NORTHERN VIRGINIA TRANSPORTATION COMMISSION

Transit Dashboard Documentation

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1.0 Dashboard

The Northern Virginia Transportation Commission (NVTC) funds and promotes transit in the counties of Arlington, Fairfax and Loudoun and the cities of Alexandria, Fairfax and Falls Church, a 1,000 square-mile region with a population of 2 million. Seven transit agencies have services operating in this area, including: Arlington Transit, CUE, DASH, Fairfax County Connector, Loudoun County Transit, Metro[1], OmniRide and Virginia Railway Express (VRE). NVTC's Transit Resource Center (TRC) collects, analyzes, and reports data about all transit systems that operate within NVTC's jurisdictions. This purpose of this dashboard is to aggregate and visualize these data. The goal is to make the region's transit data more accessible and transparent to both the public as well as professionals who might find the data useful for their own work.

The purpose of this document is to describe all the data used in the creation of this dashboard, including where the data was sourced and how data was manipulated to calculate any of the information provided in the dashboard. Only publicly available data was used to create this dashboard. Thus, through identifying the data sources and explaining calculation methodologies, any of the numbers or graphics from NVTC's dashboard can be independently verified.

1.1 Home Page

The home page is the landing page for the dashboard. The purpose of this page is to give an overview of NVTC's jurisdictions as well as the transit agencies that operate within these jurisdictions.

Figure 1 shows a screenshot of the homepage. The home page summarizes two types of data. On left of is jurisdiction data, including a map as well as summary jurisdiction statistics. On the right is summary information for transit agencies. Each unique aspect of the page is labeled and described below.

A. Ridership page. This page provides an overview of ridership trends in the region. It is described further in Section 1.2.

B. Transit service page. This page summarizes transit services and provides an overview of service trends in the region. It is described further in Section 1.3.

C. Transit productivity page. Transit productivity combines transit ridership and transit service. It is described further in Section 1.4.

D. Access to transit page. This page summarizes how many people, households or commuters have access to transit in the region. It is described further in Section 1.5.

E. Access to jobs page. This page summarizes how many jobs are accessible to transit stops or stations. It is described further in Section 1.6.

