted into movement for internal combustion engine vehicles (US Department of Energy, 2021).

- **Connected Vehicle (CV) Applications**: A CV is a vehicle that is equipped with a wireless communication device and technology to communicate with other vehicles on the road, roadside infrastructure, and other travelers (University of Virginia Center for Transportation Studies, 2018). CV applications in transit include vehicle-to-pedestrian (V2P), vehicle-to-infrastructure (V2I), and vehicle-to-vehicle (V2V) technologies to improve safety and

security for all road users.

- **Hydrogen Fuel Cell**: A hydrogen fuel cell uses the chemical energy of hydrogen to cleanly and efficiently produce electricity. The only products of hydrogen fuel cell are electricity, water, and heat. Fuel cells are unique in terms of the variety of their potential applications. Fuel cells work like batteries, but they do not run down or need recharging. They produce electricity and heat as long as fuel is supplied. Fuel cells have several benefits over conventional combustion-based technologies currently used in many vehicles. Fuel cells can operate at higher efficiencies than combustion engines and can convert the chemical energy in the fuel directly to electrical energy with efficiencies capable of exceeding 60 percent. Fuel cells have lower or zero emissions compared to combustion engines. Hydrogen fuel cells emit only water, addressing critical climate challenges as there are no carbon dioxide emissions. There also are no air pollutants that create smog and cause health problems at the point of operation. Fuel cells are quiet during operation as they have few moving parts (US Department of Energy - Hydrogen and Fuel Cell Technologies Office, 2021).

- **Driving Automation Systems**: Driving automation systems are hardware and software systems that are collectively capable of performing part or all driving tasks on a sustained basis (SAE International, 2019). There are six discrete and mutually exclusive levels of driving automation, in which this Driving Automation Systems term is used generally to describe any system capable of Level 1 to 5 driving automation. There are several domestic planned, in-operation, and completed automated transit bus testing activities. Most examples involve smaller vehicles (low-speed automated shuttles and light-duty vehicles); however, development and testing for full-size transit bus applications is increasing. Five broad transit automation use cases were identified in the U.S. Department of Transportation's Strategic Transit Automation Research Plan (STAR) Plan (Machek, et al., 2018):
    1. Transit bus advanced driver assistance systems
    2. Automated shuttles
    3. Automated maintenance and yard operations
    4. Automated mobility-on-demand service
    5. Automated bus rapid transit (BRT)

Table 40: Levels of Driving Automation (Source: SAE International)

Level	Name	Control	Description
0	No Driving Automation	Human	Driver only
1	Driver Assistance	Human	ADAS and steering support
2	Partial Driving Automation	Human	Traffic supervision
3	Conditional Driving Automation	System	Driver takeover if required
4	High Driving Automation	System	No driver intervention needed
5	Full Driving Automation	System	No driver or steering wheel

Equity Considerations

Emerging vehicle technologies present opportunities to make positive impacts on equity in the areas of safety, the environment, and accessibility. With proper configuration and intensive testing, ADAS and CAV technologies could improve safety by avoiding obstacles and eliminate crashes caused by human factors. By strategically dispatching zero-emission vehicles in areas with poor air quality, transit agencies could prevent worsening the

environment in such areas. Automated vehicles can potentially operate as first- and last-mile connections in areas unreachable by fixed-route or demand-responsive services.

On the other hand, ADAS and CAV technologies are at risk of potential system failures, configuration errors, and cyberattacks. Moreover, transit agencies run the risk of accumulating unrealized costs from technology and transition expenditures, workforce retraining expenses, and increased labor costs due to the need for specialized skills, and technological obsolescence, thus reducing budget in other established capital and operational focus areas (Federal Transit Administration, 2019).

State of Industry

The typical state of deployment of vehicle propulsion and control technologies for US transit agencies is summarized in **Table 41** for established technologies and **Table 42** for emerging technologies. The next section includes a comparison to Virginia.

Table 41: State of Industry – Established Vehicle Propulsion and Control

Category	Established Technologies	Industry Deployment Status (by Transect)		
		Demand Responsive or Fixed Route (Rural Reporter)	Fixed Route (Non-Rural Reporter)	Enhanced Fixed Route
Vehicle Propulsion and Control	**FIXED ROUTE SERVICE TECHNOLOGIES**			
	Compressed natural gas (CNG)	**High**	**High**	**High**
	Diesel	**High**	**High**	**High**
	Gasoline	**High**	**High**	**High**
	Hybrid	**Low**	**Low**	**High**
	DEMAND RESPONSE SERVICE TECHNOLOGIES			
	Compressed natural gas (CNG)	**Medium**	**High**	**High**
	Diesel	**Medium**	**Medium**	**Medium**
	Gasoline	**High**	**High**	**High**
	Hybrid	**Low**	**Low**	**Low**

Low = Approximately less than 50 percent of agencies use the technology; Medium = Approximately 50 to 75 percent of agencies use the technology; High = Approximately more than 75 percent of agencies use the technology

Table 42: State of Industry – Emerging Vehicle Propulsion and Control

Category	Emerging Technologies	Industry Deployment Status		
		Concept Development	Limited Deployment	Full/In-Service
Vehicle Propulsion and Control	Advanced driver assistance systems (ADAS)		**FR**	
	Battery electric			**FR, DR**
	Connected vehicle (CV) applications	**FR, DR**		
	Hydrogen fuel cell			**FR**
	Driving automation systems	**FR**	**DR**	

FR = Fixed Route, DR = Demand Response

Virginia Deployment Analysis

Analysis of vehicle propulsion technologies in Virginia is covered in the **Electrification** technical area. In the transit agency survey, alternative energies or electric buses was the most common response (10 transit agencies) when asked what technology the transit agency is most interested in implementing. Furthermore, 32 percent of transit agencies are actively pursuing or planning to implement fleet electrification in the next 5 years. Three transit agencies reported they operate zero-emission transit buses or paratransit vehicles.

In general, deployment of ADAS, CV, and driving automation system aligns with the industry deployment status—primarily in the concept development or limited deployment phase. Since 2019, three autonomous shuttle pilots were launched in Virginia—in Fairfax County, Arlington, and Crozet. In 2017, DRPT provided demonstration grants to install ADAS on buses at multiple transit agencies in Virginia. In the transit agency survey, 50 percent of transit agencies expressed interest in vehicle automation with 21 percent actively pursuing or planning to pursue it in the next 5 years.

Shared Mobility

Definition

Shared mobility refers to the use of shared vehicles, bicycles, or other modes. Short-term access to these transportation modes on an as-needed basis enables users to travel in a cost-effective way without taking complete ownership of the resource. The term also includes various forms of carsharing, bikesharing, ridesharing, and on-demand services. In the traditional sense, shared mobility includes demand response services, micromobility, and ridesharing such as carpooling or vanpooling as defined in **Table 43**.

Table 43: Established Technologies – Shared Mobility

Established Technology	Description
Demand response service	Any non-fixed-route system of transporting individuals that requires advanced scheduling by the customer, including services provided by public entities, non-profits, and private providers (49 CFR Section 604.3(g))
Micromobility	Small, low-speed, human- or electric-powered transportation device, including bicycles, scooters, electric-assist bicycles, electric scooters (e-scooters), and other small, lightweight, wheeled conveyances (SAE International, 2019); may be personally owned or part of a shared fleet
Ridesharing	The practice of sharing rides or transportation, especially by commuters, typically in the form of carpooling and vanpooling (US Department of Transportation, 2021)

A key advantage of shared mobility is its ability to fill gaps where traditional public transportation service is absent, inadequate, or ineffective. Lack of access to public transit is all too common, particularly in rural areas, especially for many low-income populations. While improving public transit is a long-term goal, shared mobility can play a role in connecting underserved populations to jobs, commerce, and recreation. Cities around the world are already starting to include vehicle-sharing programs in their long-term planning. These cities recognize that connectivity is a crucial component to a vibrant, healthy city, improving economic growth and quality of life. Further, emerging trends toward smart cities focus on integrating shared mobility with mass transit by creating strong intermodal connections to improve equity and access. Embracing shared mobility also will keep cities competitive at attracting residents and businesses.

Emerging Technologies

- **First- and Last-Mile Connections**: First mile is the gap between a rider's origin and the transit stop, while last mile is the gap between the transit stop and the rider's destination. Most riders may walk or ride a bicycle to and from the transit stop, but at times, a sidewalk or bicycle path may not be available for safe first- and/or last-mile travel, or the distance may be too long. Public transportation and local government agencies are partnering with private service providers to reduce the first- and last-mile distance with innovative technology-based services.

- **Microtransit**: Microtransit is a privately or publicly operated, technology-enabled transit service that typically uses multi-passenger/pooled shuttles or vans to provide on-demand or fixed-schedule services with either dynamic or fixed routing (SAE International, 2019). Microtransit typically consists of medium-capacity public transit vehicles (8 to 15 passengers) operating with on-demand, flexible routing to provide service to areas that are inefficient to serve with a fixed route. The driver operates as an employee of the transit agency or a corporation.

- **TNC Partnerships**: A TNC is a for-hire motor carrier that provides prearranged rides for compensation using a digital platform that connects passengers with drivers using personal vehicles (Virginia Department of Motor Vehicles, 2021). TNC drivers are referred to as TNC partners. A digital platform is any online-enabled application, software, website, or system offered or utilized by a TNC that enables the prearrangement of rides with TNC partners. Transit agencies are forming partnerships with TNCs to make their services more available to a wider audience, to leverage new technology, and to improve mobility choices for their customers (American Public Transportation Association, 2021).

Equity Considerations

As some shared mobility providers are privately owned and operated, a principal concern is to ensure any new service arrangement meets all equity requirements, including Title VI of the Civil Rights Act. The four key areas of equity concerns on shared mobility services are (Virginia Department of Rail and Public Transportation, 2019):

- **Service availability:** Where and when service is provided
- **Fare:** How much is charged to use the service
- **Technology access:** Ensuring that riders have access to the service without requiring a smartphone
- **Rider access:** Nondiscrimination based upon rider characteristics, including ADA and Title VI of the Civil Rights Act

With an increased number of transit agencies in the US partnering with TNCs and mobility providers to improve first- and last-mile connections, the associated regulatory framework has not caught up with deployments. To ensure shared mobility options improve transit accessibility for underserved communities and narrow the gap of customer experience with other riders, increased governance and audits should be considered.

State of Industry

The typical state of deployment of shared mobility for U.S. transit agencies is summarized in **Table 44** for established technologies or services and **Table 45** for emerging technologies or services. The next section includes a comparison to Virginia.

Table 44: State of Industry – Established Shared Mobility

Category	Established Technologies	Industry Deployment Status (by Transect)		
		Demand Responsive or Fixed Route (Rural Reporter)	Fixed Route (Non-Rural Reporter)	Enhanced Fixed Route
Shared Mobility	Demand response service	Medium ^	Medium ^	High
	Micromobility	Low	Medium v	High
	Ridesharing – carpool	Low	Low	High
	Ridesharing – vanpool	Low	Low	High

Low = Approximately less than 50 percent of agencies use the technology; Medium = Approximately 50 to 75 percent of agencies use the technology; High = Approximately more than 75 percent of agencies use the technology

Comparison to Virginia:

^ applicable Virginia agencies have a **higher** level of deployment compared to industry

v applicable Virginia agencies have a **lower** level of deployment compared to industry

Table 45: State of Industry – Emerging Shared Mobility

Category	Emerging Technologies	Industry Deployment Status		
		Concept Development	Limited Deployment	Full/In-Service
Shared Mobility	First- and last-mile connections			FR
	Micromobility			DR
	Microtransit			DR
	TNC partnerships			FR, DR

FR = Fixed Route, DR = Demand Response

Virginia Deployment Analysis

Established Technologies

Table 44 contains icons that indicate whether Virginia has higher, lower, or similar (not marked) levels of deployment for shared mobility technologies across the transects compared to the industry. In general, Virginia is in line with the industry. Many communities of the fixed-route and enhanced fixed-route transects have micromobility, including various communities in the Northern Virginia and Hampton Roads regions, Richmond, Roanoke, Lynchburg, Harrisonburg, Charlottesville, and Blacksburg.

Emerging Technologies

There are several examples of existing shared mobility deployments in Virginia.

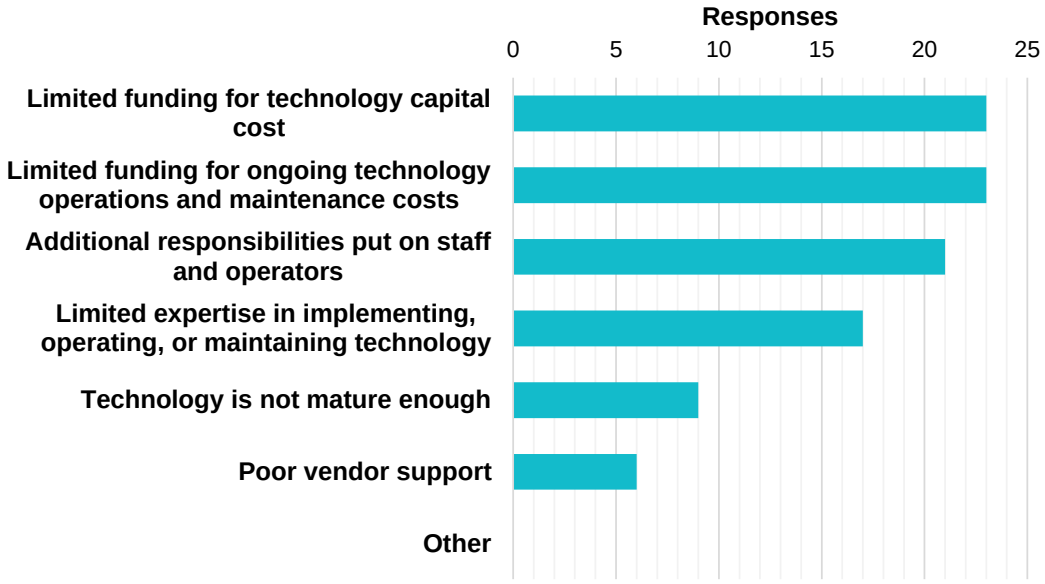
Two agencies—Bay Transit and Mountain Empire Older Citizens—are currently piloting microtransit service in partnership with DRPT. Multiple agencies in the enhanced fixed-route or fixed-route transects are in the concept development stage for microtransit—either recently or actively studying the feasibility or planning a pilot program. GRTC in Richmond also has partnered with two TNCs for its CARE On-Demand service since 2017.

Based on the transit agency survey, 74 percent of transit agencies are interested in on-demand shared mobility, with 42 percent actively pursuing or planning to pursue it in the next 5 years.

Barriers and Needed Support

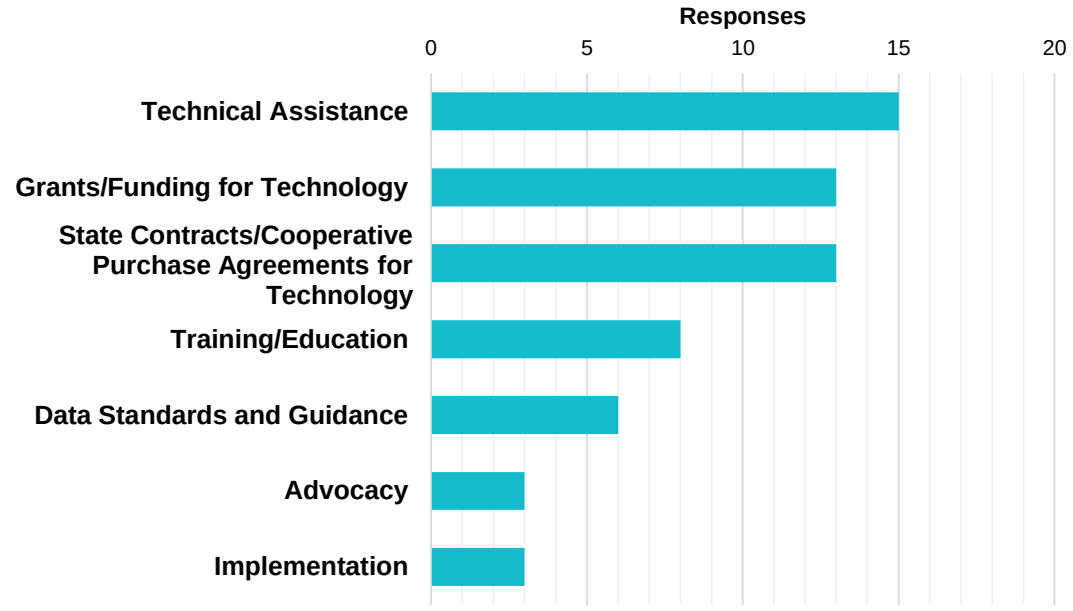
Virginia transit agencies were surveyed on common barriers to implementing technology. The results shown in **Figure 71** indicate challenges with capital, operations, and maintenance funding for technology; the additional responsibilities technology puts on staff and operators; and limited expertise with technology. Some agencies reported concerns over technology maturity and vendor support as well.

Figure 71: Barriers to Implementing Technology Reported by Virginia Transit Agencies



When asked how DRPT or the Commonwealth can support agencies in modernizing transit through the use of technology, Virginia transit agencies replied with the support needs shown in Figure 72.

Figure 72: Technology Support Needs Reported by Virginia Transit Agencies



Electrification

Overview and Definition

For the purposes of this study, "electrification" is defined as the process of replacing transit buses that use fossil fuels (e.g., diesel, gasoline, and natural gas) with zero-emission buses (ZEBs) that use electric-drive propulsion systems, specifically battery electric buses (BEBs). The overall analysis also will include assessing the overall feasibility and requirements for the installation of charging systems to provide the energy needed to power the buses. Over the course of this study, we will provide insights within the six specific subtask areas below:

- Analysis of Current State of Transit Agencies (subject of this memo)
- Market Assessment (see Appendix C)
- Opportunity for Transit Electrification
- Utility Readiness
- Analysis of Obstacles to Implementation
- Electric Vehicle (EV) Transition and Deployment Checklist

The subject of the first two technical memos will be a combined baseline conditions and opportunities assessment for this topic area will cover items A and B above, answering the following questions:

- What is the current state of fleet vehicles across the state?
- What is the current state of electrification across the state?
- What are the opportunities to electrify fleet vehicles across the Commonwealth based on current conditions?
- What are the challenges, obstacles, and tools needed that are associated with electrification?
- What are the characteristics of the current ZEB market?

Electrification also is related to the Implementation of Emerging Technology technical area, which considers innovative technology and technology-enabled services that are or could be deployed by transit agencies. There are similarities and complementary overlap between these two subject areas that will be identified throughout the study. As the study progresses, the combined team will point out those similarities while also identifying opportunities for a more equitable distribution of ZEBs in the Commonwealth of Virginia.

Baseline Conditions

Introduction

The Electrification effort is rooted in the aforementioned six main subtasks. First, the current state of transit agencies in the Commonwealth will be outlined in a detailed report. This will be inclusive of the current state of fleet vehicles across the Commonwealth, the current state of electrification, the current state of planning, and identified obstacles and benefits. Second, a market analysis will be developed to identify current ZEB technologies and availability. This will include ZEBs, chargers, and supporting systems. The market analysis also will provide insight into federal and state incentive programs for ZEB technology. This effort is captured in Appendix C. The third objective will be a more detailed analysis exploring the opportunities for transit electrification. This requires a statewide fleet assessment to determine electrification feasibility and opportunities to transition to ZEBs, estimates of fuel use, required facilities, and vehicle maintenance. These assessments will provide information to estimate capital costs for electrification and an estimated total cost of ownership (TCO) that includes operational costs and savings relative to electrification across the state. The fourth objective will examine utility company readiness across the state as well as utility electric vehicle rate schedules. The fifth objective is an analysis of the obstacles to implement ZEBs across the state. Obstacles,

challenges, and overall concerns related to transit electrification will be discussed to determine the overall feasibility to electrify vehicles across the state. The last objective will provide tools for transit agencies to understand steps in transition planning and the deployment of ZEBs.

Methodology

Current State of Transit Agencies

Determining the current state of transit agencies in their efforts to electrify their fleets includes the following primary objectives: 1) to develop an understanding of buses currently being used in transit services in the Commonwealth of Virginia and the type of service in which they are used, and 2) to develop an understanding of current electric buses in operation in the Commonwealth and plans to deploy additional electric buses.

The primary method in determining the vehicles currently in operation is to query the appropriate, existing data sources that contain elements that enable reasonable fleet profiling using a number of characteristics. In this initial phase of analysis, these characteristics include vehicle type, length, and propulsion type in addition to the type of service and planned replacement schedule for each type of vehicle. This provides a directional indication of the opportunities available in fleet electrification. The data extracted in this phase, along with additional data collection currently underway to obtain fuel consumption and cost, daily mileage requirements, and available utility programs, will act as input data in the full opportunity assessment to be completed in a later phase. In determining the current state of electrification in the Commonwealth, survey questions and follow-up research are used to understand the electric vehicles currently deployed and any associated challenges, planning levels for future electrification, and perceived obstacles and expected benefits from electrification.

Data Sources and Assumptions

The primary source for vehicle data in this phase of the project is the TransAm database. While there are some instances of missing and/or incomplete data, this data source is sufficient to provide the profile information described above and result in valid decision-making. Assumptions associated with the analysis of this data include:

- The vehicles analyzed are limited to those in the 39 agencies scoped by the team to represent fleets in the Commonwealth of Virginia as of July 2021
- Vehicles are limited to those labeled with a service status of In Service, Spare, and Out of Service. Those labeled as Disposed or Unknown or with null fields are not included
- Vehicle types of Automobiles, Van, and Minivan are included for completeness in this phase but will not be the focus of future analysis phases due to either low numbers in each category for the agencies selected or a large number of unknown transportation modes (Primary Mode)
- Fuel Types for each vehicle have been combined where labels are similar and have been determined to actually represent the same fuel type
- Fields with attributes of #N/A, Other Vehicles Operated (Primary Mode), or Unknown are combined and labeled as Unknown/Other for the purposes of this analysis

The above filters and assumptions resulted in a group of 2,168 vehicles in the analysis dataset.

Analysis Results

Evaluation of Current Transit Fleets

At this phase of the analysis, it is useful to understand the distributions of the types of vehicles, size, and primary fuel types to point to potential opportunities associated replacement of vehicles that may result in high emissions based on their innate design (e.g., fossil fuel vehicles, larger/heavier vehicles, those that represent a

high percentage of the overall fleet in the Commonwealth, etc.). It also is useful to describe the type of service they are employed in as context in ascertaining the type of duty cycle/demands place on the vehicles. Finally, another way to define opportunities for electrification is by looking at the planned replacement schedule for different vehicle types to define some potential schedule considerations to provide the maximum benefits in the shortest period of time.

Vehicle Types

The distribution of the vehicle types across the 39 representative agencies in the Commonwealth are as follows:

Table 46: Vehicle Type Distribution

Vehicle Types	# of Vehicles	% of Total
Bus (25'-40' and trolleys)	1,048	48%
Cutaway (all sizes)	782	36%
Over-the-Road Coach	215	10%
Auto/Van/Minivan	91	4%
Articulated Bus (60')	27	1%
Unknown/Other	5	0%
Total	2,168	100%

These data point to a large potential opportunity in replacing large, heavy, low-floor transit buses with potentially lighter, more-efficient models (also see Fuel Types below). Furthermore, many traditional cutaways are designed with a passenger cabin on top of an existing truck chassis, which is useful from a cost efficiency standpoint but may be less energy efficient than one designed as electric from the ground up. The large Cutaway group above also represents vehicles of many sizes, so there may be additional opportunities to replace larger, heavier vehicles that are part of this group. Finally, there are more battery electric over-the-road, high-floor coaches available today than in the recent past, and given the higher speed/higher energy commuter routes they typically traverse, (see Service Types section below) this group represents another potential opportunity.

Service Types

The distribution of the types of service (as defined by the field Primary Mode) on which the vehicles are employed are as follows:

Table 47: Service Type Distribution

Service Types	# of Vehicles	% of Total
Bus (Fixed Route)	1,368	63%
Demand Response	418	19%
Unknown/Other	209	10%
Commuter Bus	139	6%
Bus Rapid Transit	34	2%
Totals	2,168	100%

In urban settings, these routes can involve slower speeds that require less energy and a large number of stops, which is less efficient. **Table 48** shows a cross section of Service Type with Vehicle Type. This cross section shows that a large number of fixed routes are run by larger, low-floor buses, but there are still a significant number of fixed routes being run by cutaways and over-the-road coaches (OTR). As noted in the Vehicle Type section, cutaways, as a group, represent a diverse array of vehicles, so replacing cutaways with zero-emission models would have an impact on fixed routes and demand response routes, which are largely serviced by

cutaway models. More efficient OTRs would have a positive impact on the higher-speed, longer-distance (and therefore higher-energy) commuter routes as well.

Table 48: Vehicle Totals by Service Type

	Vehicle Types						
Service Types	**Bus**	**Cutaway**	**OTR**	**Auto/Van/Minivan**	**Articulated**	**Unk/Other**	**Totals**
Bus (Fixed Route)	950	276	122	5	14	1	1,368
Demand Response	0	373	0	42	0	3	418
Unknown/Other	45	114	6	44	0	0	209
Commuter Bus	40	17	81	0	0	1	139
Bus Rapid Transit	13	2	6	0	13	0	34
Totals	1,048	782	215	91	27	5	2,168

Fuel Types

The distribution of fuel type across the Commonwealth of Virginia fleets are shown in **Table 49** below.

Table 49: Vehicles by Fuel Type

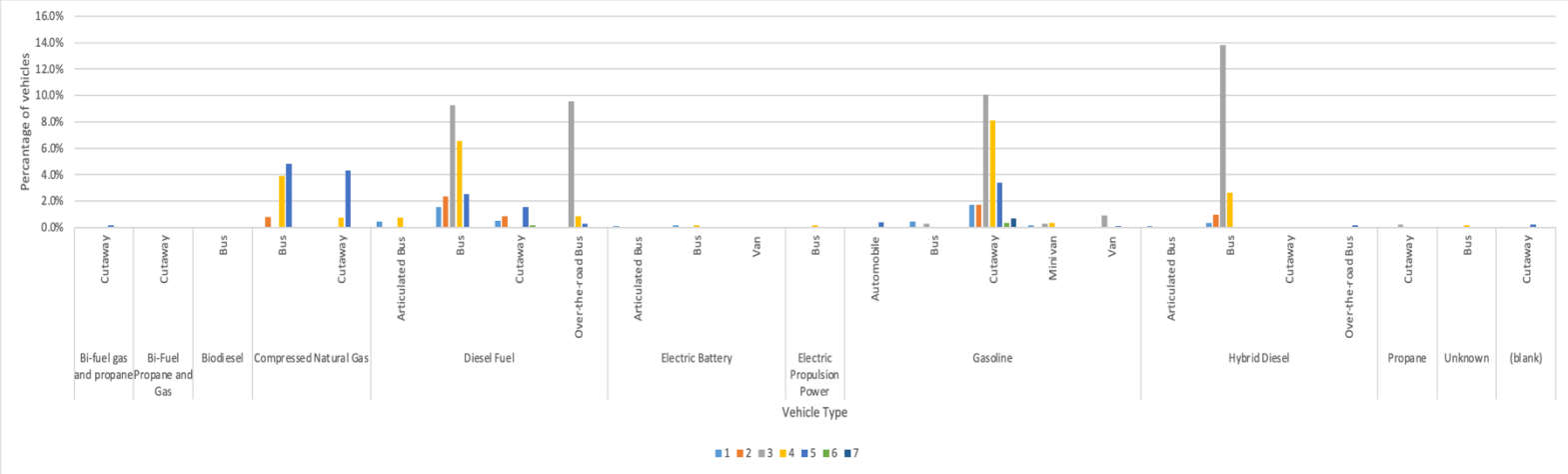
Fuel Type	# of Vehicles	% of Total
Diesel	774	36%
Gasoline	716	33%
Hybrid Diesel	359	17%
Compressed Natural Gas	290	13%
Battery Electric	12	1%
Propane or Propane/Gasoline	8	negligible*
Unknown/Other	7	negligible*
Biodiesel	2	negligible*
Totals	2,168	100%

* Less than 1% for these categories combined

This distribution is expected in a fleet that is in the early stages of transitioning to zero-emission vehicles, with a larger percentage of the heaviest emission fuel types (diesel and gasoline). Although replacing vehicles of these fuel types generally provide the biggest emissions reductions, significant reductions also can be achieved by replacing hybrid diesels and compressed natural gas (CNG) vehicles with battery electric vehicles. Many agencies across the country are doing just that.

VPI Assessment

The Vulnerable Population Index (VPI) for the Virginia Department of Rail and Public Transportation (DRPT) was assessed using vehicle and fuel types as the filter to find out which areas were the most vulnerable. As it stands now, the higher VPI numbers are mostly concentrated around CNG, diesel, and gasoline vehicles. There may be opportunity to serve more vulnerable populations by replacing CNG, diesel, and gasoline vehicles in these areas.



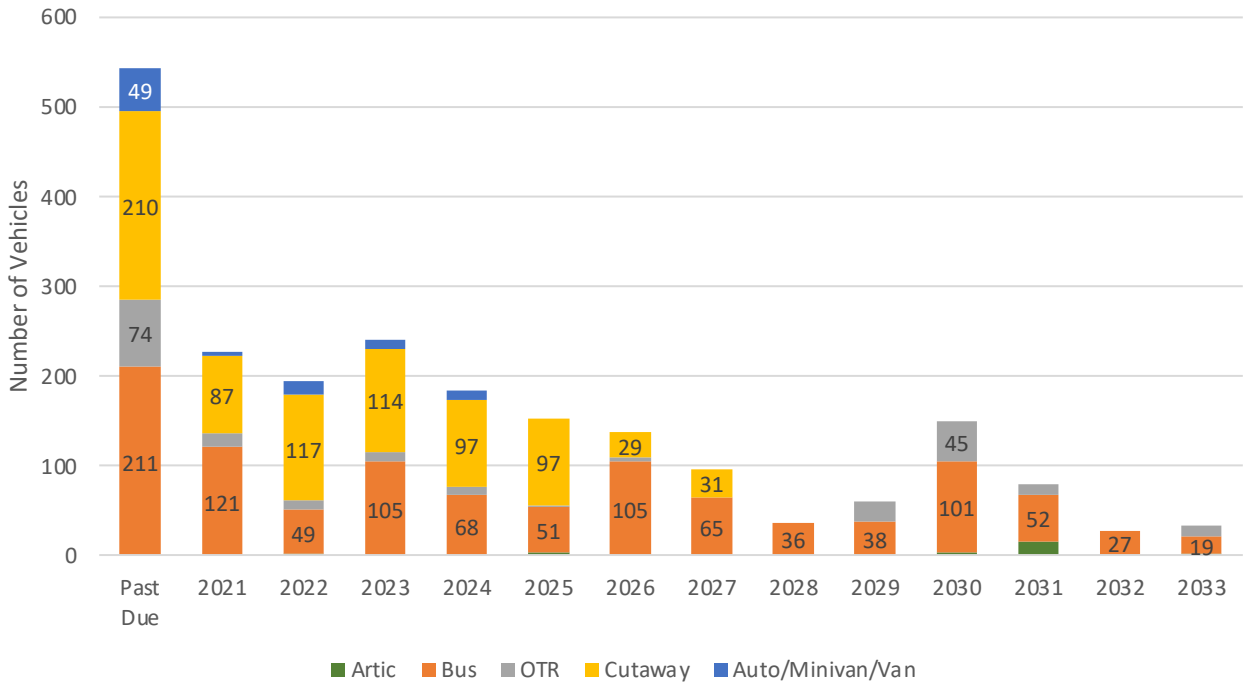
Each Census tract can contain a concentration greater than the regional threshold for each individual population group considered sensitive. Tracts above the regional concentration are divided into two categories with a score of "1" at 0% to 50% above the mean and "2" for 51% to 100% above the mean. As a result, each Census tract is considered vulnerable for between zero and seven sensitive populations with a total score between zero and fourteen. The number of vulnerable populations in each Census tract is referred to the Vulnerable Population Index—or VPI. A lower VPI indicates a less vulnerable area, while a higher VPI indicates a more vulnerable area.

Replacement Schedule

Finally, the study team looked at opportunities associated with the planned replacement schedule of existing vehicles based on service life (Minimum Service Life Policy). **Figure 73** depicts the dates at which vehicles meet their service life (in years) and are therefore due for replacement based on that policy. First, note that there is a large number of vehicles (544) that are past due for replacement based on service life, which represents an immediate opportunity, depending on what types of vehicles can be procured in the short term. Second, a large number of cutaways and low-floor buses are due for replacement in the next 2–5 years, which is a very reasonable timeframe to incorporate a large number of BEBs and charging infrastructure. Third, the potential to replace low-floor buses remains consistent throughout the entire time period studied, with another particularly good opportunity around the year 2030. Fourth, there are two primary opportunities to replace the existing OTR Coaches—one in the near term based on overdue and soon-to-be due replacements, and another in the 2029–2030 timeframe. Fifth, articulated buses currently in the fleet are generally newer, with the biggest

opportunity for replacement being in 2031. Finally, note that cutaways typically have a lower minimum service life than buses. Therefore, for those vehicles that get replaced with traditional vehicles in the short term, the replacement vehicles would come due for replacement again in the latter portion of the study timeframe.

Figure 73: Replacement Due Dates by Vehicle Type



State of Electrification

Current Electrification Deployments

In the Commonwealth, there are several active electrification projects, all involving battery electric low-floor transit buses (BEBs). A total of 25 vehicles have been ordered to date. Hampton Roads Transit currently has six 40-foot Proterra buses in their fleet. The Town of Blacksburg has five New Flyer buses, consisting of three 35-foot and two 60-foot vehicles. Finally, The City of Alexandria (DASH) has a total of six BEBs in operation, consisting of three 40-foot Proterra buses and three 40-foot New Flyer buses. The agency also has four 60-foot New Flyer and four 40-foot Proterra vehicles on the way. This will bring their total BEB fleet size to 14 vehicles.

Electrification Goals, Policies, and Barriers

Hampton Roads Transit, the Town of Blacksburg, and the City of Alexandria have active fleets of BEBs. These three agencies represent 8 percent of the 39 agencies studied. All three have defined goals to convert their respective fleets to electric, with two of the three agencies having written transition plans. All three of these agencies cite the need to reduce emissions to improve air quality and address climate change as their primary motivations to electrify their fleets.

In addition to these three agencies, the study team surveyed the complete list of 39 agencies to gain their additional perspective and plans for electrification. Of the agencies that responded that they do not currently operate any zero-emission transit buses or paratransit vehicles, 37 percent are in discussions or are considering how to approach a ZEB policy. Furthermore, the following concerns were cited regarding integrating BEBs into their fleet (**Table 50**).

Table 50: BEB Integration Concerns

Immediate Concerns in Integrating BEB's	# Agencies Citing the Concern
Additional funding for vehicles	24
Impact to operations and maintenance	17
Training	13
Understanding the differences in technologies and benefits	12

Based on the small number of agencies that have experience with deploying ZEBs in the Commonwealth of Virginia and the responses received pertaining to concerns for electrification implementation, we can conclude that there is a need for explicit information and additional insights on the subject of transit electrification, the available funding, and overall transition and deployment planning.

Transit Safety

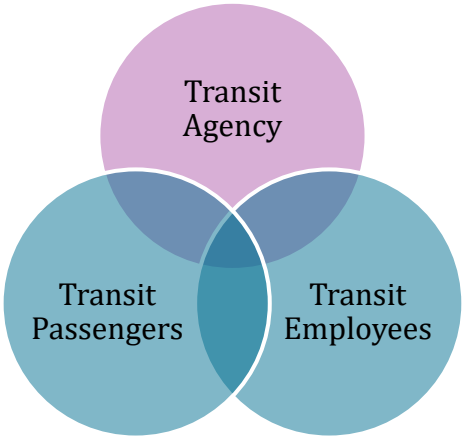
Overview and Definition

Safety, in its broadest definition, describes a condition of being protected from harm or other danger. As a part of everyday life, safety is determined by how an individual experiences and perceives the condition of their surroundings—whether through the built environment or the behavior and actions of people around them. Because the ability to travel is inherent to and necessary for maintaining a high quality of life, the way that people experience travel safety is critical in deciding which modes to use.

This is where safety diverges slightly from its partner terminology, security; a distinction that is small but important. Security has a similar definition to safety, where they both describe a state of being protected from harm; however, unlike safety, which is more about perception, security describes the protection or tactics that are used to secure individuals from external threats that are likely to cause harm. In its simplest explanation, security helps to control the risk-causing factors that affect an individual feeling of being safe.

Through the lens of transit, the assessment of safety and security starts as an individual begins their journey to a transit facility or transit vehicle and continues through the entirety of the trip. For the purposes of this study, an understanding of transit safety is built around two groups of people—the riders and the employees. Transit security is built around the transit agencies. Each of these groups is assessed further in its role in transit safety and security, the guidance/policies that may exist that govern the behavior and conditions of each, and the individual groups interact with each other.

Figure 74: Transit Safety Group Interactions



What About COVID-19?

The COVID-19 pandemic vastly altered the landscape of public transit within the past 2 years. The new reality of transit services required agencies to implement a variety of new and more-vigorous processes to protect riders and employees from exposure to the virus, while still serving the community at large. As a part of this process, the impacts of COVID-19 on transit safety and security will be identified and discussed; however, the focus of the discussion regarding COVID-19 and its impact will be more on the lessons learned through the pandemic that will support transit systems becoming more resilient in the future.

About This Chapter

For this memorandum, this topic area aims to establish information that is readily available in terms of literature, procedures, policies, and requirements. Thus, much focus for this chapter is given to transit agencies and related documentation and procedures that help to control risk-causing factors from the agency level. The next steps for this topic area will include interviews with both passengers and employees to further understand the implications of the built environment and surrounding persons on transit perception.

Literature Review

Establishing the baseline conditions for transit safety and security, as defined as a part of this chapter, requires an initial review and understanding of existing reports, newspaper articles, surveys, and interviews related to transit safety. The following section includes major takeaways from the some of the literature that was reviewed and an assessment of relevancy to the three groups identified (passengers, employees, and agencies).

Traveling by Transit is Much Safer than Traveling by Car

- **Name:** American Public Transportation Association (APTA)
- **Groups Impacted:** Passengers

APTA found that the chance of being in an accident decreases by more than 90 percent when taking public transit instead of driving, meaning that transit is approximately 10 times safer than automobile. Using data from the National Highway Traffic Safety Administration (NHTSA) and Federal Transit Administration (FTA), researchers found that metro areas where residents average more than 40 bus or train trips a year have about half the traffic fatality rates of metro areas where residents average fewer than 20 trips annually.

Travel Safety is the Mediator of the Relationship between Service Quality and Perceived Accessibility

- **Name:** Public Transport Quality, Safety, and Perceived Accessibility, April 2020
- **Groups Impacted:** Passengers, Agencies

This article, published in a sustainability journal in 2020, aims to consider dimensions of service quality within public transport as fundamental determinants of perceived accessibility. The two quality attributes are 1) perceived attributes that are direct experiences of the service and 2) physical attributes that need not involve direct experiences of the service.

Based on the article, it was found that service quality was positively related to perceived accessibility. When the transit service was valued as a high-quality one, service dimensions that contribute to the perception of accessibility include functionality, information, comfort, and cost. Of the service dimensions, service quality was found to be the most influential, followed by information and cost. Low-quality information and low comfort were most likely to increase risk calculations and feelings related to personal safety concerns, which both affect perceptions of accessibility. These relationships may be explained by aspects such as available seating; adequate information at critical junctures, stops, and terminals; or modern, clean, and well-lit interiors. Cost was the service attribute least important for perceived accessibility and thus for the perception of safety.

As public transit does not always serve as a door-to-door option for travel, it is important to emphasize a focus on the attributes that are related to people's perceived ease of travel accessibility. This highlights the importance of service quality and its effect on travel safety perception.

Certain Aspects of the Built Environment Affect the Perception of Safety More than Others

- **Name:** Evaluating Transit Stops and Stations from the Perspective of Transit Users, California Department of Transportation, August 2007
- **Groups Impacted:** Passengers

In 2007, 12 transit stops and stations around metropolitan Los Angeles were used to distribute a passenger survey with a goal to understand the factors that influence transit passengers' evaluation of the facilities. The survey asked 749 transit passengers to assess the level of importance of multiple service features, and their level of satisfaction at the stop or station where the survey was administered under the current conditions on a four-point scale from "very important" to "not important," and "strongly agree" to "strongly disagree," respectively.

For each of the 16 questions asked, the passengers were asked to first rank the importance of the statement. The passengers were then asked to rank their personal satisfaction of each of the statements for those twelve stops and stations. 5 of the 16 questions asked were related to safety and security. The safety-specific questions and the relative ranking of importance is shared in **Table 51**.

Table 51: Safety Importance and Satisfaction

Safety Related Question on the Survey	Importance Ranking (# out of 16)	Satisfaction Ranking (# out of 16)
I feel safe here during the day.	2	3
I feel safe here during the night.	1	13
There is a way for me to get help in an emergency.	4	15
This station is well lit at night.	5	7
Having security guards here makes me feel safer.	10	5

Out of the five safety-related questions, four were prioritized as the most important statements of the 16. The top two prioritized safety questions in terms of importance to passengers were "safety at night," which received the highest importance ranking (78 percent), followed by the "safety during the day" (77 percent). This indicates that passengers utilizing transit at these stops felt that safety and security is very important when making a transit trip; in fact, the two most important aspects to riders was how they felt regarding safety during the day and at night. Following closely behind the top two responses were "there is a way for me to get help in an emergency" and "the station is well lit at night." Interestingly, the presence of security guards at the facilities was not ranked as high in terms of importance.

Crime Affects Transit Systems in a Different Way than Other Modes

- **Name:** A New Transit Safety Narrative, Victoria Transport Policy Institute, 2014
- **Groups Impacted:** Passengers, Agencies, Employees

The *Journal of Public Transportation* published an article in 2014 that discusses the safety narrative around transit and how transit agencies can help create a new transit safety narrative by better communicating transit's overall safety and security impacts and providing better guidance concerning how users and communities can enhance transit safety and security.

In general, comparing crimes that affect transit versus automobiles is challenging due to the varied risks. For example, transit passengers may be more likely to face theft or personal assault risks while motorists may be more likely to face risks of road rage, vehicle assault, vehicle theft, and vandalism. Both transit and automobile users face similar risks while walking to and from the vehicles. The study, however, suggested that increased transit travel by responsible passengers tends to reduce total crime, and there is much that individuals can do to increase their security.

Based on the study, it was found that fare evasion was the highest-reported crime year-over-year on transit properties (vehicles, stations, and park-and-rides) between 2000 and 2009 (**Table 52**)**.** Fare evasion is a different category of crime than crimes that directly affect transit riders.

The study also found that between 2000 and 2009, most other types of crimes had decreased, such as theft, vandalism, and assault. **Table 53** shows the ratio between violent crimes reported on transit compared to total crime from 2000 to 2009. This study only focuses on the data available for the years 2000 to 2009; while there is updated data available via NTD, the following tables are from a report that uses these years only.

Table 52: Reported Crimes on Transit Property 2000-2009

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Transit trips (billions)	9.3	9.7	9.6	9.4	9.6	9.8	10.0	10.2	10.5	10.4
Murder	12	16	0	4	1	1	2	4	9	9
Forcible rape	37	37	65	25	24	23	5	1	4	3
Robbery	3,480	3,308	1,641	1,408	1,561	1,656	2,222	2,634	2,799	2,849
Aggravated assault	2,217	2,286	2,560	1,638	1,330	1,332	1,768	2,066	310	300
Theft	13,393	13,636	12,843	8,146	7,847	6,007	6,409	7,943	8,446	9,267
Vehicle theft	2,112	1,909	2,117	1,800	1,584	1,361	1,051	1,756	1,442	1,008
Arson	50	44	23	23	42	27	26	26	0	1
Other assaults	2,799	2,441	1,589	1,752	1,546	1,530	2,141	2,266	2,748	2,702
Vandalism	7,312	2,971	1,130	953	994	1,298	1,748	1,751	1,493	1,184
Trespassing	4,303	4,597	2,278	4,126	3,162	3,220	4,503	4,919	6,402	6,296
Fare evasion	53,863	47,258	74,385	69,950	103,156	129,590	126,092	135,602	197,819	249,004

Table 53: Violent Crimes Reported on Transit Compared to Total Crime Ratio

	Murder	Forcible Rape	Robbery	Aggravated Assault
Reported on Transit as percent of all crime (2015-2019)	0.058%	0.003%	00.697%	0.036%

Safety Should be a Core Value of Transit Agencies and Requires Strong Management Commitment and Enforcement of Standards

- **Name:** Improving Safety Culture in Public Transportation, The National Academies of Sciences, Engineering and Medicine, 2015
- **Groups Impacted:** Agencies, Employees

This report aimed to provide public transportation agencies a working definition of the culture of safety and the key components that drive culture at the agency level. The article presented methods and tools for assessing safety culture, identified performance indicators and reporting practices to support improved safety culture, presented best practices in use by public transit and other organizations, and provided guidelines that can be used to initiate and build a program for improving safety culture by public transportation agencies.