F. The circled "i" links to the definitions page. It is described further in Section 1.7.

[1] Washington Metropolitan Area Transit Authority

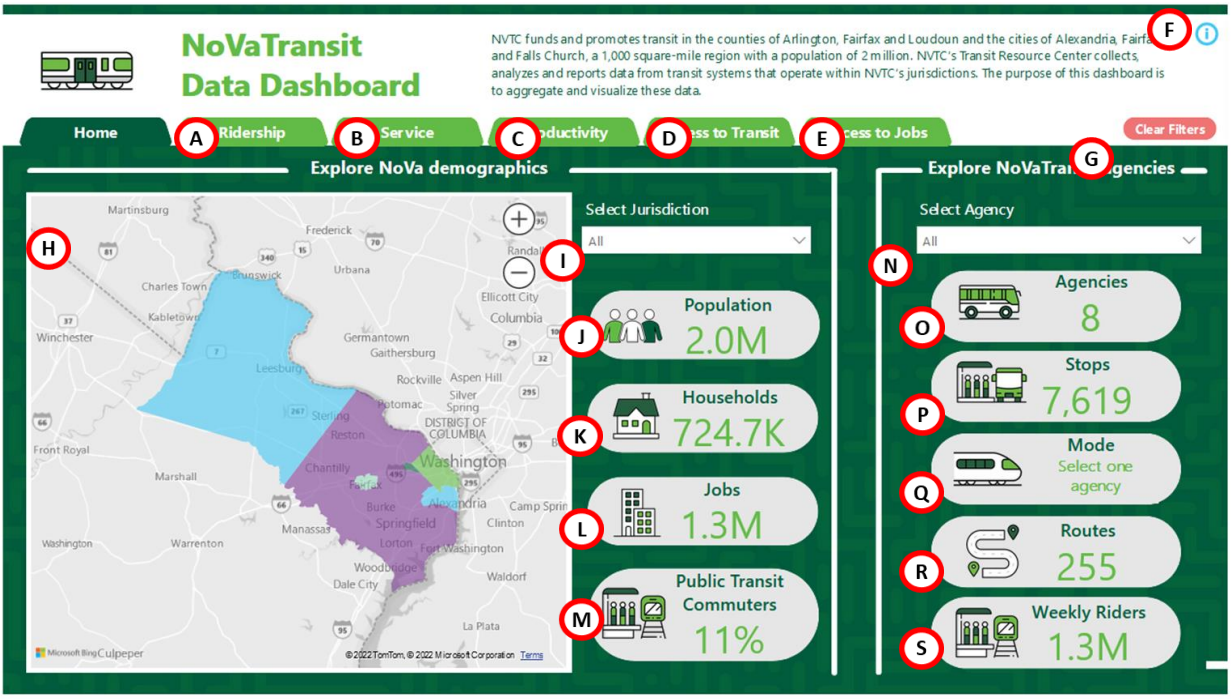

Figure 1: Dashboard home page

G. This button clears all filters that have been selected on the page.

H. The jurisdiction map shows the political boundaries for each of the counties and cities within the NVTC region. These boundaries were created using census geographic data (see Section 2.3). Specific jurisdictions can be selected by clicking on the jurisdiction on the map or by using the jurisdiction filter (see G).

I. The jurisdiction filter allows a user to look at metrics for a specific jurisdiction or number of jurisdictions (multiple jurisdictions can be selected). Specifically, this filter affects the map (H), population (J), households (K), jobs (L) and public transportation commuters (M). It does not affect the transit agency metrics on the right of the home page.

J. The jurisdiction population is the number of people who live in NVTC jurisdictions. It was obtained using census data (see Section 2.3).

K. Jurisdiction households is the number of households in NVTC jurisdictions. It was obtained using census data (see Section 2.3).

L. Jurisdiction jobs is the number of jobs in NVTC jurisdictions. It was obtained using Metropolitan Washington Council of Governments (MWCOG) data (see Section 2.4).

M. Percent of jurisdiction commuters who use public transportation.

Equation 1: Percentage of commuters who use public transportation

$$Percentage\ of\ Transit\ Commuters = \frac{\sum(Commuters\ using\ public\ transportation)}{\sum(Commuters\ using\ all\ modes\ of\ transportation)} \cdot 100$$

N. The transit agency filter allows a user to look at metrics for a specific transit agency or a number of transit agencies (multiple agencies can be selected). Specifically, this filter affects the number of agencies (O), the number of transit stops (P), transit modes (Q), the number of transit routes (R) and the average weekly transit ridership (S).

O. Number of agencies operating within the NVTC region.

P. Number of transit stops within the NVTC region. This is the number of unique stops made by each transit agency according to General Transit Feed Specification (GTFS) data (see Section 2.2). Note: If two transit agencies stop at the same stop the stop is counted twice.

Q. When a single transit agency is selected, this bubble shows all transit modes operated by the specified transit agency. If more than one transit agency is selected, no specific modes are shown.

R. Number of transit routes within the NVTC region. This is the number of unique transit routes touching the NVTC region according to GTFS data (see Section 2.2).

S. Number of average weekly transit riders within NVTC region. More about ridership is explained in Section 1.2.

Equation 2: Average weekly transit riders

$$Average\ Weekly\ Riders = \frac{\sum(Previous\ 6\ months\ of\ transit\ ridership)}{26}$$

Where we assume there are 26 weeks in 6 months with each measure representing half a year.

1.2 Ridership Page

Ridership is the number of people who board public transportation vehicles. Passengers are counted each time they board vehicles no matter how many vehicles they use to travel between their origin and destination[2].