The research team's methodology to collecting data from the public transportation industry included a transit stakeholder survey, a selection of mini-case studies based on stakeholder recommendations and performance indicators, and mini-case studies of nine transit agencies that are considered by the transit community to have a positive safety culture. This included interviews with employees at all levels.

The study identified best practices regarding prioritizing the culture of safety. These are listed below along with the most common components of safety culture:

- Direct employee involvement
    - Requiring strong leadership and management commitment

- Organization
  - Involving unions continuously in the safety process (where employees are unionized)
- Reporting
  - Maintaining an effective reporting system, with visible action taken on issues reported, and ensuring timely responses to concerns and issues
  - Enforcing high performance standards
- Safety rules and procedures
  - Empowering individuals at each organizational level to be responsible for safety
  - Providing adequate resources for safety
- Safety training
  - Emphasizing learning, education, and training
- Key safety performance indicators
  - Monitoring performance continuously
  - Using leading and lagging safety indicators to gauge the effectiveness of safety programs on employee behavior
- Management commitment
  - Maintaining safety as a core value
  - Demonstrating leadership behaviors that encourage mutual trust between management and employees
- Recruitment
- Safety communications
  - Ensuring open, honest, and effective communication within the organization and encouraging a questioning environment
- Safety culture survey
- Planning
- Recognition and awards
  - Treating employees fairly

As a part of this study, a transit stakeholder survey was completed by 137 respondents representing various transit agency safety professionals, national and local unions representing transit employees, federal agency and transit industry association representatives, and state oversight agencies. The participants were asked to rank the components of safety culture in order of importance. There were 13 components of safety culture listed in this section of the survey, with the respondent being allowed to add up to four more. Each statement was ranked as "very important," "important," "moderately important," "of little importance," "unimportant," or "don't know." Numerical scores were assigned, with 1 for "very important" through 5 for "unimportant." The smaller the average score, the higher the ranking, with an average of 1 representing a perfect score. The list of the key elements and their respective ranking is shown in **Table 54**.

Table 54: Core Safety Value Elements

Key Elements Ranked by Total Average Importance	Average Ranking
Safety is recognized as the highest organizational priority, and both management and employees are committed to it.	1.32
Adequate training is provided so that employees understand how to perform their jobs in a safe manner.	1.66
There is open, frequent, and effective communication on safety.	1.71
Adequate financial and human resources are dedicated to ensuring the safety and health of employees.	1.81
Management and employees are willing to interrupt schedules and service for safety reasons.	1.82
There is competence within the organization to draw appropriate conclusions from safety information.	1.83
The organization takes action visible to employees on all reported safety issues.	1.87
The organization collects and analyzes relevant data and actively disseminates safety information.	1.90
There is significant employee involvement in the continuous improvement of safety policies and rules.	1.90
The culture of safety is deeply ingrained within the organization, and no leadership transition within either management or union will likely change that commitment.	1.90
Accidents are reviewed from the perspective of future prevention rather than focusing exclusively on finding someone to blame.	1.96
There is a high level of trust between management and frontline staff.	1.99
Employees are encouraged to report near misses and other safety events without fear of blame or retribution.	2.00
Where there is union representation, the union is continually involved in the safety processes as a full partner, including in joint safety data collection, analysis, and problem solving. Where there is not, the same result is sought—shared ownership with and responsibility by employees.	2.03
Employees are rewarded for reinforcing safety at work.	2.23

This study also shared various tools that should be leveraged to assess the state of safety culture of transit agencies. These included direct observation, interviews, focus groups, surveys, and performance indicator tracking.

Federal Efforts

In July 2018, FTA published the Public Transportation Agency Safety Plan (PTASP) Final Rule (49 C.F.R. Part 673), which requires certain operators of public transportation systems that receive federal funds under FTA's Urbanized Area Formula Grants to develop safety plans that include the processes and procedures to implement Safety Management Systems (SMS).

What are PTASPs?

PTASPs are an important tool in transit safety as they consider administrative policies while tracking employee incidents as well as rider safety. PTASPs allow agencies to look at their responsibilities within transit safety, especially as it relates to equitable treatment of employees and passengers.

At a minimum, each safety plan created by transit agencies required:

- An approval by the agency's Accountable Executive and Board of Directors (or an equivalent authority)

- The designation of a Chief Safety Officer
- The documented processes of the agency's SMS, including the agency's Safety Management Policy and processes for safety risk management, safety assurance, and safety promotion
- An employee reporting program
- Performance targets based on the safety performance measures established in FTA's National Public Transportation Safety Plan (NSP)
- Criteria to address all applicable requirements and standards set forth in FTA's Public Transportation Safety Program and the NSP
- A process and timeline for conducting an annual review and update of the safety plan; a rail transit agency's safety plan also must include or incorporate by reference an emergency preparedness and response plan or procedures

Who is Required to Have a PTASP?

PTASPs are required for transit agencies that are recipients or subrecipients of FTA financial assistance through Urbanized Area Formula Grants as well as operators of rail systems subject to FTA's State Safety Oversight Program. There are several entities who are not required to have PTASPs including commuter rail service that is regulated by the Federal Railroad Administration (FRA), passenger ferry service that is regulated by the US Coast Guard, and operators of public transportation systems that only receive financial assistance under the Formula Grants for Enhanced Mobility of Seniors and Individuals with Disabilities Program and/or Formula Grants for Rural Areas Program. To reduce the burden to small and rural operators, FTA has deferred the applicability of the requirements of the rule for approximately 2,000 small operators, including several transit agencies in Virginia.

While there are agencies within the Commonwealth of Virginia that are not required to prepare a PTASP, safety must remain a high priority for the employees and passengers.

Tier I (Virginia)

Three agencies in the Commonwealth completed their own PTASP (Hampton Roads Transit [HRT], GRTC, and Potomac and Rappahannock Transportation Commission [PRTC]). These three Tier I agencies finalized their PTASP in July 2020, following the FTA guidelines requiring certain operators of public transportation systems that receive federal funds under FTA's Urbanized Area Formula Grants to develop safety plans that include the processes and procedures to implement SMS. The following sections describe common safety training, reporting, and performance information that is included in Tier I PTASPs.

Safety Training

Many of the Tier I PTASPs provide information regarding new hire employee training as well as refresher training. Typically, formal training programs are conducted entailing in-class activities, curriculums, training manuals, lesson plans, field exercises, drills, communications, and testing. Additionally, training programs can be developed by managers to address safety topics and concerns that may be faced by employees during the performance of their daily duties. Refresher training is conducted annually for all transit employees.

Safety Reporting

In many Tier I agencies, safety department staff work with employees to facilitate the reporting of hazards. Employees are typically required to report any unsafe conditions to their departmental director. Agencies have established various ways to report safety incidents including, but not limited to, electronic submission, an anonymous safety suggestion box, or an anonymous safety hotline that allows them to leave a message for their respective safety department. Once a safety concern has been received, the respective safety departments

typically coordinate with management from the appropriate department to perform a review and determine the best course of action.

Safety Performance

Tier I transit agencies have developed annual safety performance targets based on safety performance measures under the NSP. These agencies will evaluate the safety performance targets annually and the updated targets will be shared with the necessary government entities.

Tier II (Virginia)

The Virginia Statewide PTASP for Small Public Transportation Providers is a comprehensive plan outlining the SMS programs at 15 small transit agencies in the Commonwealth. A small transit agency is defined as a non-rail, fixed-guideway agency that receives federal financial assistance under 49 U.S.C. 5307 and runs 100 or fewer vehicles in total during peak revenue service. This comprehensive plan is required by 49 United States Code 5329 and 49 Code of Federal Regulations (CFR) Part 673. The following transit agencies are covered by the Statewide PTASP:

- Blacksburg Transit
- Blue Ridge Intercity Transit Express (BRITE)
- City of Bristol Virginia Transit (Bristol Transit)
- Charlottesville Area Transit (CAT)
- Fredericksburg Regional Transit (FRED Transit)
- Greater Lynchburg Transit Company (GLTC)
- Greater Roanoke Transit Company (Valley Metro)
- City of Harrisonburg Department of Public Transportation (HDPT)
- Jaunt, Inc.
- District Three/Mountain Lynx Transit
- Petersburg Area Transit (PAT)
- Radford Transit
- Suffolk Transit
- Williamsburg Area Transit Authority (WATA)
- Winchester Transit (WinTran)

Virginia Transit Equity and Modernization Efforts

With guidance from the Virginia Department of Rail and Public Transportation (DRPT), eight transit agencies in the Commonwealth were selected to serve as case studies for this topic area. These agencies vary in service area, populations served, modes, and ridership and will be described based on these characteristics.

Many of the agencies included in the case studies have information regarding safety and security available on their website, in plans they have written, or in their PTASP. Using these resources and a desktop publishing review of the eight case study agencies, readily available information regarding safety and security measures are shared below. The Vulnerable Population Index (VPI) represents the region's vulnerable people and groups on a scale of 1 to 7. A higher index (closer to 7) represents a higher concentration of vulnerable populations compared to the rest of the Commonwealth.

The transit service transects will guide the breakdown of agencies within the transit safety analysis. The transit service transects leverage sociopolitical boundaries to provide an understanding of transit service area characteristics. These transects are represented through a range of service from demand responsive to fixed-

route buses to rail systems. Additional characteristics such as population and employment density are provided for context of reasonable service characteristics.

Table 55: Virginia Transit Case Study Information

Transit Service Transect	Annual Trips	Modes	Number of Vehicles	Service Area	Approximate Population	Vulnerable Population Index
Demand Responsive	<500,000	Demand Response/Paratransit/Deviated Fixed Route	20 – 60	Single town/multi-county	40,000 – 100,000	2 – 5
Fixed Route	500,000 – 2 million	Demand Response/Paratransit Fixed Route	20 – 100	Medium-sized cities/suburbs	40,000 – 500,000	2 – 5
Enhanced Fixed Route	>2 million	Fixed/Commuter Route/High-Capacity Transit	100 – 400	Regional metropolitan areas	150,000 – 2 million	3 – 4

Demand Responsive Transit Agencies

Safety and security measures that various demand responsive transit agencies in Virginia include:

- Surveillance cameras on vehicles and around facilities
- Audio and visual monitoring devices at administrative and maintenance facilities
- Part-time security officers stationed in shifts at various facilities
- Local alert system to notify service updates, closures, or announcements directly to email addresses or phones
- Safe Rider Guide with tips and rules for safe transit riding (available in multiple languages)

Fixed-Route Transit Agencies

Safety and security measures that various fixed-route transit agencies in Virginia currently provide include:

- Surveillance cameras on vehicles and around facilities
- Fenced/gated parking areas and facilities
- Safe Rider Guide with tips and rules for safe transit riding (available in multiple languages)
- A customer newsletter that can be subscribed to via the website
- An adopted Passenger Code of Conduct that governs behavior on all property, facilities, or equipment owned, leased, or controlled by the agency/provider
- Email and phone number to report safety problems
- Two-way radios used on vehicles so drivers can communicate with dispatch in event of an emergency
- Panic buttons on vehicles for the drivers to use in event of an emergency
- Onboard intelligent transportation systems (ITS) used onboard vehicles for geographic tracking features that can show real-time location of vehicles

Enhanced Fixed-Route Transit Agencies

Safety and security measures provided by enhanced fixed-route transit agencies in Virginia include:

- An adopted Passenger Code of Conduct that governs behavior on all property, facilities, or equipment owned, leased, or controlled by the agency/provider
- Safe Rider Guide with tips and rules for safe transit riding (available in multiple languages)

- Online safety videos regarding transit safety (Passenger Safety, On Board & Beyond safety video)
- Editable website banner with urgent news for riders and service alerts
- Visible onboard emergency instructions
- Strict standards for passenger and parking facilities that ensure they are well-lit, properly monitored, maintained, and patrolled
- Alert systems that allow transit agencies/providers to contact residents who opt in during an emergency by sending an email or text message

Other Related Efforts

Beyond regularly communicated materials, there are several examples of agencies in the Commonwealth who have conducted surveys and studies to further understand the relationship between safety and the services offered. Examples of such surveying efforts are documented below.

Arlington Transit Satisfaction Study, June 2019

In 2019, Arlington Transit completed a satisfaction survey including riders and non-riders. They asked the riders about the importance of safety in their decision to use transit. Arlington Transit found that public transit ridership is affected by perceived safety issues: when riders feel safe on public transit, they are more likely to ride. While perceived safety risk is found to significantly deter non-bus riders and significantly impact frequency of public transit use, they found that other factors, such as basic service level, are more influential.

The safety of areas around transit stops also is found to have an impact on ridership. Perceptions of public transit safety largely have to do with how safe one feels on the street at night, which depends on neighborhood factors as well as gender and age.

A few of the safety and security measures that Arlington Transit currently implements on vehicles and at stations include:

- Onboard security cameras
- Safety, courtesy, and security tips on their website
- Operation of a “See Something, Say Something” nonemergency phone number
- Access to local Police Department email address
- An alert system that allows the transit agency to contact residents who opt in during an emergency by sending an email or text message
- An annual program that emphasizes the education of motorists and pedestrians through mass media

Richmond 2019 Passenger Survey

GRTC completed a passenger survey in 2019 to gather information from its passengers on its fixed-route services. 1,513 riders were surveyed who participated in identifiable bus boardings. The survey included asking the survey respondents to consider 10 possible changes to GRTC service, and to rank their three preferred options by marking them 1 for first priority, 2 for second priority, and 3 for third priority. The 10 choices included:

- Cost: GRTC kept fares low
- Schedules at Bus Stops: Your bus stop had information about scheduled arrival times
- Shelters: Your bus stops had shelters, benches, etc.
- Frequency: GRTC buses ran more frequently on WEEKDAYS
- Weekends: GRTC buses ran more frequently on WEEKENDS
- Reliability: GRTC buses had better on-time performance
- Comfort: GRTC buses had softer seats, looked spotless

- Destinations: GRTC service included bus routes to _____ (fill in location)
- Security: Regular security patrols at transit centers
- Website: GRTC had a more mobile-friendly website and text alerts

Keeping fares low was a priority for half of the respondents, suggesting that while riders felt GRTC fares were reasonable now, they might not feel the same way with a fare increase. For the weighted percent of answers, security received the following percentages:

- 1st priority: 12 percent
- 2nd priority: 8 percent
- 3rd priority: 7 percent

As a comparison, cost was the first priority for 36 percent of participants, second priority for 8 percent of participants, and third priority for 6 percent of participants.

Virginia Transit Equity and Modernization Efforts Agency Survey

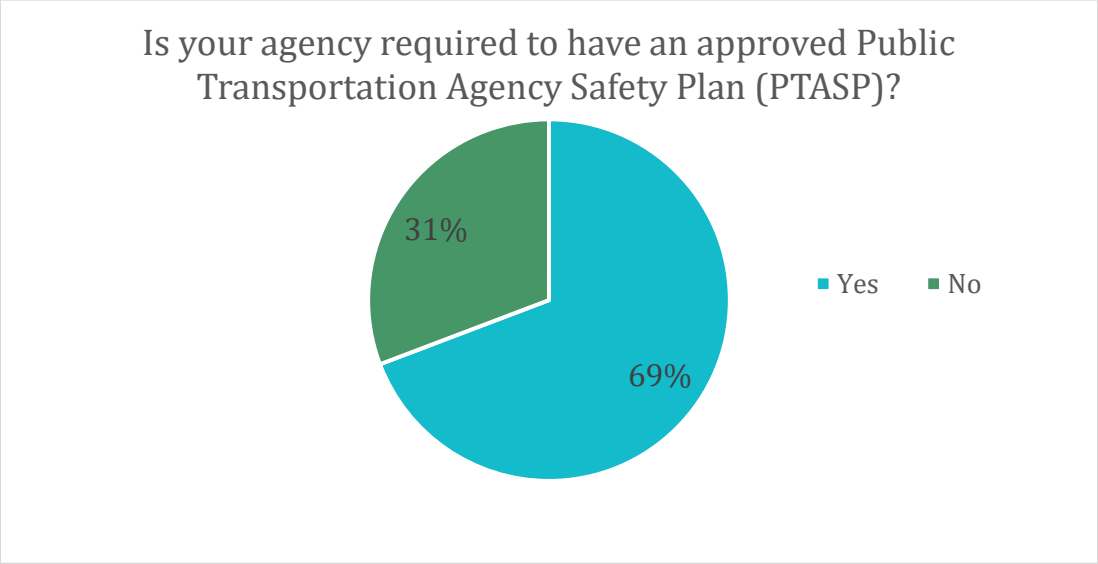
As a part of this study, a transit agency survey that was sent to transit agencies across the Commonwealth, including agencies that offer demand response, fixed-route, and enhanced fixed-route services. Approximately 45 responses were collected.

The survey questions pertaining to transit safety were used to gather information directly from agencies. Questions were asked regarding whether they have a current and approved PTASP, areas to describe their current system for communicating safety protocols to frontline employees, and how they record safety incidents as well as questions regarding the common safety concerns they have from their customers. One question was added regarding COVID-19 safety measures that are planned to continue post-pandemic. The results of the transit safety survey questions are included below.

Survey Results

The following figures provide a summary of the responses received from the survey. **Figure 75** shows that 69 percent of the participating agencies have a current and approved PTASP. For those that have a PTASP, the agency was asked how safety policies outlined in their PTASP are communicated to their frontline employees. As mentioned previously, there are numerous entities who are not required to have PTASPs, which include commuter rail service that is regulated by FRA, passenger ferry service that is regulated by the US Coast Guard, and operators of public transportation systems that only receives financial assistance under the Formula Grants for Enhanced Mobility of Seniors and Individuals with Disabilities Program and/or Formula Grants for Rural Areas Program.

Figure 75: PTASP Status



Transit agency employees are integral resources in understanding the concerns or issues or its riders. To gather a better understanding of safety, the survey participants were asked three questions regarding how safe their agency is perceived to be, what the common safety concerns from their customers are, and what COVID-19 safety measures they plan to continue utilizing. The results of these responses can be found below in **Figure 76**, **Figure 77**, and **Figure 78**.

Figure 76: Transit Agency Safety Perception

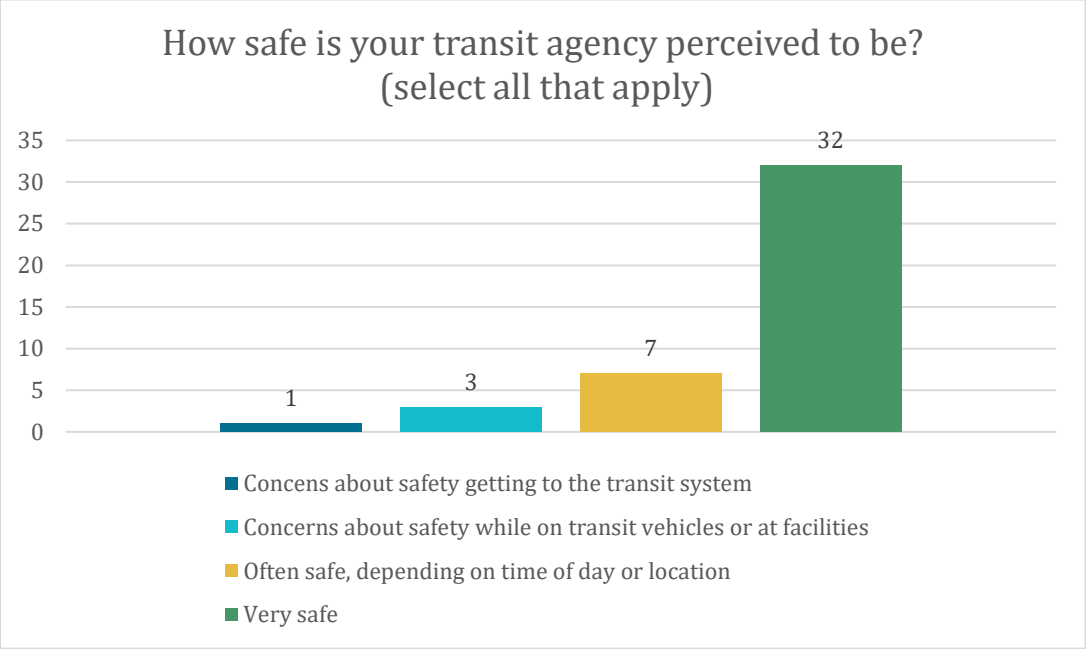
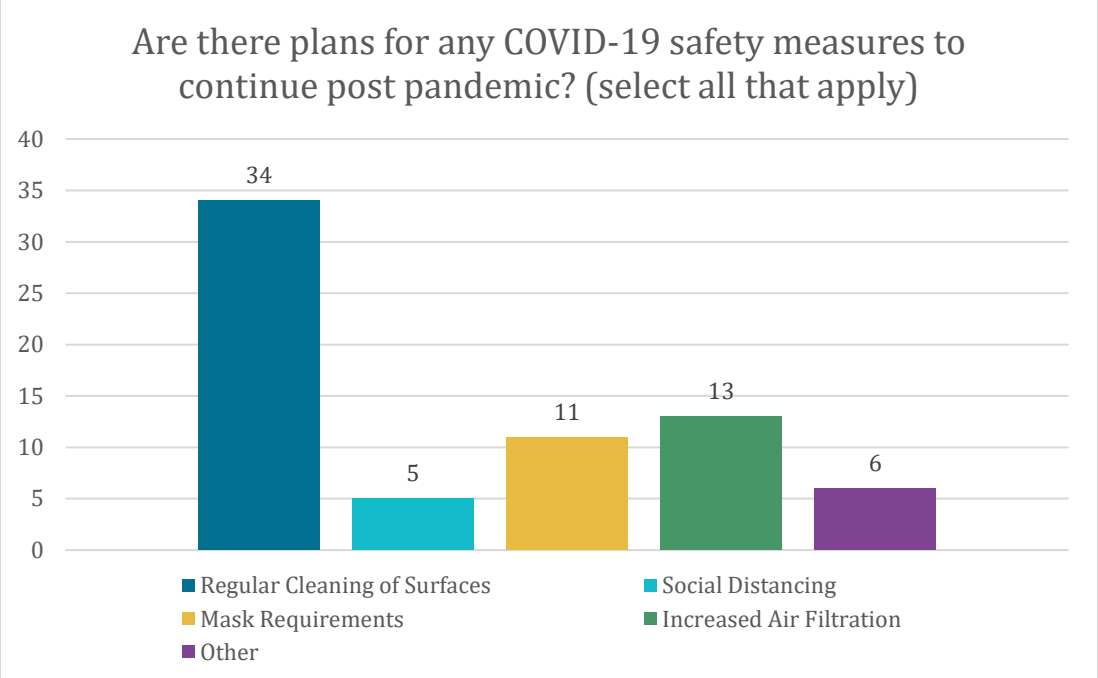


Figure 77: Transit Safety Concerns

Figure 78: Continuing COVID-19 Safety Measures



The survey participants were asked how they currently communicate safety protocols to transit employees. Many of the agencies communicate safety protocols through regular staff safety meetings, posted memos, and real-time safety concerns that can be sent out to employees through a communication system.