Ridership data is sourced from the Virginia Department of Rail and Public Transportation (DRPT) data portal (see Section 2.1). Figure 2 provides a screenshot of the ridership page. Each unique aspect of the page is labeled and described below.

A. The transit agency filter allows a user to look at metrics for a specific transit agency or a number of transit agencies (multiple agencies can be selected). Specifically, this filter affects the ridership by year (D), the ridership by mode (E) and the ridership by agency (F).

[2] Ridership uses the Federal Transit Administration (FTA) definition for Unlinked Passenger Trips

Figure 2: Dashboard ridership page

B. The transit mode filter allows a user to look at metrics for a specific transit mode or a number of transit modes (multiple agencies can be selected). Specifically, this filter affects the ridership by year (D), the ridership by mode (E) and the ridership by agency (F).

C. The year filter allows a user to look at metrics for a specific time period or multiple time periods. Selections can be made at the year and/or month level. Specifically, this filter affects the ridership by year (D), the ridership by mode (E) and the ridership by agency (F).

D. Ridership by year plots all ridership by month and year. This graph allows for seasonal and year over year trends to be observed. All data is from DRPT (see Section 2.1).

E. Ridership by mode shows how the region's ridership is allocated between different transit modes. Although this graph does not show time, it is affected by the year filter. All data is from DRPT (see Section 2.1).

F. Ridership by agency shows how the region's ridership is allocated between different transit agencies. Although this graph does not show time, it is affected by the year filter. All data is from DRPT (see Section 2.1).

1.3 Service Page

Transit service is the activity of buses, trains, and other transit vehicles when a vehicle is available to the general public and there is an expectation of carrying passengers[3]. Transit service is split into two main categories. Scheduled service is what a transit agency plans to happen (i.e., what you see on transit schedules) while actual service is a record of what actually happened.

Service data is sourced from both GTFS (see Section 2.2) and the DRPT data portal (see Section 2.1). Figure 3 gives a screenshot of the ridership page. Each unique aspect of the page is labeled and described below.