Table 56: Current System for Communicating Safety Protocol

Transit Service Transect	Please describe your current system for communicating safety protocol to frontline employees.
Demand Responsive	• Internal director reviews operating policy and procedures with all new drivers • Safety meetings with supervisors and the division director • Safety protocols are communicated through monthly or quarterly mandatory safety training meetings • Memoranda regarding safety are provided to employees • Proper forms are used for recording and reporting safety incidents ○ Incidents reports must be filled out anytime an incident has occurred while boarding, unloading and on a vehicle • Brief messages about real-time safety concerns (storms, flooding, road closures, etc.) are sent through onboard tablets
Fixed Route	• Radio, telephone, and text messages are utilized to contact employees • The established safety plan protocols are provided and discussed with employees • Coordination with internal risk management staff from local municipality to record incidents and accidents • Monthly or quarterly meetings to review incidents and accidents reports • Communicate safety protocols via internal memos to staff
Enhanced Fixed Route	• The established safety plan protocols are provided and discussed with employees

Table 57: Current Process to Communicate PTASP Policies

Transit Service Transect	How do you communicate safety policies outlined in your PTASP to your frontline employees?
Demand Responsive	• Formal and informal daily/monthly meetings (including meeting with drivers only) • Yearly meetings with testing procedures • Posted notices in areas that are frequented by employees (electronic monitors with scrolling announcements), company newsletters, posters • Electronic communication • Annual training for all staff as well • New driver orientation training • Ongoing training
Fixed Route	• Weekly meetings between supervisors and operations director • Daily and monthly safety meetings with employees • General training to all staff, including management and frontline staff • Classroom training as well as behind-the-wheel training for drivers • Onboarding, training, and safety audits done by insurance agency • Information discussed during biannual employee evaluations • TAPCO and PASS training • All employees have a copy of safety plan
Enhanced Fixed Route	• Email, SMS text alerts, and bus announcements • Physical postings in staff areas • In-person and virtual training for employees • One-on-one meetings with staff • Operator/staff training, safety meetings, employee training, and continuous annual reinforcement

Part of the purpose of the Transit Equity and Modernization Study is to determine the Commonwealth of Virginia's role regarding transit safety. Understanding how transit agencies currently communicate and coordinate with local governments and the Virginia Department of Rail and Public Transportation (VDRPT) will help achieve this goal. The following table shows the various ways transit agencies currently coordinate with local governments and DRPT regarding safety in and around transit facilities.

Safety communication/coordination between an agency and an SSOA currently exists within the Commonwealth. For example, HRT is a rail transit agency (RTA) subject to FTA State Safety Oversight rule 49 CFR 674 as well as 673. DRPT is the FTA certified State Safety oversight agency (SSOA) with oversight of HRT's Tide light rail system. As such, HRT is required to communicate and coordinate with the DRPT SSOA on all safety and security issues related to the Tide. This is an example of the current communication and coordination between select transit agencies and the DRPT SSOA program.

Table 58: Agency Coordination with Government and VDOT

Transit Service Transect	Describe how your agency coordinates with local governments and DRPT on improving safety in and around bus stops and stations.
Demand Responsive	• Direct communication with local governments regarding safety ○ Public Works, Law Enforcement, Town Manager, Town Council • Rely on local municipality for communication with DRPT • DRPT attends MPO meetings in which safety issues are discussed with respect to road projects • Ridership data is provided to DRPT per their request • Our agency is a local government agency; if there is an issue around bus stops, appropriate law enforcement personnel would be notified to monitor the situation
Fixed Route	• Drivers ask administrative personnel to contact local government offices ○ Public Works, Parks and Recreation, City Community Development Department, Police Department • Agency board members assigned to safety committee • Communication is relayed to DRPT related to right-of-way concerns and line of sight • Coordination with DRPT and other stakeholders regarding construction projects in the area to ensure that any upgrades are conducive to public transportation
Enhanced Fixed Route	• Ongoing coordination meetings are held with DRPT and other large, regional transit providers • Staff-level monthly meetings • Communication with local municipality departments such as Public Works for issues such as: park-and-ride maintenance, bus stops, crossings, crosswalks and signals, signage, lighting, shelters, stops • Local communication is used for improving bus stop accessibility and safety • Submit requests for assistance to local law enforcement for crime, vagrancy, and loitering • Cooperation with municipal local law enforcement and hiring of off-duty police officers • Communication with VDOT and DRPT when new projects are being developed • Collaboration with DRPT on long term plans to identify existing locations that could use improved access

Safety Events

This section describes the baseline conditions found regarding safety statistics in Virginia during the past 5 years, and how Virginia compares to select other states. The frequency, location, and cause of the safety events were gathered. The safety data from NTD also was gathered that describes each safety incident during the past several years.

National Transit Database Safety Events

The information in the following tables show the number of reported safety events in the entire Commonwealth of Virginia. It is important to note here that the safety events reported are not indicative of all instances where passengers or employees felt unsafe.

Given the impact of COVID-19 on transit ridership in 2020 and 2021, the measurable changes over time will use the differences between 2015 and 2019. Twenty agencies within the state reported their safety incident information to NTD, which was used in the development of these tables. The following three tables show the safety-related incidents in Virginia as reported to the NTD. **Table 60** shows the number of collisions in the state during the past 7 years. Between 2015 and 2019, the number of collisions and reported injuries have increased slightly. Collisions have increased 24 percent during this time and reported injuries have increased 6 percent. Most events and injuries are experienced by larger transit agencies providing various service types over large service areas. The transit mode that experienced the highest rate of events and injuries was fixed route. Demand response has the least number of events and injuries, which was almost 0 across the state every year that data was accessible.

Table 59: Collisions (Country-wide) 2015-2021

	2015	2016	2017	2018	2019	2020	2021	Percent Change (2015–2019)
with Motor Vehicle	5,560	5,796	5,538	5,664	5,680	4,213	1,460	2%
with Person	776	741	806	784	852	628	183	10%
with Fixed Object	171	196	186	193	225	142	57	32%
with Rail Vehicle	27	28	32	32	31	26	7	15%
with Bus Vehicle	59	60	56	49	53	37	16	(10%)
with Other	24	30	32	75	36	25	9	50%
Collision Total	6,617	6,851	6,650	6,797	6,877	5,071	1,732	**4%**
Derailment Total	63	72	88	81	68	68	12	8%
Fire Total	1,571	1,679	1,717	1,566	1,393	1,579	632	(11%)
Security Total	1,272	1,298	1,399	1,625	2,037	1,361	437	60%
NOC Total	13,834	14,122	12,621	12,708	12,885	8,767	3,023	(7%)
Event Total	23,357	24,022	22,475	22,777	23,260	16,846	5,836	**0%**

Table 60: Collisions (VA only) 2015-2021

	2015	2016	2017	2018	2019	2020	2021	Percent Change (2015–2019)
with Motor Vehicle	59	76	60	53	80	46	17	36%
with Person	6	5	6	2	2	6	2	(67%)
with Fixed Object	2	1	4	6	6	1	1	200%
with Rail Vehicle	0	1	-	2	4	1	-	400%
with Bus Vehicle	2	2	1	1	5	-	1	150%
with Other	1	-	-	-	1	1	-	0%
Collision Total	**70**	**85**	**71**	**64**	**98**	**55**	**21**	**40%**
Derailment Total	1	-	-	2	-	-	-	(100%)
Fire Total	7	9	4	8	4	8	3	(43%)
Security Total	2	8	7	11	1	4	-	(50%)
NOC Total	88	114	87	103	105	82	37	19%
Event Total	**168**	**216**	**169**	**188**	**208**	**149**	**61**	**24%**

Table 61 shows the historical fatalities countrywide from 2015 to 2021 and **Table 62** shows the fatalities within Virginia only. There have been almost no transit-related fatalities in the Commonwealth during this time period.

Table 61: Fatalities (Countrywide) 2015–2021

	2015	2016	2017	2018	2019	2020	2021
Passenger	12	14	16	15	15	24	10
People waiting or leaving	17	38	31	25	38	33	10
Operator (employee)	1	6	1	4	3	6	2
Employees	1	2	3	6	1	4	1
Other Workers	1	-	2	1	1	-	0
Bicyclist	7	9	10	5	7	6	3
Ped Crossing	19	15	16	14	12	12	2
Ped not in Crossing	28	9	6	11	14	9	4
Ped Crossing Tracks	11	-	-	-	-	-	0
Ped Walking Along Tracks	9	9	9	5	7	10	9
Other Vehicle Occupant	51	48	62	42	43	53	21
Trespasser	0	-	-	-	-	-	0
Suicide	73	79	65	85	73	60	23
Total Fatalities	250	258	249	260	268	289	95

Table 62: Fatalities (VA Only) 2015–2021

	2015	2016	2017	2018	2019	2020	2021
Passenger	0	0	0	0	0	1	1
People waiting or leaving	0	0	0	0	0	0	0
Operator (employee)	0	0	0	0	0	0	0
Employees	0	0	0	0	0	0	0
Other Workers	0	0	0	0	0	0	0
Bicyclist	0	0	0	0	0	0	0
Ped Crossing	0	0	0	0	0	0	0
Ped not in Crossing	0	0	0	0	0	0	0
Ped Crossing Tracks	0	0	0	0	0	0	0
Ped Walking Along Tracks	0	0	0	0	0	0	0
Other Vehicle Occupant	0	2	1	3	0	1	0
Trespasser	0	0	0	0	0	0	0
Suicide	0	1	0	1	0	0	0
Total Fatalities	**0**	**3**	**1**	**4**	**0**	**2**	**1**

Table 63 displays the historical transit-related injuries throughout transit services across the country while **Table 64** displays these injuries within Virginia from 2015 to 2021. While injuries throughout all transit services have decreased slightly (4 percent), reported injuries in the Commonwealth have increased approximately 6 percent during this time period.

Table 63: Reported Injuries (Countrywide) 2015–2021

	2015	2016	2017	2018	2019	2020	2021	Percent Change (2015-2019)
Passenger	9,671	9,400	9,202	9,302	9,550	5,685	1,730	(1%)
People waiting or leaving	9,283	9,342	7,464	7,479	7,675	5,273	1,793	(17%)
Operator (employee)	1,495	1,605	1,729	1,820	1,943	1,364	447	30%
Employee	379	518	494	438	495	375	122	31%
Another worker	10	10	7	36	60	11	3	500%
Bicyclist	126	96	136	120	139	95	20	10%
Pedestrian in crossing	151	155	166	178	166	108	33	10%
Pedestrian not in crossing	181	141	109	104	105	57	17	(42%)
Pedestrian crossing tracks	17	-	-	-	-	-	0	(100%)
Pedestrian walking along tracks	14	39	34	29	39	27	18	179%
Another vehicle occupant	2,271	2,376	2,407	2,248	2,107	1,578	539	(7%)
Other	642	626	977	988	973	706	247	52%
Trespasser	0	-	-	-	-	-	0	0%
Suicide	98	77	105	95	111	75	34	13%
Total Injuries	24,338	24,385	22,830	22,837	23,363	15,354	5,003	(4%)

Table 64: Reported Injuries (VA Only) 2015–2021

	2015	2016	2017	2018	2019	2020	2021	Percent Change (2015-2019)
Passenger	82	165	102	84	108	53	14	32%
People waiting or leaving	36	53	33	43	43	34	20	19%
Operator (employee)	22	21	20	16	23	14	8	5%
Employee	7	4	2	7	4	1	1	(43%)
Another worker	0	0	0	0	0	0	0	0%
Bicyclist	1	1	2	0	0	3	0	(100%)
Pedestrian in crossing	0	2	2	1	1	2	0	100%
Pedestrian not in crossing	3	2	1	1	1	0	1	(67%)
Pedestrian crossing tracks	0	0	0	0	0	0	0	0%
Pedestrian walking along tracks	0	0	0	0	0	1	0	0%
Another vehicle occupant	34	39	15	28	24	17	10	(29%)
Other	12	11	7	10	5	5	2	(58%)
Trespasser	0	0	0	0	0	0	0	0%
Suicide	0	0	0	0	0	0	0	0%
Total Injuries	**197**	**298**	**184**	**190**	**209**	**130**	**56**	**6%**

System Engagement and Governance

Overview and Definition

Public engagement is essential to the provision of modern and equitable transit service in Virginia. Through effective public engagement, Virginia's transit agencies can identify and understand the needs of the communities they serve, and incorporate those needs into transit planning, development, programming, improvement, and day-to-day operations. Through effective engagement, transit agencies can factor public, rider, and stakeholder input into transit decision-making; help ensure accessibility; and support efforts to identify and document environmental, social, and economic impacts of transit policies, projects, and initiatives.

Public engagement is a broad term, and can include "one-way" communications (i.e., a transit agency providing information to its riders) or "two-way" communications (i.e., a transit agency working to facilitate discussion with and obtaining input and feedback from its riders). Further, public engagement also is a means for a transit agency to build trust, develop enduring relationships, and affirm commitments to its riders, stakeholders, and broader communities. Ongoing exchanges between a local transit agency and members of the community—which includes existing and potential transit riders—should be handled with care and intention to maintain the quality of these relationships.

With that, it is important that public engagement methodology continues to evolve with the world around it to reflect changes in transit, transportation, and society at large—an increased role of technology and greater needs to ensure diversity, equity, and inclusion.

During the ongoing COVID-19 pandemic, many Virginia transit agencies successfully made the switch to a virtual engagement environment. Virtual public engagement has provided a positive impact on engagement strategies since a greater number of riders can be reached; this type of engagement allows for riders that otherwise would not have had the time or resources to attend an in-person meeting to take part in discussion. Although there are many positives to virtual engagement, this also can negatively affect or exclude populations with a lack of internet access or those that may be less familiar with technology.

Transit agencies throughout the Commonwealth have different governance structures that define the makeup and guide the operations of their organization. Among other things, transit agency governance structures can affect whether riders have a "seat at the table" within the decision-making process. In some transit agencies, rider advocacy committees (RACs) have been formed to act as representatives of the communities, some of which have opportunities to provide RAC input and feedback directly to the boards of directors and other key decision-makers. In other instances, existing governance structures through written bylaws and requirements for bodies such as boards of directors lack provisions that ensure direct rider representation and membership in decision-making settings.

For the purposes of this study, "transit system engagement" refers to transit agency engagement with the general public with a particular emphasis on opportunities for disadvantaged populations and underserved communities. The baseline conditions and opportunities assessment for this topic area explores the following questions:

- What community engagement mechanisms do agencies commonly use?
- What mechanisms do agencies use to approach and reach disadvantaged populations?
- What are the most successful engagement mechanisms (tools, dates/times, locations, etc.) for communicating with disadvantaged populations and underserved communities?

- How do transit governance and operational structures (city department, independent organization, private operator, etc.) impact engagement opportunities with the general public, disadvantaged populations, and underserved communities?
- How are disadvantaged populations and underserved communities represented on transit agency governing boards? Do transit agencies have rider advisory committees or rider advocates?
- How do transit agencies monitor passenger demographics and how is this information used to improve engagement opportunities?
- What state and local policy considerations impact transit system engagement opportunities?
- What role does the Commonwealth play with ensuring engagement opportunities for the general public, disadvantaged populations, and underserved communities?

The objective of this chapter is to evaluate the state of existing transit agency public engagement efforts across the Commonwealth and identify preliminary opportunities for transit agencies to enhance and expand their practices in a way that makes them more effective and equitable. The results of the broader study will be the identification of strategies, actions, and other tactics that, if deployed, can enable transit agencies across Virginia to facilitate more inclusive and equitable public engagement; build meaningful, enduring relationships; and better serve their communities.

Baseline Conditions

Introduction

This chapter will discuss existing conditions regarding transit system engagement and governance across the Commonwealth of Virginia. The study team conducted a review of current engagement practices for select transit agencies, as well as current guidance and requirements for engaging communities, to gain a deeper understanding of how Virginia's transit agencies engage and communicate with their communities.

Methodology

To develop this chapter, the study team developed a detailed approach strategy and document. In coordination with Virginia Department of Rail and Public Transportation (DRPT) staff, this approach for System Engagement and Governance was finalized to include the following elements that together will shape this technical topic area of the broader Virginia Transit Equity and Modernization Study.

Identify Agency Spotlights

Through consultation with and guidance from DRPT staff, the study team identified five Virginia transit agencies to serve as the subjects of the review of current practices identified in the next subtask. Selected transit agencies have a mix of sizes, types, service offerings (e.g., fixed-route vs. demand-response/paratransit), contexts (e.g., urban vs. rural), and geographic location for statewide representation, and include:

Table 65: Spotlighted Agencies and Transect

Agency	Transit Service Transect
Four County Transit	Fixed Route
Harrisonburg Department of Public Transportation	Fixed Route
Farmville Area Bus	Fixed Route
Hampton Roads Transit	Enhanced Fixed Route
Alexandria Transit Company (DASH)	Enhanced Fixed Route

Review of Current Practices (Desktop Review) for Selected Agency Spotlights

With the above five transit agencies selected, the study team conducted its review of current transit agency practices for engaging communities, especially transit-disadvantaged communities. Current practices were informed through documentation and sources such as agency public participation plans, transit development plans (TDPs), transit strategic plans (TSPs), and transit management plans. The study team also reviewed transit agency board requirements for representing riders, transit-disadvantaged communities, and other groups. To get additional information from agencies across the state, several engagement-related questions were included in the study's Transit Agency Survey effort during the summer of 2021.

Review of Current Guidance and Requirements (State and Federal)

The study team reviewed DRPT TDP and TSP guidelines for engaging communities to develop an understanding of existing statewide and federal guidance, guidelines, and/or requirements for local transit agencies for engaging communities, especially transit-disadvantaged communities. A review of federal guidelines and requirements for engaging communities also was conducted, many of which are tied to the provision of federal funding.

Analysis Results

Transit Agency Spotlights

The five Virginia transit agencies selected to serve as the subjects of the review of current practices are described below within their transit service transect grouping.

Fixed Route

Agencies that fall within the fixed-route transit service transect have standard systems and service offerings (fixed-route bus and demand-response service); are typically centered around smaller cities, towns, or counties; and often have more modest organizational/governance structures and staff base.

Four County Transit

Four County Transit is operated by the Appalachian Agency for Senior Citizens (AASC), providing public transit services to Buchanan, Dickenson, Russell, and Tazewell Counties in southwestern Virginia. AASC is a private non-profit organization formed in 1975 to improve the quality of life of older adults through charitable, educational, social services and other appropriate means. The agency serves as the designated Area Agency on Aging (AAA) for the Four County region and, by contract with Virginia Department for the Aging, develops and administers the area plan that provides for a comprehensive and coordinated system of services for older adults and people with disabilities. Four County Transit's service area is predominantly rural and not within any Urbanized Area.[16]

Four County Transit has a **Vulnerable Populations Index (VPI) of 4**.

Harrisonburg Department of Public Transportation (HDPT)

The City of Harrisonburg is an independent jurisdiction, surrounded by Rockingham County, located in the Central Shenandoah Valley of Virginia. The city is part of the Harrisonburg-Rockingham County Urbanized Area, which also includes the nearby Towns of Dayton, Bridgewater, and Mount Crawford. Public transportation in the city is provided by HDPT, a department within the City government.

[16] Transit Development Plan FY 2018-2027, Four County Transit, April 2017.

HDPT operates fixed-route bus service, Americans with Disabilities Act (ADA)-complementary paratransit service, scheduled shuttles to Bridgewater and Dayton, and school bus service. The transit system operates six year-round routes geared toward city residents and numerous seasonal routes during the school year, geared toward the needs of James Madison University (JMU) students. Historically, ridership associated with JMU has accounted for about 90 percent of the total system ridership. HDPT receives funding assistance from the City of Harrisonburg, JMU, DRPT, and the Federal Transit Administration (FTA).[17]

HDPT has a **VPI of 4**.

Farmville Area Bus (FAB)

FAB operates five fixed-route services and a demand response ADA-paratransit service that provides door-to-door service within ¾ miles of fixed-route service in the Town of Farmville.

Three of the routes operate entirely inside Farmville—the Blue Line, Express Line, and Campus Line. The Blue Line and Express Line operate throughout the town, whereas the Campus Line, which began in 2005, caters to Longwood University students. Along with local, state, and federal funding, the university provides a significant annual contribution. An additional two routes, the Green and Orange Lines, connect rural parts of Prince Edward County with Farmville. These routes are deviated fixed routes and are operated by FAB, funded by the county, and branded as Prince Edward Regional Transit (PERT) service.[18]

FAB has a **VPI of 5**.

Enhanced Fixed Route

Agencies that fall within the enhanced fixed-route transit service transect have systems and service offerings across many transit modes (rail- or guideway-based transit, fixed-route bus, and paratransit); are typically centered around larger, more urban communities; and often have more complex organizational/governance structures with a larger staff base. Because of this, engagement practices and methods among these transit agencies are sometimes more wide-reaching and robust in nature compared to those in the fixed-route or demand response transit service transects. With greater resources, staffing, and funding levels, these transit agencies have a full suite of diverse community engagement tools that are deployed on a regular basis.

Hampton Roads Transit (HRT)

HRT serves a 431-square-mile area within the Hampton Roads region. HRT consists of six member jurisdictions—Newport News, Hampton, Norfolk, Virginia Beach, Portsmouth, and Chesapeake. The population of the six jurisdictions combined is approximately 1.3 million. All six jurisdictions in the service area are home to United States military installations, including Naval Station Norfolk, Joint Expeditionary Base Little Creek–Fort Story, Naval Air Station Oceana, Fort Eustis, and the Langley Airforce Base. There are approximately 150,000 active duty and civilian personnel in the region, and Norfolk is home to the world's largest naval base.

In 2008, HRT began an eight-route express bus service linking all six (then) current jurisdictions; in 2011, HRT completed and opened Virginia's first light rail line, the Tide, which provides service through Downtown Norfolk to the border of Virginia Beach. HRT currently operates 70 fixed-bus routes, including three seasonal routes serving tourists in Virginia Beach.[19]

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[17] Transit Development Plan FY 2018-2027, Harrisonburg Department of Public Transportation, November 2017.

[18] Transit Development Plan FY 2016-2021, Farmville Area Bus.

[19] Transit Development Plan FY 2018-2027, Hampton Toads Transit, January 2018.

HRT has a **VPI of 4**.

Alexandria Transit Company (DASH)

DASH provides fixed-route transit within the City of Alexandria, generally focused on local trips to destinations inside the city, but also provides commuter trips to the Pentagon—a major regional employment center. DASH service complements Metrobus service running in the city, which is focused more on regional and interjurisdictional trip connections.

DASH fixed-route service consists of 10 fixed routes that run predominantly in an east-west direction toward Old Town Alexandria and the King Street Trolley, which connects the King Street Metrorail station and the Waterfront.

Despite currently operating only fixed-route bus service, DASH is classified in the enhanced fixed-route transit service transect due to its role in facilitating key connections to several Metrorail stations along the Blue and Yellow Lines as well as intercity and commuter rail connections at Alexandria Union Station and bus rapid transit (BRT) service along the Route 1 Metroway corridor. The City of Alexandria also is actively planning and designing several dedicated transitways for future BRT service in the city.[20]

DASH has a **VPI of 4**.

Current Engagement Practices

Transit agencies across Virginia currently employ a wide range of engagement practices, methods, tactics, and tools to reach and communicate with their communities on a regular basis. These practices can vary based on agency size, type, and service offerings, and are discussed in more detail by transit service transect in the following sections.

Standard Practices and Strategies

When it comes to communicating and engaging with their communities for service changes, fare adjustments, public meeting or hearing announcements, planning projects, or other standard business, Virginia's transit agencies have a wide range of engagement practices and strategies to turn to. The strategies identified below reflect commonly used public engagement methods among transit agencies across Virginia.

- Creating background information and updates for posting on websites and for use in newsletters, factsheets, handouts, and other materials
- Convening stakeholders for discussion around topics of a local or regional scale
- Using social media to connect constituencies to news, updates, or planning efforts and promote involvement—both for two-way discussion and one-way information sharing
- Designing and disseminating informal surveys to ask questions and promote discussion
- Maintaining electronic mailing lists to share information with relevant stakeholders, interested riders, and members of the public
- Offering open opportunities to learn about planning efforts, projects, or other initiatives through open houses or public meetings
- Soliciting in-depth information by hosting focus groups or small-group discussions about issues, activities, or public perceptions from stakeholders and riders

[20] Transit Development Plan FY 2017-2022, City of Alexandria, November 2016.

Beyond these standard engagement practices and strategies, many transit agencies make routine use of additional tactics that are unique to their individual location, needs, agency size, or service offerings.

Fixed Route

The agency spotlights below provide additional detail on specific engagement practices that are commonly used or most successful for agencies within this transit service transect.

Four County Transit

Robust public engagement does not need to occur in a large city or across a large transit system to be successful. Despite the rural nature and relatively low population density of the Four County Transit service area, AASC makes use of several engagement practices and strategies to meet its goal to provide a comprehensive and coordinated system of services for older adults and people with disabilities. The agency has developed a Marketing Plan, which serves as a guiding document that identifies specific outreach strategies that the agency can use to reach and communicate with riders and members of the community. In its most recent TDP update, Four County Transit noted a desire to expand their Marketing Plan to include enhanced guidance on public outreach, education, and information sharing. Specifically, the TDP includes a stated goal to focus outreach and engagement efforts at key locations along their service corridors and provide informational route maps with their existing route and schedule materials throughout the community.

The agency routinely works to get information and announcements to its riders in a direct and conducive manner through written surveys that are disbursed by drivers directly on buses and newspaper articles in popular local publications.

HDPT

The governance structure of HDPT presents unique opportunities and advantages when it comes to public engagement. As a formal department within the City government, regularly scheduled City Council meetings serve as the main forum through which HDPT gathers public input. City Council meetings are conducted twice per month and are open to the public. As outlined in its TDP, HDPT policies, budgets, and service changes are presented at City Council meetings and meeting agendas and minutes are shared on the City government website.

As a jurisdiction within the Harrisonburg-Rockingham Metropolitan Planning Organization (MPO), HDPT also is included in the public planning processes conducted through MPO. As outlined in the HDPT TDP, all regular and special meetings of the MPO Policy Board and Technical Advisory Committee (TAC) provide a public comment period that can be used by citizens to voice concerns or provide input on issues relevant to metropolitan transportation planning, including transit. HDPT also leverages its partnership with the MPO to translate materials and surveys into other languages to ensure that non-English-speaking communities can fully participate in outreach and engagement opportunities.

Since HDPT provides service to surrounding universities, most notably James Madison University (JMU), the agency regularly conducts public outreach and engagement with students and staff on campus. HDPT takes part in JMU's student orientation to provide information on available transit services, conducts on-board rider surveys, and uses social media platforms such as Twitter and Facebook to connect with riders. It is noted in HDPT public participation documents that the agency plans to improve student-focused marketing efforts through educational videos on platforms such as YouTube.

FAB

Similar to HDPT, FAB also is able to leverage regularly scheduled Town Council meetings as a forum through which the agency can gather public input. As noted in responses from the transit agency survey, despite the

community's small size, it is very close-knit and engaged and the Town Council serves as a trusted and strong link between the transit agency and the broader community.

Students at nearby Longwood University rely on FAB as a primary mode of transportation around campus and FAB conducts public outreach with students in a number of ways. FAB provides bus route information at university facilities, on university websites, and in orientation packets for incoming students. Rider surveys are conducted on-board buses to get feedback throughout the year. Additionally, during FAB's most recent update of its TDP, the agency conducted stakeholder interviews with executive-level representatives from Longwood University and conducted student riders in focus groups to gather input.

Enhanced Fixed Route

The agency spotlights below provide additional detail on specific engagement practices that are commonly used or most successful for agencies within this transit service transect.

HRT

With dedicated marketing, communications, and public outreach staff, HRT is able to effectively mobilize outreach and engagement efforts when the agency is proposing a major service change(s), elimination of a route, or fare increase. HRT's engagement efforts are guided by its *Policy and Procedures Manual for Public Hearings and Meetings* that details the formal process of scheduling public hearings and meetings relative to various projects and service or fare changes, including internal procedures, external communications, and follow-up actions needed.

According to its TDP, HRT adheres to a "proactive public participation process" and works to ensure that all public involvement activities are "functional for HRT decisions and meaningful to the public," increasing public awareness and giving the public an active voice in planning decisions. HRT's public participation process includes the following steps:

- **Step 1**: Outline a public participation plan at the beginning of key HRT planning projects.
- **Step 2**: Previously established mailing and email lists are identified.
- **Step 3**: Update existing mailing and email lists; new lists are identified.
- **Step 4**: All project documentation is archived with HRT's records management department throughout the life of the project.
- **Step 5**: Based on a project's milestones and requirements, a public involvement timeline is created. The public involvement timeline outlines each activity of the project's outreach efforts.
- **Step 6**: The effectiveness of the public participation plan is periodically assessed throughout the life of the project, to determine if the public involvement objectives were achieved.

HRT has a standalone Marketing and Communications Department that is responsible for promoting HRT within the organization and to the general public. HRT's marketing and communications staff supports other departments within the agency with initiatives and programming through public outreach, planning, and communication development. Its duties and responsibilities include:

- **Marketing and advertising campaigns** to teach the public about transit and introduce customers to new or evolving services
- **Media campaigns** promoting alternative transportation options through congested regional transportation corridors
- **Internal information sharing** among departments and coordination of public and private events, including formal public hearings

- **Providing content for agency websites**, Gohrt.com and Insite (the agency's intranet), and the agency's electronic bulletin board.
- **Maintaining public outreach campaigns** that will engage the public, our customers, and promote the agency as a whole

HRT offers travel training programs to the community that teach individuals how to use public transportation safely and independently. Travel training programs are intended to encourage behavior changes by giving people a level of comfort with and understanding of travel options that are new to them. These programs can be offered in a group setting or one-on-one and can be specialized for seniors or people who have cognitive or physical mobility challenges. Travel training can improve access to the community, build independence, and open opportunities.

Between November 2018 and February 2019, HRT conducted a survey to gather community feedback on how to best prioritize improvements to the HRT bus system as part of the Transit Transformation Project. This survey highlighted, from the user perspective, the system's most pressing needs. Nearly 2,500 people participated in the survey, with about 40 percent of participants self-identifying as HRT bus users. Of potential improvements to the system, surveyed users weighed more reliable and frequent service as well as real-time bus arrival information most heavily.

DASH

Engagement efforts conducted by DASH are the result of an aggressive public outreach program, one with a stated focus on increasing awareness of the system among residents of Alexandria. In addition to the aforementioned standard practices and strategies, DASH staff conducts targeted outreach to City schools and at various community events, including pop-up events at various locations across the city. Other efforts include business- and employee-focused outreach, joint promotional efforts with other City efforts and initiatives, sponsorship of DASH routes, and discounts for riders at local retail establishments.

The agency frequently turns to onboard outreach and engagement across its system, utilizing onboard audio announcements, posters and advertisements at bus stops and on bus vehicles, and staff ride-alongs.

Pop-up events are an additional successful engagement tool in Alexandria, with staff meeting riders and members of the community where they're at—including major bus stops, community centers, farmers' markets, and other neighborhood institutions and destinations. Pop-up events have been used to seek feedback and input for several recent City and DASH efforts, including the Alexandria Transit Vision (ATV) Plan and the Alexandria Mobility Plan.

In the fall 2019, DASH conducted an extensive public outreach campaign with hearings, meetings, pop-up events, and surveys to collect feedback on its draft transit network redesign. The ATV Plan process included three phases of engagement involving outreach with project stakeholders, community groups, members of the public, and DASH/City staff including bus drivers. The new bus networks will provide more useful bus service for the City of Alexandria by introducing frequent, all-day bus service to areas where more people will be able to use it. The new bus networks will significantly increase access to frequent transit for low-income, minority, and senior residents, while establishing important bus connections to the future Potomac Yard Metrorail station and other key development areas.

In 2020, the City of Alexandria launched Duke Street in Motion, a project to ensure that transit improvements on the Duke Street corridor align with all the community's needs, provide adequate transportation choices, and keep the region moving. This effort is intended to revisit plans and study findings from 2012 and ensure they align with present-day transportation priorities, land use plans, and home-to-work travel patterns.

Partnerships

Local partnerships also are commonly leveraged, including those with local educational institutions, community organizations, human service providers, and social service providers. These partnerships provide direct lines of communication and collaboration to many transit-dependent and historically underserved populations, helping transit agencies reach and hear from the people who need transit most.

Fixed Route

Four County Transit

Through efforts to create its TDP, Four County Transit has committed to a goal of expanding partnerships with key agencies and organizations in the region. Objectives to realize this goal include expanding partnerships with higher education institutions to promote Four County Transit as an option for students, faculty, and staff; working with county Departments of Social Services on expanded partnership opportunities; and assessing opportunities to expand connections with other transit providers in Southwest Virginia.

In working to develop its latest TDP (FY2018–2027), Four County Transit conducted interviews with stakeholder partners in the system's service region representing civic, educational, governmental, and human service agencies. These interviews provided Four County Transit the ability to gain an understanding of needs, challenges, and opportunities relating to public transit. While stakeholder feedback was primarily positive and underscored transit as filling an important need in the community, the agency also learned that many others in the community were not familiar with all the agency's current transit service offers, identifying a key need to expand and enhance marketing and engagement efforts.

HDPT

Like Four County Transit, HDPT also places a strong emphasis on its university partners at JMU. Through its TDP, HDPT has established goals to continue to partner with JMU to help minimize the need for students, faculty, and staff to drive to campus. HDPT also works closely with its partners at the Central Shenandoah Planning District Commission (of which Harrisonburg is a member) and leverages this partnership to expand and enhance engagement opportunities.

FAB

FAB discusses its strong, significant, and expanding relationship with Longwood University in its TDP (FY2016–2021). In tandem with the university's vision for an increase of 1,000 students in the next decade, FAB recognizes the transportation of these students in a convenient and efficient manner as critical to fulfilling the vision of their university partner. With that, the transit agency has expressed its desire to work closely with the university to adequately plan for potential increases in service expansion.

Enhanced Fixed Route

HRT

HRT has strong stated goals to build partnerships with employers, the military, colleges and universities, and other private and public stakeholders to fulfil its role in fostering regional quality of life and economic vitality. In its TDP, HRT commits to these goals and objectives with performance measures to track the number of public-private partnerships and formal partnerships with community organizations.

DASH

GO Alex, the City of Alexandria's transportation demand management (TDM) program, provides residents, commuters, and employers with resources to help promote mobility options through developing employer-specific plans and resources; assisting in rideshare matching; promoting regional incentives to try different transportation options; and providing travel tools and information across Alexandria. Several partnerships with employers and organizations exist through the GO Alex program, and DASH transit offerings are a critical

component of the nondriving transportation options that the program promotes to the community. Through the Alexandria Mobility Plan, the City's long-range transportation plan, the City has set a goal to increase the number of community partnerships through the GO Alex program in the years ahead.

Board Representation Requirements and Advisory Bodies

While nearly all transit agencies in Virginia have formally established Boards of Directors that work to help guide transit decision-making and priorities, few of them explicitly appoint members intended to represent the general riding public, including disadvantaged populations and underserved communities. Several agencies also have rider advisory bodies and rider advocate groups to further elevate this representation. The section below describes these efforts that exist for the selected agency spotlights.

Fixed Route

Four County Transit

The Board of Directors for AASC (Four County Transit's operating agency) has stated objectives and purposes of "*Developing and maintaining a public transportation system that is for all ages and socio-economic status within the Planning Service Area which comprises Buchanan, Dickenson, Russell and Tazewell Counties using a seamless and coordinated method.*" According to Article V of AASC's bylaws, Board membership requirements lack specific provisions for rider representation, but generally call for membership to be comprised of local residents, as outlined below:

> ***Section 5.3. Membership**: The membership of the Board shall be as broadly representative as possible of all lay and professional elements of the District.*
>
> *A. The Board of Supervisors of the corporation's members, the Counties of Buchanan, Dickenson, Russell and Tazewell, shall each appoint four (4) residents to represent their respective jurisdiction on the Board of Directors. The Chairperson representing the AASC Advisory Council and the Chairperson of the Program of All-Inclusive Care (PACE) Advisory shall also be voting members of the AASC Board of Directors*

Article VIII of AASC's bylaws outlines the establishment of Advisory Councils, providing a forum through which riders, including those representing disadvantaged populations and underserved communities, can advise the Board of Directors of AASC's programs, including Four County Transit.

The AASC Advisory Council must be made up of more than 50 percent older persons, including minority individuals who are participants or who are eligible to participate in programs offered by AASC. The Program of All-Inclusive Care for the Elderly (PACE) Participant Advisory Council must have a majority composition of program participants and/or representatives of the participants.

HDPT

While HDPT lacks its own Board of Directors, the City of Harrisonburg is a key member of the Harrisonburg-Rockingham MPO, which serves as the transportation planning organization that provides support for multimodal transportation projects in the City of Harrisonburg; the Towns of Bridgewater, Dayton, and Mt Crawford; and the surrounding portions of Rockingham County. The Harrisonburg-Rockingham MPO Policy Board is responsible for making all official decisions of the MPO, including adoption of the Unified Planning Work Program (UPWP), Transportation Improvement Program (TIP), and other plans and programs as necessary.

According to Article III of the Harrisonburg-Rockingham MPO Policy Board bylaws, there are no specific provisions for rider membership representation. The Policy Board consists of 12 voting members, five of which

are representatives from the City of Harrisonburg, including representatives from the Mayor's Office, City Manager, City Council, and Department of Public Transportation.[21]

FAB

FAB operates under the jurisdiction of the Town Council of Farmville and does not have a Board of Directors, advisory bodies, or advocate groups. A Transit Manager oversees the daily operations of agency and reports directly to the Town Manager, who then reports to Town Council. The Transit Manager also is the liaison between the agency and DRPT to assist FAB in coordinating with surrounding transit agencies and to ensure that bus service is meeting state and federal requirements.

Enhanced Fixed Route

HRT

HRT is governed by the Transportation District Commission of Hampton Roads, which has a stated purpose "to provide reliable and efficient transportation services and facilities to the Hampton Roads Community." As described in Article II of the Commission's bylaws, Board membership requirements lack specific provisions for rider representation, but generally call for membership to be comprised of local residents, as outlined below:

> ***Commissioners**. The Commission will consist of 17 members. Each of the seven component governments will appoint two members (who may, but need not be, a member of its governing body), who will serve at the pleasure of his or her respective component government. The Chairperson of the Commonwealth Transportation Board, or the Chairperson's designee, will be a member, ex-officio. The Speaker of the House of Delegates and the Committee on Privileges and Elections of the Senate will appoint one member of the House of Delegates and one member of the Senate, one of whom will be a resident of the City of Hampton or the City of Newport News and one of whom will be a resident of the City of Chesapeake, the City of Norfolk, the City of Portsmouth, the City of Suffolk or the City of Virginia Beach. The member appointed by the Speaker of the House of Delegates will serve a term of two years and the member appointed by the Committee on Privileges and Elections of the Senate will serve a term of four years. The members of the General Assembly will be eligible for reappointments so long as they remain members of their respective houses, but their terms will terminate if they are no longer members of their respective houses. Members other than those appointed by the General Assembly will serve at the pleasure of their appointing bodies.*

HRT also has a Transit Riders Advisory Committee (TRAC), with the stated purpose of providing HRT administration and staff with feedback and recommendations for improving service, providing input into HRT's customer outreach activities, and providing HRT customers and the community at-large with information about HRT services. TRAC membership, which consists partly of local residents, is described below:

- *The TDCHR Executive Committee's bylaws note that the TRAC is created to "advise…relative to necessary transit services and the quality of current services and work with the President to communicate and address customer needs"*
- *TRAC may be comprised of up to 14 voting members and may include at least one resident from each city and one service representative.*
- *Members should include (but not be limited to) HRT customers and persons who currently use or have the desire to use public transportation.*
- *Members are appointed by the TDCHR Executive Committee Chairperson upon recommendation by HRT staff and/or the Commissioner(s) of the represented city.*

[21] HRMPO Policy Board Bylaws, Harrisonburg-Rockingham Metropolitan Planning Organization, September 2008.

- *The TRAC reports to the TDCHR Executive Committee at each regularly scheduled meeting. A written report is prepared by the Recording Secretary and reviewed by the committee Chairperson and/or Vice-Chairperson and HRT staff. It is submitted to the TDCHR Executive Committee Chairperson prior to presentation to the full TDCHR Commission meeting. The HRT staff will provide assistance as required to ensure that the report is prepared and placed on the TDCHR Executive Committee and TDCHR agendas.*

DASH

DASH is characterized as a quasigovernmental entity and is overseen by its Board of Directors; however, DASH is wholly owned by the City of Alexandria, and its Board members—representing a mix of private citizens and City staff—are appointed by the Alexandria City Council. As described in Article II of the DASH bylaws, the Board is to consist of a minimum of nine and a maximum of 11 members, some of which are to be actual DASH riders or City residents. While these provisions do ensure that the Board has several members that are riders themselves, it lacks specific provisions for representation by members of disadvantaged populations and underserved communities:

Directors need not be stockholders, and shall be comprised of the following:

a. The City Manager or designee
b. The City's Chief Financial Officer or designee
c. The City's Transportation and Environmental Services (T&ES) Director or designee
d. A City resident with transportation experience
e. A City resident with financial experience; and
f. *A minimum of four , maximum of six additional riders or City residents who are not employees of the City, Alexandria Transit Company, or any subsidiary thereof. One of which shall also serve as a representative to the Alexandria Transportation Commission.*

Current Governance Structures

Transit agency governance and operational structures (e.g., city department, independent organization, private operator, etc.) also can have an impact on the engagement opportunities that are made available to the general public, disadvantaged populations, and underserved communities.

Of the five transit agency spotlights selected for the focus of this assessment, those with a local government governance structure were found to offer the most consistent and abundant opportunities for engagement with their riders and communities. Local governments are often the closest to the community and provide a highly visible and familiar entity through which the public can communicate. Transit agencies governed by local governments often have dedicated staff teams that can focus on transit-specific projects, initiatives, and outreach and often have the benefit of broader municipal budgets and resources, to either conduct work in-house or procure the services of consulting firms or outside experts for larger projects or initiatives.

Transit agencies with a private non-profit governance structure often serve smaller, more rural, and aging communities and often have smaller organizations and staff bases. Despite this, agencies with this governance structure can conduct meaningful engagement with their communities that seeks to meet the unique needs of more rural and aging communities, even if at a smaller scale and scope.

The governance and organizational structures of the five spotlight transit agencies selected for this assessment (as described in each agency's TDP) are described in the following section. A full inventory of Virginia transit agencies and their governance structure is included in **Table 66**.

Four County Transit

Four County Transit is operated by AASC, a private non-profit organization formed in 1975 to improve the quality of life of older adults through charitable, educational, social services and other appropriate means. The agency serves as the designated Area Agency on Aging (AAA) for the Four County region and, by contract with Virginia Department for the Aging, develops and administers the area plan that provides for a comprehensive and coordinated system of services for older adults and people with disabilities.