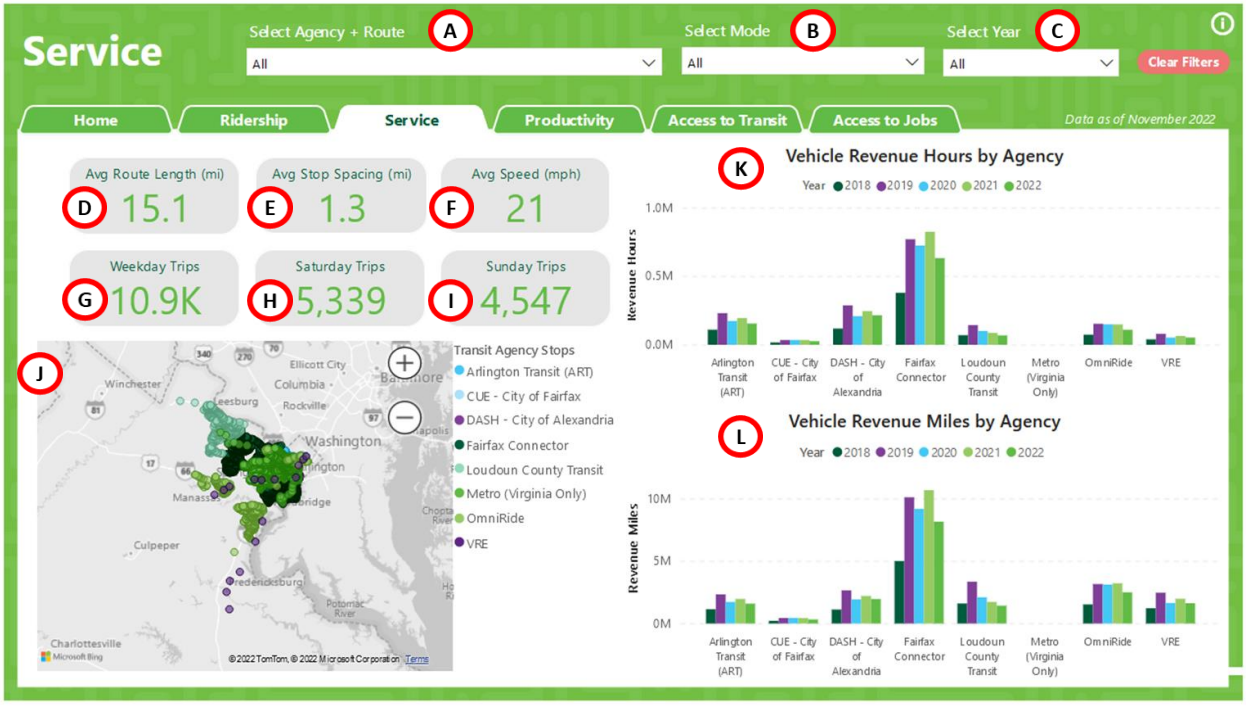

Figure 3: Dashboard transit service page

A. Transit agency and route filter. The transit agency and route filter allows a user to look at metrics for a specific transit agency or transit route or a number of transit agencies or routes (multiple agencies or routes can be selected). Selecting a transit agency affects all graphs and data shown on this page (from D through L) while selecting a route only affects the averaged value bubbles (D through I) as well as the map of transit agency stops (J).

B. Transit mode filter. The transit mode filter allows a user to look at metrics for a specific transit mode or a number of transit modes (multiple modes can be selected). Selecting a transit agency affects all graphs and data shown on this page (from D through L).

[3] Service uses the Federal Transit Administration (FTA) definition for Revenue Service https://www.transit.dot.gov/ntd/national-transit-database-ntd-glossary

C. Year filter. The year filter allows a user to look at metrics for a specific time period or multiple time periods. Selections can be made at the year and/or month level. This filter only affects vehicle revenue hours by agency (K) and vehicle revenue miles by agency (L).

D. Average route length is the average length of transit routes for all selected agencies and routes. In many cases, return trips are included in this value as many agencies define a route as a round trip. The stops displayed in the stops map (J) indicate the extent of the route. Route data is sourced from GTFS (see Section 2.2).

E. Average stop spacing is the average distance between two transit stops for all selected agencies and routes. It is calculated using Equation 3. All data is sourced from GTFS (see Section 2.2).

Equation 3: Average stop spacing

$$Average\ stop\ spacing = \frac{Average\ route\ length}{Total\ number\ of\ stops}$$

F. Average speed is the average speed between two transit stops for all selected agencies and routes. It is calculated using Equation 4. All data is sourced from GTFS (see Section 2.2).

Equation 4: Average speed

$$Average\ speed = \frac{Average\ route\ length}{Average\ scheduled\ route\ travel\ time}$$

G. Number of average weekday transit trips for all selected agencies and routes. A transit trip is defined as two or more stops a transit vehicle in revenue service makes during a specific time period.

H. Average number of Saturday transit trips for all selected agencies and routes. A transit trip is defined as two or more stops a transit vehicle in revenue service makes during a specific time period.

I. Average number of Sunday transit trips for all selected agencies and routes. A transit trip is defined as two or more stops a transit vehicle in revenue service makes during a specific time period.

J. A map of all transit stops for all selected agencies and routes.

K. Vehicle revenue hours by agency shows how many hours of service are actually operated by a transit agency in a specific month or year.

L. Vehicle revenue miles by agency shows how many miles of service are actually operated by a transit agency in a specific month or year.

1.4 Productivity Page

Transit productivity is the relationship between transit output (ridership) and transit input (service). It helps us to understand how transit service might affect ridership as well as better understand service efficiency.