HDPT

As a City Department, the governing board for HDPT is the Harrisonburg City Council, which is elected by the citizens of the City of Harrisonburg. HDPT is comprised of three enterprise funds—Transit, School Bus, and Central Garage. The entire department is led by the Director of Transportation, who reports to the City Council and meets with the City Manager regularly to discuss needs and issues. The Director also meets with JMU staff to discuss issues related to university services and serves as a member of the Harrisonburg-Rockingham MPO's policy board to represent HDPT in regional transportation planning efforts.

FAB

FAB operates under the jurisdiction of the Town Council of Farmville (the Council), which operates as a council-manager system. The Council consists of seven members, who are elected every 4 years. Five of the members are elected through the town's ward system with an additional two members voted at-large. The Council then appoints a Town Manger to implement the policies and ordinances and supervise all Town departments, including FAB.

Daily operations of FAB are overseen by a Transit Manager who reports directly to the Town Manager, who then reports to Town Council. The Transit Manager also is the liaison between the agency and DRPT, working together to coordinate with surrounding transit agencies and to ensure that bus service is meeting state and federal requirements.

HRT

The Transportation District Commission of Hampton Roads is HRT's governing body. It consists of 13 members, one elected official and one citizen representative from each city served by HRT, the chairman of the Commonwealth Transportation Board (CTB), or a designee. The Commission meets every month at alternating locations between Norfolk and Hampton.

DASH

The Alexandria Transit Company, the entity that operates the DASH bus system, is a separate public service corporation that is wholly owned by the City of Alexandria. The DASH Board of Directors is elected by the Alexandria City Council, serving in the capacity of DASH's stockholders. The DASH Board of Directors is composed of nine members and includes six citizen members and three city officials.

The Transit Services Division of the City of Alexandria's Department of Transportation and Environmental Services (T&ES) coordinates DASH bus service, DOT paratransit for the mobility impaired, Metrobus and Metrorail service, ridesharing to promote the formation of car- and vanpools, Virginia Railway Express (VRE) commuter rail, bus stop amenities, and other programs designed to increase the use of alternatives to the single-occupant vehicle and to protect the environment. The Transit Services Division also coordinates with the Transportation Planning Division within T&ES to improve mobility throughout the city.

Table 66: Transit Agencies by Governance Type

Agency	Governance Type
Alexandria Transit Company (DASH)	Local Government
Altavista Community Transit System	Local Government
Arlington County Transit	Local Government
Bay Transit	Private Non-Profit
Blacksburg Transit	Local Government
Blackstone Area Bus System	Local Government
Bristol Virginia Transit	Local Government
Central Shenandoah Planning District Commission (BRITE)	Planning District Commission
Charlottesville Area Transit	Local Government
Chincoteague Pony Express	Local Government
City of Fairfax (CUE)/Fairfax City University Energy Saver	Local Government
Danville Transit	Local Government
District Three Public Transit (Mountain Lynx)	Governmental Cooperative
Fairfax County (Fairfax Connector)	Local Government
Farmville Area Bus	Local Government
Four County Transit	Private Non-Profit
Fredericksburg Regional Transit (FRED)	Local Government
Graham Transit	Local Government
Graham Transit	Local Government
Greater Lynchburg Transit Company	Public Service Corporation
Greater Richmond Transit Company	Public Service Corporation
Greater Roanoke Transit Company (Valley Metro)	Public Service Corporation
Greensville-Emporia Transit	Local Government
Hampton Roads Transit	Transportation District Commission
Harrisonburg Department of Public Transportation	Local Government
Jaunt	Public Service Corporation
Lake Country Area Agency on Aging	Private Non-Profit

Loudoun County Transit	Local Government
Mountain Empire Older Citizens	Private Non-Profit
Petersburg Area Transit	Local Government
Potomac and Rappahannock Transportation Commission (OmniRide)	Transportation District Commission
Pulaski Area Transit	Private Non-Profit
RADAR	Private Non-Profit
Radford Transit	Local Government
STAR Transit	Transportation District Commission
Suffolk Transit	Local Government
Virginia Railway Express	Public (Jointly Owned by NVTC and PRTC)
Virginia Regional Transit	Non-Profit Organization
Williamsburg Area Transit	Local Government
Winchester (WinTran)	Local Government

Source: Virginia Department of Rail and Public Transportation

Current Guidance and Requirements

In the review of statewide and federal guidance, it was found that Virginia does not have overwhelming amount of public engagement guidance for transit agencies. Federally, the United States Department of Transportation (USDOT) provides requirements through Title VI for all state agencies that are recipients of federal funding. Guidelines and requirements at both the state and federal level are outlined in the following section.

Statewide Guidance

DRPT requires transit agencies in the Commonwealth to complete either a TDP (for smaller agencies) or a TSP (for larger agencies). These documents are meant to act as planning, management, and policy documents for the transit agency. Additionally, they serve as a resource to inform DRPT of agency funding needs across the Commonwealth. These guiding documents have limited detail on public engagement and participation requirements, specifically in relation to transit-dependent and underrepresented communities.

A major update to an agency's TDP is required every 6 years, and agencies may wish to amend the document with minor changes annually. A TSP is a requirement for transit agencies in the state that satisfy both of the following conditions: the agency serves an urbanized area with 50,000 or more people and the agency operates a fleet of 20 or more buses. A TSP is meant to replace the TDP for the agencies that meet these conditions. Out of the 39 transit agencies in the Commonwealth of Virginia, 16 are required to complete a TSP. Each of these agencies must complete a major update to their TSP every 5 years and amend the document annually with minor updates.

> *"A TSP is intended to replace the previously required Transit Development Plan (TDP) for agencies that are required to complete one. With this in mind, the TSP must also provide a foundation for future funding requests, directly advising each agency's programming process in the years that follow its adoption. Smaller agencies that do not require a TSP must still develop a TDP under Virginia Department of Rail and Public Transportation guidelines." – DRTP Transit Strategic Plan Guidelines*

Both the TDP and TSP have the same requirements for public outreach documentation. Each require agencies to describe their agency's public outreach and involvement process, including outreach relative to service schedule or fare changes, service expansion, and service reduction. DRPT's TSP guidelines note that, depending on each agency's public engagement process, it is likely a public outreach phase will be necessary to understand the community's priorities to complete certain sections of the document.

Federal Requirements

Through USDOT, the federal government requires that state agencies have a Title VI Plan. This includes not only statewide agencies such as DRPT, but also transit agencies in Virginia that accept federal funding. According to USDOT, "receiving federal funding" refers to any federal financial assistance including grants and loans of federal funds, the grant or donation of federal property, the detail of federal personnel, the sale and lease of federal property, and any federal agreement, arrangement, or contract that has the provision of assistance as one of its purposes. In any of these circumstances, a transit agency will need to complete a Title VI Plan or Program.

The federal government provides specific requirements to ensure that underrepresented communities are engaged with, but they do not detail exactly how to engage with these communities. The Title VI requirements pertaining to public engagement include the following:

1. A Public Participation Plan that includes an outreach plan to engage minority and Limited English Proficient (LEP) populations as well as a summary of outreach efforts made since the last Title VI Program submission.

2. The agency to have a plan to provide language assistance to persons with Limited English Proficiency (LEP), based on the Department of Transportation LEP guidance.
3. A table depicting the racial breakdown or demographics of the committee membership and a description of efforts made to encourage the participation of minorities on committees.
4. If there is a constructed facility, the agency shall include the Title VI equity analysis conducted during the planning stage with regard to the location of the facility.

Transit Agency Survey Results

The study team developed a transit agency survey that was sent to all Virginia transit agencies, covering all current transit service offerings of demand response, fixed-route, and enhanced fixed-route services. Thirty-nine submissions were collected from all transit agencies in the Commonwealth. This section describes the results received regarding transit system engagement and governance.

Survey Questions

The survey questions pertaining to transit system engagement and governance were used to gather information directly from agencies. Questions were asked regarding whether agencies have public engagement or public participation plans, what engagement mechanisms have proven to be most successful, what level of influence disadvantaged communities have on agency decision-making processes, and whether agencies have rider advisory committees or advocate groups. The results of the transit system engagement and governance survey questions are included in the following section.

Survey Results

The following figures provide an abbreviated summary of the responses received from the transit agency survey that relate to system engagement and governance.

Does your agency have a public engagement plan?

Responses to question 34 (**Figure 79**) show that 62 percent of transit agencies have a public engagement plan. Reponses to question 34a (**Figure 80**) show that, for agencies that responded to this question, most have made significant updates to their public engagement strategies within the past 5 years.

Figure 79: Does your agency have a public engagement plan?

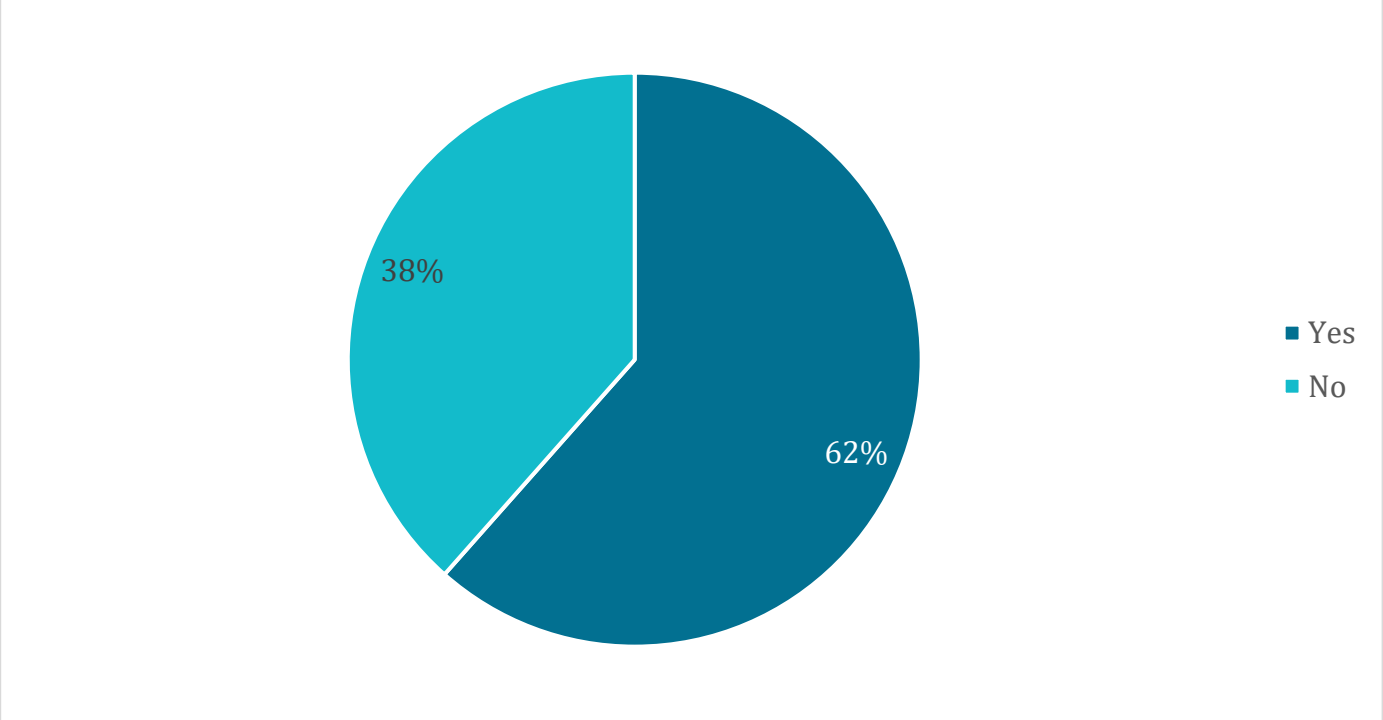
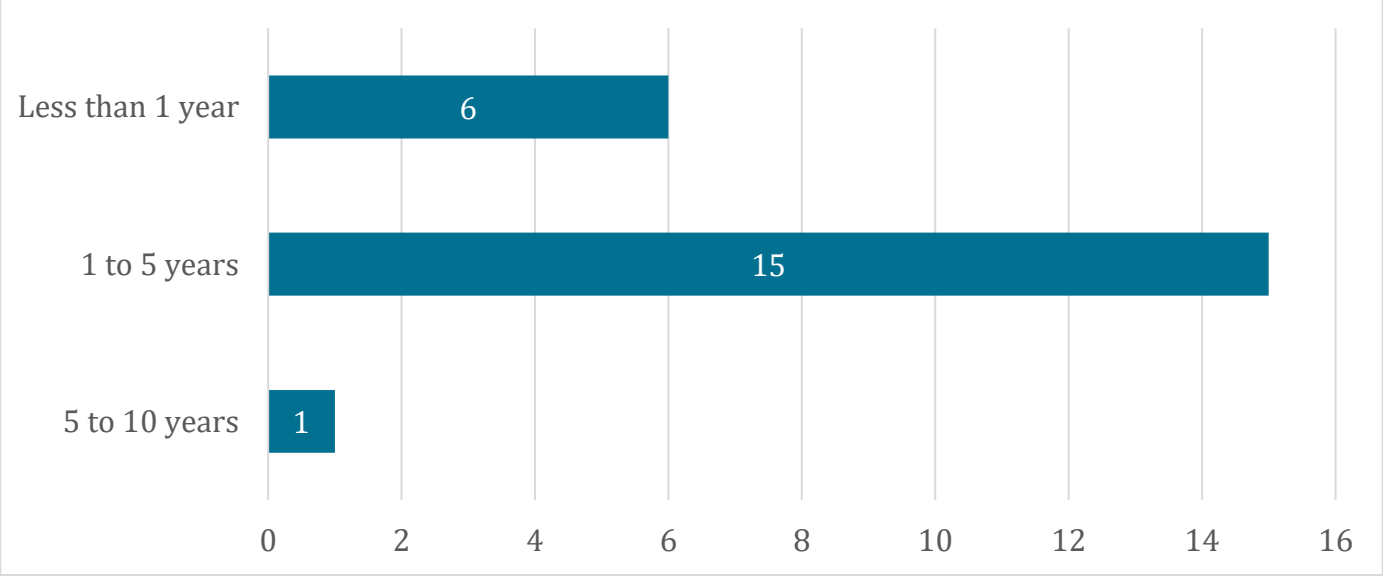


Figure 80: How long has it been since significant updates to your public engagement strategy have been made?



What have been the most successful engagement mechanisms (tools, dates/times, locations, etc.) for communicating with disadvantaged communities?

Responses to question 35 provide insight into successful engagement mechanisms across the Commonwealth's various transit agencies for engaging and communicating with disadvantaged communities.

The engagement mechanisms discussed show that there is a wide variety of tools used by agencies to connect with their communities. Some of the most common by transit service transect include:

- **Demand Response** transit agencies make use of standard, regularly occurring meetings to engage and communicate with their communities
- **Fixed Route** transit agencies, in addition to the above, make use of in-person meetings at community centers and gathering spaces, social media platforms, local newspaper postings, agency websites, written/online/on-bus surveys, and posters and flyers at community centers and on-board buses. For agencies that have access to them, Metropolitan Planning Organizations and/or advisory bodies provide an additional conduit for public engagement and outreach.
- **Enhanced Fixed Route** agencies, in addition to the above, often have more robust public participation plans and dedicated outreach and engagement staff to conduct more targeted and intentional engagement activities. Pop-up events are a common tool among these agencies and allow agency staff to meet members of the community where they already are without the need for them to attend a formal public meeting that might not be held in their community or when they are available to attend. These agencies also make use of direct mailers, more robust online engagement, and community ambassadors/champions. Additionally, many of these agencies seek to reduce or eliminate barriers to participation through disseminating information in multiple languages, providing childcare at engagement events, and providing transportation to engagement events.

How does your agency define disadvantaged and underserved communities?

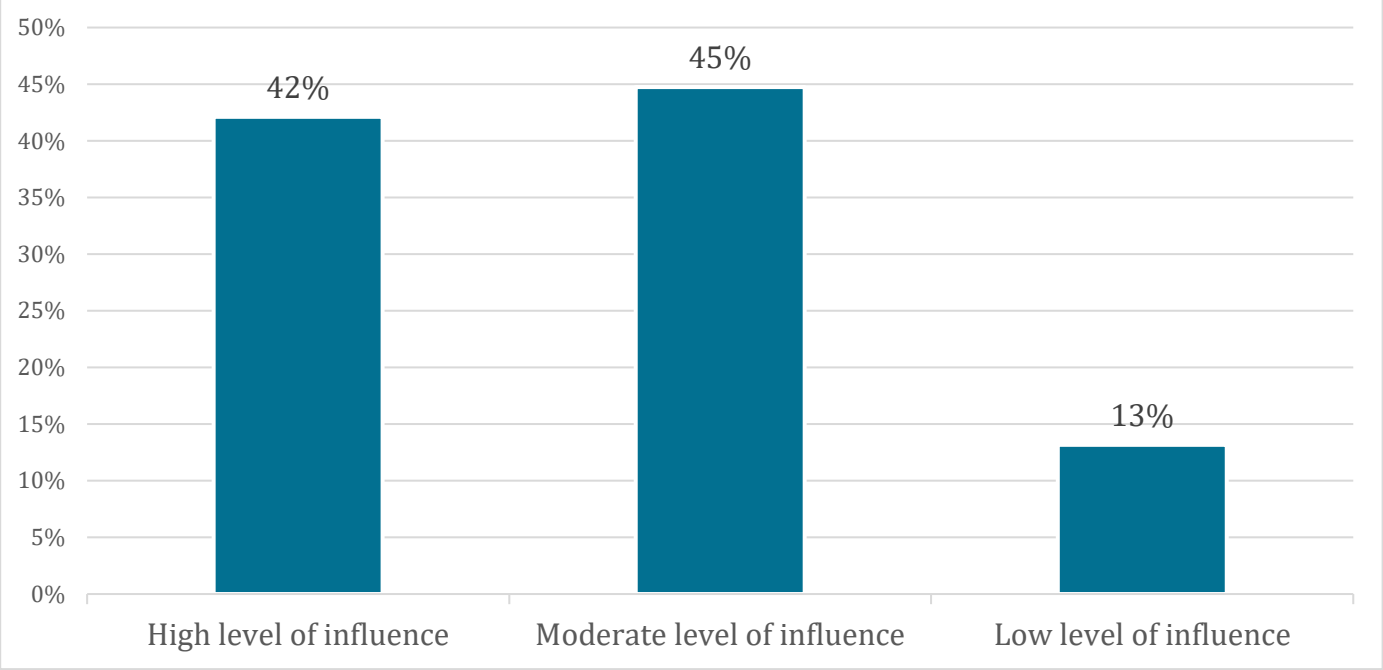
Responses to question 36 provides insight into how various transit agencies approach defining "disadvantaged" and "underserved" communities as it related to their engagement practices.

Transit agencies across all transit service transects provided varying explanations about how they define disadvantaged and underserved communities, with no clear trends per transect grouping. Some agency definitions are derived from their own public engagement plans, federal sources such as FTA and Title VI definitions, and general terms and definitions. It is clear that some agencies follow specific definitions of "disadvantaged" and "underserved" communities, whereas others do not have a working definition in place.

What level of influence do disadvantaged communities have on the decision-making process?

Responses to question 37 (**Figure 81**) show that there are varying levels of influence that disadvantaged communities have on transit agency decision-making processes. Eighty-seven percent of responding agencies indicated that disadvantage communities have either a moderate or high level of influence on decision-making process, with 13 percent of responding agencies indicating that this influence is low.

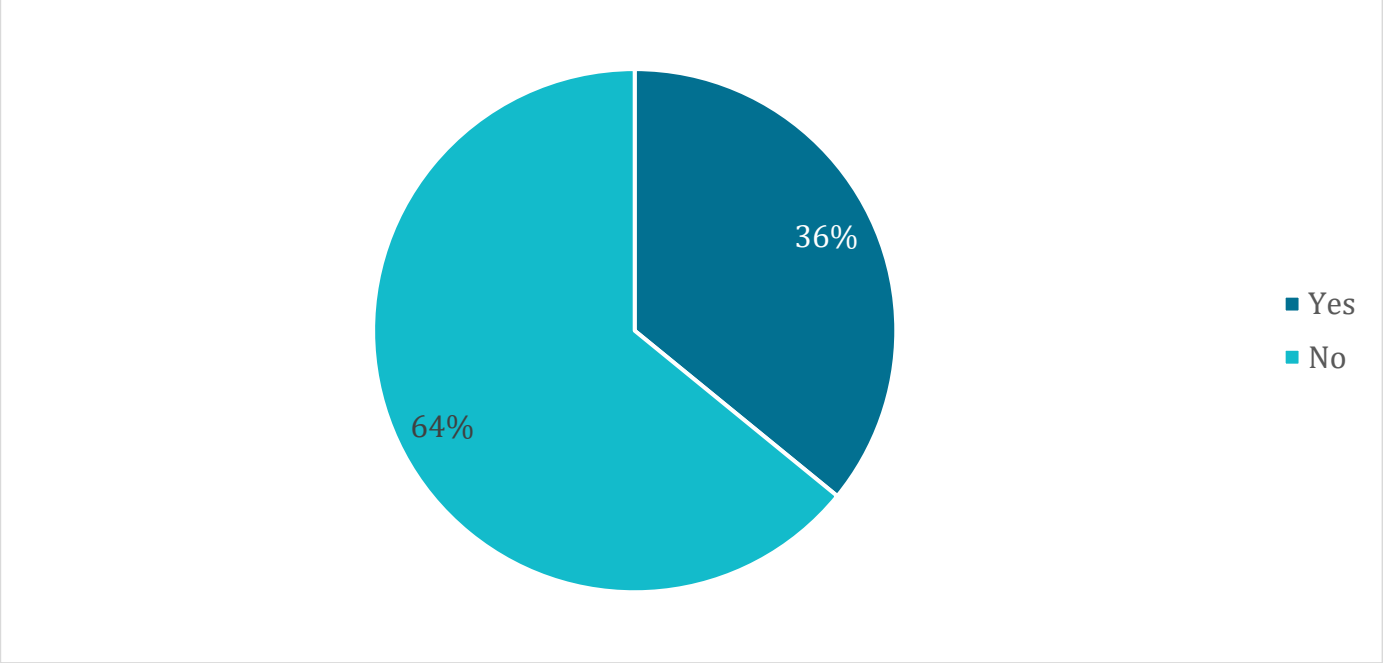
Figure 81: What level of influence do disadvantaged communities have on the decision-making process?



Does your transit agency have rider advisory committees or rider advocates?

Responses to question 38 (**Figure 82**) show that just more than a third of Virginia's transit agencies have rider advisory committee or advocate groups that are active.

Figure 82: Does your transit agency have rider advisory committees or rider advocates?



How does your transit agency monitor passenger demographics and how is this information used to improve engagement opportunities?

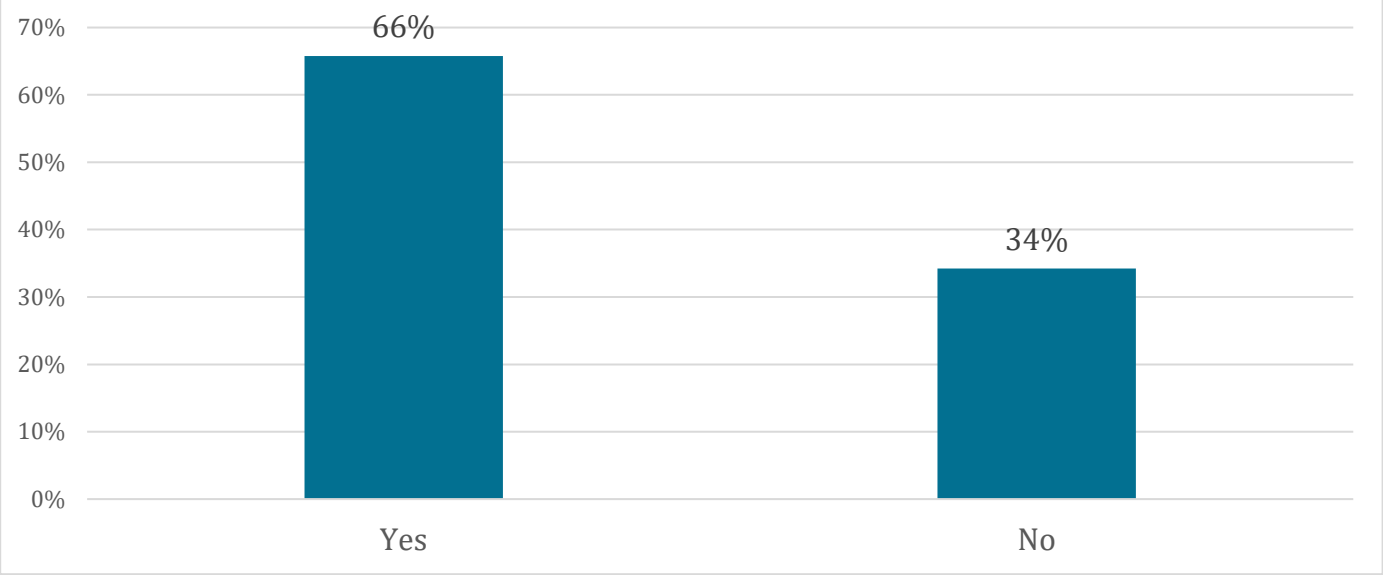
Responses to question 39 provide insight into how various transit agencies monitor passenger demographics and how this information is used to improve engagement opportunities.

Transit agencies across all transit service transects provided varying answers, with no clear trends per transect grouping. The responses received indicate that many transit agencies in the state turn to Census data to monitor their passenger demographics. A select few track customers contacts, utilize rider surveys, and collect qualitative data from operators. The responses also indicate that many agencies do not monitor passenger data at all.

Have there been initiatives to review your agency's Title VI requirements?

Responses to question 40 (**Figure 83**) show that two-thirds of Virginia's transit agencies have pursued efforts of review their Title VI requirements.

Figure 83: Have there been initiatives to review your agency's Title VI requirements?



Next Steps for Analysis

While this technical memorandum provides an overview of baseline conditions, additional analyses on existing conditions will be necessary for the development of an action plan. A description of how each technical area will proceed with its investigation of baseline conditions is provided in this section.

Accessibility

The two main analyses conducted as part of this report provide a basis for further exploration of trends and refinement by area type and transect. The study team intends to explore more about how transit service levels vary specifically through the day on an hour-by-hour basis and how commuter density may impact transit need. The Access to Opportunity scores provide a basis for understanding overall levels of opportunity throughout the state; however, the study team plans to analyze the proportion of opportunity accessible within each area by transit. If these analyses are to be used in the future as starting points for agencies, further refinement of the methodologies and results will be necessary. The maps are being developed into online resources and interactive dashboards that, with proper framing, could be used by the public and other transit agencies. Finally, the state of accessibility of paratransit service in the Commonwealth should be further explored.

Adequacy of Infrastructure

Given the limited availability of data related to bus stop amenities and their physical accessibility for most agencies in the Commonwealth, the study team will determine a representative sample size for bus stops within each VPI group. This sample will be used for a desktop review of aerial imagery and data collection of bus stop amenities and accessibility. The collected bus stop amenity data will be used to determine any relationships between the provision of amenities and physical access and local demography, as represented by VPI.

Emerging Technologies

To further the assessment of emerging technologies in the Commonwealth, the study team will continue to gather input and details on common barriers to implementation of technologies with engaged stakeholders. To contribute to this discussion, a list of available and soon-to-be available technology products will be developed. These technology products will be reviewed for their utility in solving identified needs and opportunities for deployment. Roles for local, state, and federal agencies in the testing and deployment of emerging technologies will be further defined. These inputs, informed by engaged stakeholders, will lead to refinement of opportunities identified in this technical memorandum and the development of specific actions for state and local agencies for modernizing and enhancing equitable service using emerging technologies.

Electrification

Additional assessment of opportunities for electrification will continue following this technical memorandum. This assessment will include a determination of feasibility and potential schedule for local agencies transitioning to ZEBs; a review of agencies' fuel needs, energy consumption, facility charging infrastructure requirements, and potential maintenance costs; and an estimate of potential statewide capital costs related to electrification as well as a comparison to estimated costs associated with maintaining the existing state of fleet composition. The study team will conduct outreach to utility companies operating in Virginia to assess their readiness to support transit electrification. The feedback collected from this outreach effort will be paired with research on existing utility programs supporting electric vehicles through rate schedule adjustments and incentive programs.

Transit Safety

The next steps for transit safety will include assessing both quantitative and qualitative sides to safety and security. The next stops following the baseline report will include interviewing agency employees one-on-one as well as transit passengers in Virginia. The project team will take appropriate steps to gather data and information from both passengers and employees that is inclusive of representative agencies and riders. The project team will investigate and interview other agencies throughout the country that have conducted equity studies to gather best practices that are in place elsewhere.

Based on the information the study team has received from local transit agencies, there are a few preliminary findings that can be noted. Frequent safety meetings are happening at virtually every transit agency. These meetings are occurring on daily, weekly, monthly bases. Other agencies across the country also have begun researching and exploring the relationship between transit safety and equity, including the impacts to vulnerable populations. Future reports will look at these external best practices and explore what methods used elsewhere are applicable to the transit agencies within the Commonwealth.

System Engagement and Governance

The system engagement and governance technical area team will continue its work toward the completion of the final study. The following technical area tasks will be completed in the next phase of the study and will be used to inform future deliverables such as the study's action plan and final report:

Review of National Best Practices and Peer State Agency Practices

The study team will conduct a review of national best practices and toolkits for public outreach strategies for underrepresented communities, Title VI requirements, and transit system governance. The following resources will be consulted to inform this sub-task:

- International Association for Public Participation (IAP2) resources
- Simon Fraser University/Morris J. Wosk Centre for Dialogue resources

The study team also will review select peer state agency practices for public outreach strategies for underrepresented communities. Through consultation with and guidance from DRPT staff, the study team intends to review the engagement practices of the following four peer state agencies:

- Pennsylvania Department of Transportation
- Washington State Department of Transportation
- Maryland Department of Transportation/Maryland Transit Administration
- Florida Department of Transportation

Opportunities Assessment

The overall, complete assessment of opportunities for the system engagement and governance technical area will be completed and documented with the study's action plan and final report. The study team will work to develop actionable goals and success criteria, state-level strategies, and local-level strategies based on current practices, existing DRPT guidance, and national best practices. Identified opportunities may include new guidelines, policy changes, requirements tied to DRPT funding to local agencies, toolkits or checklists, or online resources. Identified opportunities will not be one-size-fits-all; rather, they will be reflective of the wide range of agency types and sizes across the Commonwealth.

Preliminary Findings and Opportunities

This section details the preliminary findings and opportunities based on the analysis conducted for each technical area. The findings represent instances in which current practices related to transit program management at the state and agency levels are not effectively promoting equity. The opportunities represent decision points, institutions, or procedures at which state or transit agency decision-makers can adjust practices to better promote equity goals. Findings and opportunities are broken down by technical area and are further organized by whether the finding or opportunity applies to transit agencies or to statewide programs and procedures.

Preliminary Findings

General

- Agencies are interested in improving infrastructure and implementing technologies like vehicle electrification, but have limited funding, staff bandwidth, and expertise
- Deployment of policies and technologies appears to favor larger agencies
- Some topic areas show diverse levels of data availability and policy development among local agencies, which appears to be a result of a lack of specific standards and reporting at the federal and state level
- Gaps in communication and shared knowledge with employees and customers have resulted in misperceptions about different topic areas like electrification and safety

Accessibility

Statewide

- An estimated 1.06 million Virginia residents and 566,000 jobs are affected by a potential fixed-route transit service gap based on current service levels and estimated need
- Of the four area type classifications, the one with the largest percentage of population and jobs with service gaps was in the Urban-2 (includes the Richmond and Hampton Roads Regions)
- Implementing zero-fare transit across the Commonwealth would require between $675 and $950 million for FY22-FY27—more than either DRPT's current Capital or Operating Assistance budgets, but significantly less than the amount spent on roadway infrastructure improvements in the same timeframe[22]
- The current state operational funding formula emphasizes ridership and cost efficiency
- Overall service gaps do not disproportionally affect census block groups with higher VPI scores
- The block groups in the analysis are more often more urban rather than rural area types, as fixed-route service has wider coverage in larger urban areas
- Access to opportunity (A2O) via transit varies from location to location across the state. The access to opportunity score is based on the number of jobs and destinations available and the transit service provided. The variation in all three of those components can be seen in the variation of scores in the results.

[22] *Based on 2019 NTD reported farebox revenue, adjusted to current $ using 3% inflation and estimated expenses detailed in the FY22 DRPT and VDOT SYIPs*

- Aligning with expectations, the lowest average A2O scores are for rural and small urban areas while the highest A2O scores are for the large urban areas and NOVA. The statewide average A2O score is elevated due to the number of urban block groups with higher A2O scores included in the analysis.
- A2O scores are higher in urban areas, more varied, and more susceptible to changes by day of week/time of day.
- Access to opportunity decreases slightly as VPI increases. In addition, for those locations identified as having potential transit service gaps, those locations typically see lower A2O scores, especially as VPI increases.
- The accessibility proportions, indicating the percentage of jobs and destinations accessible with fixed route transit relative to those accessible with a 60-minute driveshed, are varied across the Commonwealth.
- Proportions across the Commonwealth range from approximately 0%-75%, with majority of census block groups scoring between 20%-40%. Accessibility proportions are higher for jobs relative to destinations. This trend is true for all area types and vulnerable populations.
- Some locations with more rural characteristics that scored relatively lower in the A2O analysis proportions have job proportion scores between ~15%-50%, similar to some locations with more urban characteristics.
- In general, for both jobs and destinations proportions, as the VPI increases so does the proportion of jobs and destinations available in a 60-minute driveshed are accessible within the 60-minute transit travelshed.

Agency Level

- Transit service levels and coverage decreases in evenings and weekends, as compared to weekday peak period levels; this is particularly evident in more urban and commuter-focused markets
- About half of the agencies in Virginia are interested in potentially implementing a zero-fare transit policy, while 11 agencies have at least partially implemented it
- While zero-fare transit can bring benefits to agencies, it is not a solution for every agency; there also are other strategies that have been shown to provide equity benefits such as removal of transfer fees, increased frequency and coverage, or targeted subsidized fares.
- When considering zero-fare transit, there are many benefits beyond ridership that should be captured, including: making service more efficient; reduced and more stable operational and capital costs; and more disposable money for new and existing riders. Few agencies that have implemented such a policy have had success in quantifying many of these additional equity benefits
- Smaller agencies do not have the staff or resources to apply for state grants, such as TRIP
- Especially for the larger transit agencies, it is much easier to plan for and assess existing service, but during implementation, limited funding exists, and so difficult choices need to be made about how to invest those resources
- Smaller agencies do not have the benefit of a dedicated stream of funding that some of the larger agencies do have
- Locally, transit competes with other critical jurisdictional line items
- Fiscal policies that operate with a direct relationship between contribution and received service can skew transit service toward wealthier cities or those with more transit-focused officials, which can have negative effects on equity
- Seven transit agencies self-identified as having an equity policy beyond Title VI requirements; some examples of these included creating internal diversity, equity, and inclusion groups; public-facing transit service goals; and policy that requires consideration of equity when delivering service

- Eighty percent of agencies agree or strongly agree that their service is currently equitable; 74 percent of agencies indicated that equity is either "higher than most" or "the highest" consideration in the provision of transit services
- Many agencies have developed ways to plan for and assess service patterns using demographic indices; however, it is important not to group the needs of individual groups of people, and instead focus on identifying a need and understanding specifically who it impacts
- For agencies with overlapping service areas, it can be challenging to divide service responsibilities and understand the cumulative picture
- Identified fixed-route service gaps are generally not disproportionally affecting individual population groups within the VPI

Adequacy of Infrastructure

Statewide

- There is no standard measure for OTP nor reliability of fleet across the Commonwealth, making statewide comparisons of fleet performance impossible
- Data in TransAM does not match NTD reports on all attributes; in addition, guideway, support systems, and data on bus stops is not collected
- Many SGR projects submitted to MERIT are scored as MIN projects due to lack of asset data for scoring or understanding asset conditions
- In terms of equity goals, there is no prioritization criterion or lens for equity-based scoring in MERIT
- In terms of modernization, there are only a small number of additional points available in MERIT scoring for alternative-fuel vehicles, LEED buildings, and improving pedestrian access; these bonus points are marginal compared to the baseline scoring of project types based on asset types
- The FY2022 SYIP included unconstrained capital needs based on DRPT 5-year capital budget submissions. The analysis revealed a state-level funding gap of $283 million for all needs. The funding gap persists if you limit the agency needs to SGR only (including both SGR and MIN projects that are SGR in character), meaning even reinvesting in existing transit infrastructure will not keep pace with emerging needs. This gap is likely underestimated as only DRPT 5-year capital budget submissions were considered, which requires agencies to prioritize and submit their most important needs to DRPT. Unsubmitted needs may increase the size of the funding gap
- More than three-quarters (79%) of Virginia's transit agencies have reported bus stops that are not connected to sidewalks and there is no statewide or federal standard for connecting bus stops to pedestrian infrastructure

Agency Level

- For SGR performance, the percentage of fleet at or beyond ULB in Virginia is roughly in line with the rest of the country, where 20 percent of vehicles were reported as at or beyond ULB in FY2019
- There is a moderately negative correlation between VPI and percentage of vehicles at or beyond ULB, suggesting that there is an equitable emphasis on replacing vehicles at agencies representing more vulnerable populations
- Vehicles and transit services have grown to meet the needs of more vulnerable areas in the past 10 years
- Virginia's transit fleet is less ADA-compliant than the national average, though this may be a result of misreporting of data

- Most transit agencies in Virginia stated that their facilities, both support and passenger-facing, have enough capacity to support current service levels, with only a few agencies noting that existing and planned facilities will not be able to support future service levels
- More than 70 percent of transit agency respondents that own passenger facilities stated that all their passenger facilities are ADA-compliant, though there is no current way to validate compliance in TransAM or NTD data; transit facilities are generally in better condition than the national average, though some agencies serving more vulnerable populations do have facilities in poor condition
- There is interest in expanding the use of bus lanes and BRT in the Commonwealth, and bus lanes miles may be increasing on roadways not owned/maintained by transit agencies
- In addition to the scarce data available on the locations and types of bus stop amenities across the state, publicly available data sources often conflict with GTFS and GIS layers, providing different locations and inventory counts

Emerging Technologies

Statewide

- The Commonwealth, and specifically DRPT, plays a critical role in the testing and deployment of emerging technologies through technical assistance, grants and funding for technology, and state contracting and cooperative purchase agreements
- DRPT does not systematically or frequently collect statewide data on what technologies are in use, planned for replacement, or planned for new deployment.
- Statewide contracts for technologies have been difficult for DRPT to implement and have been met with resistance from other Commonwealth stakeholders. Technology needs are also not always uniform among multiple agencies, adding to this challenge.

Agency Level

- In survey, agencies that have an average VPI higher than the average for Virginia agencies (i.e., more vulnerable populations) responded similarly to agencies with a VPI lower than the average; the exception is alternative energies—7 of the 10 responses came from agencies with a higher-than-average VPI
- Approximately one-third of Virginia transit agencies have electronic fareboxes; however, many agencies that do not have them consider the investment in this technology unwarranted due to relatively low levels of fare revenue collection
- Many emerging technologies identified as full/in-service or limited deployment in the industry not yet been widely deployed in Virginia. This includes real-time operations and customer-facing information technologies (detour management, transfer connection protection, vehicle occupancy, open data standards), the latest forms of payment (account-based payments, contactless open payments, mobile payments), and zero emission vehicle technology.
- Agencies of all transects cited common implementation barriers of capital, operations, and maintenance funding for technology; the additional responsibilities technology puts on staff and operators; and limited expertise with technology

Electrification

Agency Level

- A cross section of vehicle types show a heavy concentration of low-floor transit buses and cutaway vehicles, and a sizeable number of over-the-road coaches, all of which could benefit from electrification

- Fixed route bus service represents the largest percentage of the service types, followed by demand response. There is also a sizeable number of commuter routes. All these routes largely correspond to the vehicle type that would be expected to be operated for these types of service
- Fuel type is dominated by diesel and gasoline vehicles (>30 percent each), which are particularly emissions heavy; another 30 percent of vehicles consist of hybrid diesel and CNG vehicles, combined
- The current vehicle replacement schedule, based on minimum service life policy, has multiple points throughout the next 12 years to incorporate a planned, phased approach to electrification
- A significant number of agencies in the Commonwealth are considering an electrification policy, and those that have deployed BEBs have either clearly defined goals or, in some cases, a written fleet transition plan
- Even in considering the agencies that have deployed BEBs, there is still a significant knowledge gap across the Commonwealth in understanding the challenges in electrification and how to address them

Safety

Statewide

- In all cases, transit is observed as a safer mode of transportation than automobiles; data also shows that on a year-over-year basis, the highest reported crime on transit systems is fare evasion

Agency Level

- Agencies use requirements and procedures to increase security for riders and employees, such as PTASPs and general best practices
- There is an observable trend linking the availability of more safety materials and frequency of communication (both internal and external) and the overall size of the agency (based on ridership)
- Traveling to and from transit facilities or while waiting at transit stops is a major concern of many transit patrons based on available data collected for this report; for transit employees, on the other hand, building a safety culture through adequate training, open and frequent communication, and strong organizational commitment is what contributes to a positive transit safety perception—while the opposite of such qualities would result in a negative one

System Engagement and Governance

Statewide

- State-level public engagement guidance for transit agencies is lacking in detail and quantity; public outreach plans are required to be documented by the Commonwealth of Virginia and through Title IV federal requirements

Agency Level

- There is both the need and the desire for community members and stakeholders to be involved in the conversation about how to improve transit and mobility in their respective communities
- Many transit agencies have successfully turned to virtual forms of public engagement during the COVID-19 pandemic, much of which is likely to remain in place after the pandemic. Although there are many positives to virtual engagement, this also can negatively affect or exclude populations with a lack of internet access or those that may be less familiar with technology
- Agencies that fall within the fixed route and enhanced fixed route transit service transects are more likely to have the resources necessary to conduct more robust public engagement on a regular basis (i.e., public participation plans, dedicated staff, reliable funding)

- Agencies that fall within the demand response transit service transect, and smaller agencies within the fixed route transect—many of which are rural-serving agencies and governed by private non-profits—are less likely to have the resources to conduct more robust public engagement on a regular basis (i.e., public participation plans, dedicated staff, reliable funding)
- Smaller agencies that fall within the fixed route or demand response transit service transects can engage with their riders in a way that is scaled and appropriate to their unique sizes and service offerings
- Membership requirements for transit agency boards of directors lack provisions that ensure representation from riders and/or members of transit-disadvantaged communities
- While public engagement activities and practices are conducted across all Virginia transit agencies and are seen as productive, necessary, and insightful, the scale and scope of these activities vary greatly across different agencies
- Many transit agencies across Virginia recognize and value the importance of engagement with underrepresented and underserved communities, but provisions and guidance that ensure participation from and engagement with these groups is lacking in agency board membership requirements, advisory body members requirements, statewide guidance documents, and other documents

Opportunity Assessment

General

- Requirements for agency plans (TSPs/TDPs, PPPs, PTASPs, etc.) and state funding sources (MERIT) should be more explicitly aligned with equity and technology investment
- Metrics for agency reporting should be standardized across the Commonwealth and required reporting should include more detail on ADA compliance, facility and guideway condition, on-time performance, bus stop and station conditions, and surrounding built environment; aside from reporting requirements, agencies would benefit from guidance on data standards and best practices
- Agencies should improve communication with staff, riders, and peer agencies to ensure the sharing of knowledge on safety conditions and procedures, available technologies, and equitable planning

Accessibility

Statewide

- Refine the Gaps Assessment and Opportunity Score methodologies to develop a consistent framework to evaluate equity and prioritization in funding allotment
- Increase the amount of funding for TRIP so that agencies can have funds for zero-fare service longer than FY25. TRIP is codified as a percentage of the Mass Transportation Trust Fund, but the General Assembly has only authorized funding for FY22. To fully realize the equity benefits of zero-fare transit, the GA should authorize additional funding for TRIP in future years to allow for the continuation of zero-fare programs.
- Revise the TRIP project evaluation guidelines to allocate more weight to providing equitable service instead of increased ridership and applicant commitment (60 percent of an applicant's score). While important factors, TRIP was originally implemented to provide access to low-income and marginalized populations, but implications for equity and accessibility represent 30 percent of a project's score
- Recommend agencies conduct cost-benefit analyses that include the assessment of the cost of collecting fares compared to revenue as well as potential benefits of alternative approaches of using the potential revenue (such as frequency increases)
- Develop tools to assist agencies in advocating for local funding that highlight transit's community benefits

- Restructure state operating formula to include provisions for serving "coverage" or other equity-focused goals
- Devise an equitable strategic plan framework for use by for regional transit providers with overlapping service areas to facilitate cohesion
- Encourage agencies of all sizes to create TSPs; or, add equity as a section in a TDP
- Develop a common statewide framework to measure equity, potentially building from the VPI, that can be tailored to different transects and local factors
- Develop performance measures and service design guidelines that highlight equity goals.

Agency Level

- This statewide analysis provides a strong framework for individual agencies to use and assess individual gaps in service
- At the local scale, precision of this analysis could be strengthened by more comprehensive data and tailoring of thresholds to local conditions
- The implementation effort to go zero-fare increases with ridership and farebox recovery ratio and may be most applicable to demand-responsive agencies and smaller fixed-route agencies; while it may be more costly and difficult to implement for larger agencies, there is more potential to create a stronger benefit for a greater number of people
- Short-term grant funding could assist agencies transitioning budget models to zero-fare service
- Long-term state grants and funding commitments from large employers, institutions, or localities are required to implement long term zero-fare programs
- Agencies could consider implementing zero-fare over time incrementally to specific groups as supplemental funding sources are identified
- Enhanced fixed-route services such as rail or BRT have the least potential and rationale for zero fare given the high quality and high costs for operating
- Engage with multiple stakeholders beyond transit/transportation to support transit connection to opportunities; examples include community-based organizations who work within the communities impacted by transit service, community leaders, religious leaders, community resource providers, etc.
- Develop prioritization methodology to equitably allocate new service hours in a constrained budget
- Conduct assessment of the origins of historical service planning decisions and address inequities through a network redesign or incremental changes

Adequacy of Infrastructure

Statewide

- Standardize and validate ADA reporting of fleet by providing technical guidance and support to agencies.; similar to the reporting of ADA compliance, the accounting for reliability is an opportunity for DRPT to provide technical guidance and potentially generate statewide standards
- Standardize metrics and definitions of OTP to enhance analysis of agencies' services and variability across the state
- Encourage agencies to report information on the ADA compliance and accessibility of their facilities, particularly passenger-facing facilities
- Work with agencies to standardize methods for planning SGR renewal or replacement of linear assets (and other asset types so ESLs are more complete for use in MERIT scoring)
- Build up unconstrained needs from asset lifecycles for SGR from statewide inventory and lifecycle policies in TransAM to determine the full unconstrained SGR needs and funding gap for the state
- Align grant making through MERIT scoring with the goals of equity and modernization of infrastructure

- Require or incentivize (through prioritization points) reporting of more complete asset inventory to TransAM, including collecting data on infrastructure, bus stop amenities, and critical transit support systems to allow for SGR scoring in the MERIT process
- Develop minimum standards for bus stop design in a variety of contexts and share best practices with local agencies for coordinating improvements.
- Analyze MERIT Capital Assistance baseline scores for projects that replace or expand bus stop/ station/ shelter amenities.

Agency Level

- Track historical records of facilities to determine accurate changes in facilities and locations over time
- Establish processes or practices to capture more data consistently and understand trends in implementation and performance of bus or rail guideways
- Increase collection and provision of data on bus stop conditions for decision-making purposes

Emerging Technologies

Statewide

- Continue and expand existing MERIT Special Projects program (Demonstration Project Assistance grant program, Technical Assistance) to support technology investment; align program design with upcoming interest and needs of transit agencies
- Form partnerships with groups such as the Virginia Department of Aging and Rehabilitation and non-profits groups for needs assessment, proof of concept and pilots, and funding of emerging technologies
- Provide funding assistance for all aspects of technology implementation project lifecycle including project planning and management
- Establish state contracts or cooperative purchase agreements for common established or emerging technologies
- Provide technology education and training to transit agency staff and stakeholders
- Establish Commonwealth goals for emerging technology
- Continue to support implementation of established technologies in areas where Virginia has lower levels of deployment compared to the industry
- Invest in Virginia-based transit technology research programs to further the development and deployment of emerging technology
- Explore pooling technology experts among multiple transit agencies for on-demand access to technical assistance
- Facilitate information sharing among transit agencies on technologies used by others
- Facilitate information sharing among transit agencies on technologies available from vendors
- Ensure real-time customer-facing information is accurate, reliable, and accessible via multiple dissemination channels
- Provide guidance for data standards and best practices
- Promote use of open data standards
- Promote open trip planner deployment that supports demand-responsive services

Agency Level

- Prioritize investment in technologies that provide benefits to all transit riders rather than a subset of riders
- Ensure real-time customer-facing information is accessible via multiple dissemination channels

Electrification

Statewide

- Provide additional education and guidance to agencies regarding strategies to address the challenges of electrification and in developing fleet transition plans for individual agencies and accelerate adoption across the Commonwealth
- The current vehicle replacement schedule is conducive to opportunities for a phased approach in fleet electrification in the Commonwealth of Virginia, as a result of number of vehicle due or overdue for replacement in the next three years.

Agency Level

- Based on the current vehicle composition, there could be a significant opportunity in reducing emissions by replacing the large number of low-floor transit buses and cutaway vehicles
- Service types are heavily dominated by fixed bus routes, which present an opportunity for emissions reductions based on replacement of both low-floor transit buses and OTR coaches with BEBs
- The large number of diesel and gasoline vehicles present a significant opportunity in emissions reductions by electrifying those fleets
- Battery capacities of BEBs are trending upward, which will help enable the achievement of longer routes over time; due to the rapid pace of change, capacities vary widely across different size vehicles and bus OEMs
- There are multiple charging options in the marketplace, with increasingly modular characteristics, that can enable operational flexibility and extend the range of current technology BEBs
- Significant funding opportunities continue to be available at both the federal and state level to assist agencies in the deployment of electrics buses, related equipment, and facilities; funding allotments are generally determined on a competitive basis

Safety

Agency Level

- There is an opportunity for transit agencies to increase coordination with local law enforcement agencies to increase security at and near transit stops
- Better communicate how transit provides a safe environment for travel and the plans and policies that are in place to quickly and flexibly address when users do not feel safe
- Provide guidance to agencies on public safety awareness standards that should be observed by all operators and passengers to report

System Engagement and Governance

Statewide

- Improve specific state-level guidance for public engagement, specifically in the development of TDPs, TSPs, and PPPs
- Provide guidance to agencies on virtual public engagement, a likely new normal in the wake of the COVID-19 pandemic
- Create more targeted guidance and/or requirements that will ensure mechanisms to engage underrepresented communities are in place and successful, specifically for membership composition of transit agency boards of directors and advisory bodies

Agency Level

- The opportunity exists for more transit agencies to form an advisory body or bodies. Transit agencies of all sizes across the Commonwealth can consider forming a committee or group such as a rider advocacy committee (RAC) to help inform and advise local transit decision-making. These bodies can be comprised of current riders and/or community stakeholders who have an interest in preserving and enhancing transit in their respective community, and could include representatives from major local institutions and employers (e.g., hospitals or universities), city and/or county leadership or staff, MPO and/or PDC leadership or staff, and more

Appendix

Appendix A: Access to Opportunity Detailed Methodology

1. Download and obtain all relevant files needed for analyses:
    a. GTFS feeds for all agencies providing fixed-route service
    b. Underlying travel network from OpenStreetMap
    c. Destinations (point layers) from OpenStreetMap
    d. Jobs (census block group level) from US Census LEHD

    Note that in order to maintain manageable file sizes for network analyses for generating transit travel sheds, the state was sub-divided into several different regions for data organization and travel shed generation as shown below:

Analysis Area	Transit Providers Included in Analysis Area
1	Valley Metro Transit, Radford Transit, RADAR, Blacksburg Transit, Pulaski Area Transit
2	Four County Transit, Graham Transit, Bristol Transit
3	Danville Transit
4	Mountain Lynx
5	Harrisonburg, Brite, Jaunt, Blackstone, Farmville, Petersburg, Greater Richmond Transit Company
6	Altavista, Greater Lynchburg Transit Company
7	Greensville Emporia Transit
8	Hampton Roads Transit, Suffolk Transit, Williamsburg Area Transit Authority, Bay Transit
9	Arlington Regional Transit, WMATA, DASH, Fairfax CUE, Fairfax Connector, FRED, Loudoun County Transit
11	Star Transit and Chincoteague
11	Virginia Regional Transit
12	Wintran

2. For each census block group in a region in which fixed-route service is available, generate travel sheds via the available transit network:
    a. Travel sheds were generated for a weekday AM peak, weekday midday, and weekend midday. As our travel shed process using the GTFS schedule requires specific time inputs to align with schedules, the following time periods were used:
        i. Weekday AM Peak – Wednesday 7:00 AM, 7:10 AM, and 7:20 AM
        ii. Weekday Midday – Wednesday 12:00 PM, 12:10 PM, and 12:20 PM
        iii. Saturday Midday – Saturday 12:00 PM, 12:20 PM, and 12:20 PM
    b. For each of these time periods, travel sheds were developed for 30-, 45-, and 60-minute intervals.
    c. Through preliminary iterations of the analysis, it was identified that access varies for different locations within a block group. Adjusting the methodology to account for this, travel sheds were created for random points within each block group in addition to the block group's centroid. This allowed the score for the block group to more comprehensively represent access across the entire block group geography.

   d. Thus, travel sheds were generated for 10 random points in each census block group x 3 time periods x 3 start times within each time period x 3 different travel shed sizes (30/45/60 minutes), resulting in a total of 270 travel sheds for each census block group.
3. Spatially join each travel shed to the jobs and destination layers to capture the number of jobs and destinations accessible within each travel shed.
4. For a given census block group, average results across each of the 10 random points and the three start times within each time period. For example, a census block group should have one average count of jobs and destinations for the weekday AM peak/30-minute interval combination. This results in nine time period/travel shed interval combinations for each census block group: weekday AM/weekday midday/Saturday midday x 30/45/60 minutes, each with an average number of jobs and destinations that can be accessed within that time.
5. Normalize the scores against the same travel shed size for each of the corresponding time periods. For example, 30-minute travel shed results are normalized among weekday AM, weekday midday, and Saturday midday.
6. Create a composite score for weekday AM, weekday midday, and Saturday midday that is the average of the normalized scores for the 30-, 45-, and 60-minute travel sheds for each census block group. The final composite score is an average of the weekday AM, weekday midday, and Saturday midday scores.

Appendix B: Access to Opportunity Complete Destinations List

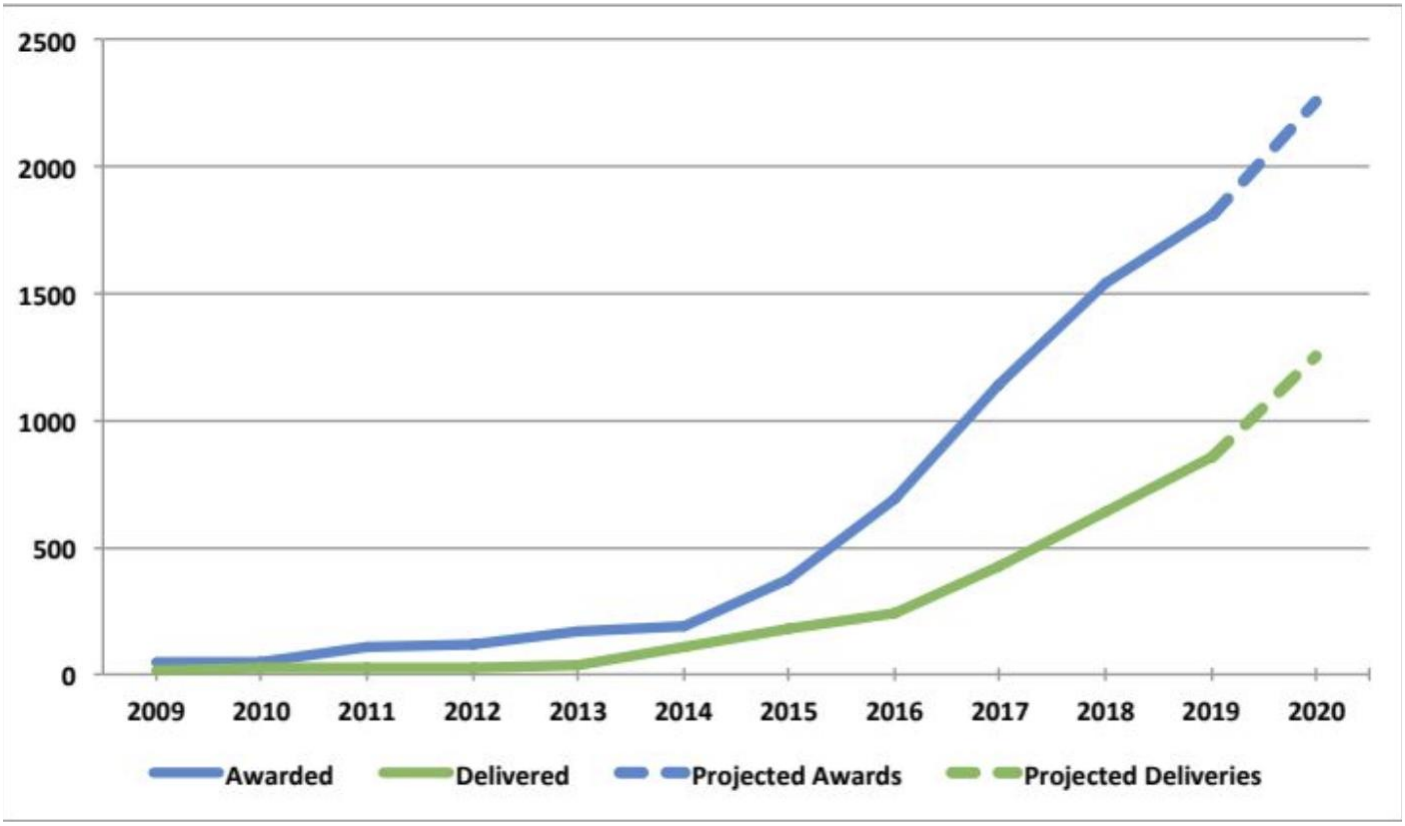
Appendix B outlines the complete list of destinations utilized in the access to opportunity analysis. Data was sourced from Open Street Map. More detailed feature contents can be found on Open Street Map's Wiki Page.

Destination Type	Data Features Utilized
Fresh/Health Food Opportunities	• Supermarkets • Farmers Markets • Fruits/Veggies/Greengrocer
Park/Plaza/Other Outdoor Public Space	• Parks
Trails	• NPS Land
Non-Emergency Healthcare Services/ Pharmacy	• Hospitals and Medical Clinics • Medical Clinics • Doctors • Pharmacy • Dentists
Community Facilities	• Colleges • Grade Schools • Childcare • Kindergarten • Universities • Recreation Centers • City Hall • Government Offices • Court Houses • Libraries • Employment Services • Big Box Stores

Appendix C: Zero-Emissions Bus Market Analysis

In general, the zero-emission bus (ZEB) market is rapidly developing. Figure 1 shows the rapid increase in orders and production of ZEBs, which include both battery electric buses and fuel cell electric buses. The market is also seeing new manufacturers enter the market, creating competition that drives the development of improved and more affordable technologies. Costs for ZEBs are still significantly higher than conventional internal combustion engine technologies; however, ZEB-specific grant funding is available from state and federal sources to help bus operators overcome the initial cost barriers and reap the benefits of zero-emission buses.

Growth in the US Zero-Emission Bus Market: U.S. Cumulative Awards and Deliveries by



Comparison of Fuel types

	Base Cost of Bus	Infrastructure Cost	Maintenance Cost	Operation Profile	Fuel Cost (per Mile)
Diesel	$400k	$	$$	Baseline	$$
CNG	$460k	$$	$$$	Similar to baseline	$$
Hybrid	$450-550k	$	$$$	Similar to Baseline	$
Battery Electric	$655k - $1.1M	$ - $$$	$	Not a 1:1 substitute	$-$$$*
Hydrogen Fuel Cell	$1.1 - 1.5M	$$ - $$$	$	Similar to baseline	$$$$**

*** Varies by location and utility tariff**

****Assumption based on CTE's observation in market trends. Price highly dependent on H2 production.**

*****Base Cost excludes options and taxes**

Zero Emission Bus & Infrastructure

	Depot Charging	On Route (Conductive)	On Route (Inductive)	Fuel Cell
Charge Interface	Plug-in or overhead pantograph at depot	Overhead pantograph and charger on-route	Overhead or in ground	On board charge via fuel cell
Batteries	Large battery packs	Smaller battery pack	Large battery packs	Smaller Battery Pack
Range	70-200 miles	Virtually Unlimited	Virtually Unlimited	300+ miles
Charger Site	50-150 kW charger	300-500 kW charger	50-250 kW charger	No charger needed
Charge Time	Full charge in ~4 hours	~2.5 miles per charge minute	Range extender	~10 minutes to full tank

40 Foot Buses

There are seven original equipment manufacturers (OEMs) currently offering 40-foot battery electric transit buses. The battery capacity offerings and reported ranges for each manufacturer are listed in the table below.

40' Low Floor Battery Electric Transit Bus Specifications by OEM

	Energy Storage Ranges	OEM Reported Range
BYD	313 - 446 kWh	157 - 203 mi
CCW	250 - 558 kWh	Not Listed
El Dorado National-California	Not Listed	140 mi
GreenPower Bus	400 kWh	>200 mi
Proterra	220 - 660 kWh	97 - 326 mi
New Flyer	350 - 525 kWh	174 - 251 mi
Gillig	444 kWh	~150 mi

35-Foot Buses

There are two original equipment manufacturers (OEMs) currently offering 35-foot battery electric transit buses. The battery capacity offerings and reported ranges for each manufacturer are listed in the table below.

	Energy Storage Ranges	OEM Reported Range
CCW	250 - 558 kWh	Not Listed
Gillig	148 kWh	~50 mi

30-Foot Buses

There are six original equipment manufacturers (OEMs) currently offering 30-foot battery electric transit buses. The battery capacity offerings and reported ranges for each manufacturer are listed in the table below.

	Energy Storage Ranges	OEM Reported Range
BYD	215 - 313 kWh	158- 196 mi
CCW	250 - 558 kWh	Not Listed
El Dorado National-California	Not Listed	140 mi
GreenPower Bus	260 kWh	>175 mi
Proterra	220 - 660 kWh	97 -326 mi
New Flyer	350 - 450 kWh	179 - 220 mi

60-Foot Buses

There are two original equipment manufacturers (OEMs) currently offering 60-foot battery electric transit buses. The battery capacity offerings and reported ranges for each manufacturer are listed in the table below.

	Energy Storage Ranges	OEM Reported Range
BYD	578 kWh	159 mi
New Flyer	525 kWh	153 mi

1.1.4 Cutaways and Minibuses

There are nine original equipment manufacturers (OEMs) currently offering Cutaway battery electric transit buses. The battery capacity offerings and reported ranges for each manufacturer are listed in the table below.

OEM	Length	Battery Capacity	Working Range
GreenPower Bus	25 ft	118 kWh	120 -150 mi
Endera	24 ft	129 kWh	130 mi
Lightning Motors	25 ft	43 – 129 kWh	80 – 120 mi
Motiv	26 ft	127 kWh	105 mi
Optimal EV	26 ft	113 kWh	125 mi
Phoenix Motorcars	23.2 ft	70-156 kWh	70 – 160 mi
SEA Electric	Na	88-100 kWh	180 mi

1.2 Charging Market Analysis

Table 5 provides an overview of charging options for battery electric buses. The most common charging method used by transit agencies is plug-in depot charging. The equipment and installation costs for depot charging are lower than those for on-route charging, which require fast-charging

infrastructure. Overnight charging, the standard operating strategy for depot-charge setups, allows agencies to take advantage of lower electricity rates during off-peak hours. Currently, depot chargers are installed with pedestal mounted plug-in dispensers located near a dedicated BEB parking area at the depot, or long-duration midday layover location. However, for large electric fleets, it may become impractical to have pedestal mounted plug-in dispensers, typically one for each bus, installed throughout the yard or garage. One alternative may be to construct a pantograph that drops down from an overhead gantry to charge the bus from the roof. Another space-saving option is wireless inductive' chargers that can be used to charge vehicles from charging pads installed in the pavement below parking areas.

Charge Interface	Plug-in Charging	Overhead Charging	Wireless Charging
Rated Power	50 – 150 kWh charger	300 – 600 kWh charger	50-300 kWh
Charge Time	Full charge in ~ 3 - 4 hours	~ 2.5 - 4 miles per minute of charging	~ 0.5 - 2 miles per minute of charging
SAE Standard (Society of Automotive Engineers)	J1772 (DC) J3068 (AC)	J3105-1	Various standards for wireless charging currently under development

Incentive/Funding Opportunities to Support Transit Agencies

The Commonwealth of Virginia allocated $14 million of the **Volkswagen Settlement** funding for all-electric transit buses. Funding is intended to cover the incremental costs associated with the purchase of the advanced technology vehicle and the cost associated with charging infrastructure. The funding is capped at $500,000 per bus, including infrastructure. The funding is being made available through the Department of Rail and Public Transportation's MERIT program. In the FY2020 grant cycle, $9 million of the allocated funds were awarded to three transit agencies to support the replacement of diesel buses with all-electric buses.

The remaining $5 million of VW Settlement funding allocated for transit is available through the FY22 public transportation grant application cycle. Eligible applicants for the VW funding must be "…eligible to apply for public state operating assistance grants and that apply for State of Good Repair diesel transit bus replacement grant projects."[23]

Federal

The Federal Transit Administration (FTA) manages the competitive **Low or No (Low-No) Emission Grant Program (5339(c))**. The program provides funding for the purchase or lease of low or no emission transit buses and related equipment and facilities. The funding can also be used for costs for workforce development and training. FTA does take note if applicants propose to use the funding only for the incremental costs associated with new technology vehicles.

In FY21, $182 million was available through the Low-No program. It is an extremely competitive program and is generally oversubscribed.

FTA manages the **Buses and Bus Facilities** competitive grant program (5339(b)) and (5339(a)). For (5339(b)) funding is made available annually and supports capital projects to replace, rehabilitate, and purchase buses and related equipment, as well as projects to purchase, rehabilitate, and construct bus-related facilities. Low or no emission vehicles and facilities are eligible. In FY20, FTA awarded $464 million in projects. Low or no emission vehicles and facilities are eligible. Similar to the Low-No program, the Buses and Bus Facilities program is generally oversubscribed