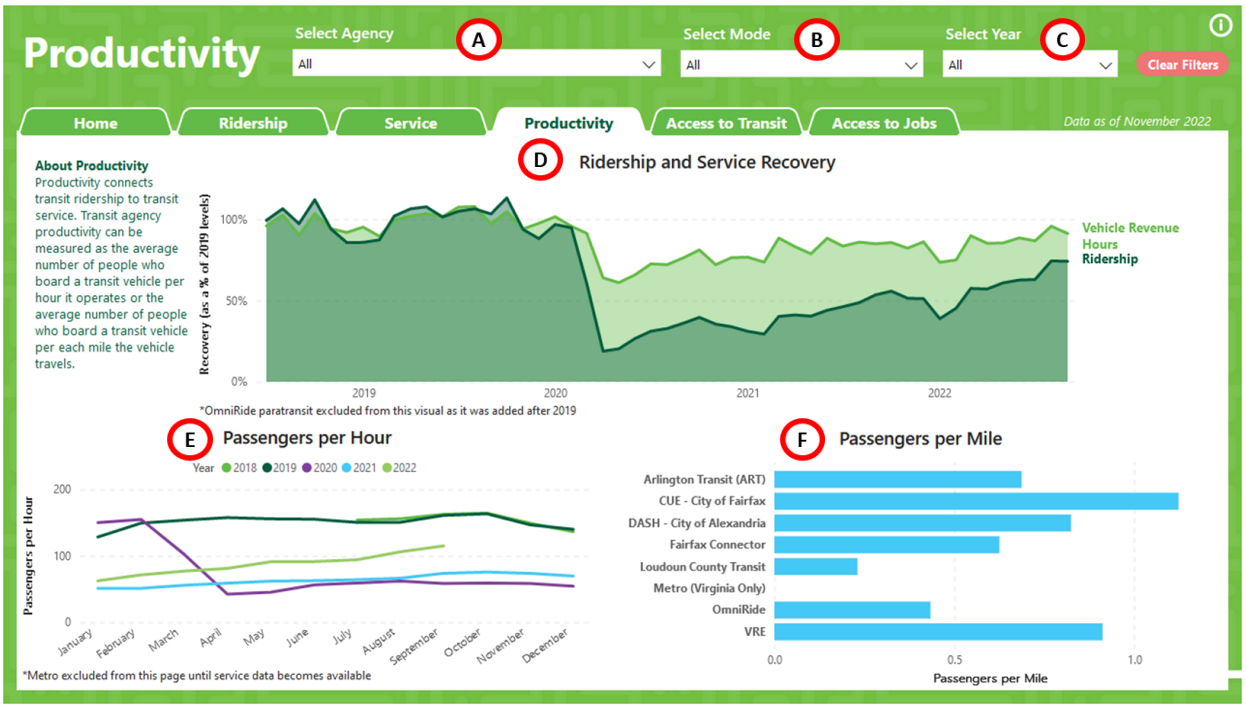

Figure 4: Dashboard transit productivity page

A. The transit agency filter allows a user to look at metrics for a specific transit agency or a number of transit agencies (multiple agencies can be selected). This filter affects the ridership and service recovery graph (D), passengers per hour graph (E) and the passengers per mile graph (F).

B. The transit mode filter allows a user to look at metrics for a specific transit mode or a number of transit modes (multiple agencies can be selected). Specifically, this filter affects the ridership and service recovery graph (D), passengers per hour graph (E) and the passengers per mile graph (F).

C. The year filter allows a user to look at metrics for a specific time period or multiple time periods. Selections can be made at the year and/or month level. Specifically, filter affects the ridership and service recovery graph (D), passengers per hour graph (E) and the passengers per mile graph (F).

D. The ridership and service recovery graph shows how well transit service and transit ridership are recovering after the COVID-19 pandemic began. The graph uses DRPT data (see Section 2.1) with the methodology explained in Section 3.1.

E. Passengers per hour is a standard measure of transit service productivity[4]. It is calculated using Equation 5. All data is sourced from DRPT (see Section 2.1).

Equation 5: Passengers per hour

$$Passengers\ per\ Hour = \frac{Monthly\ transit\ ridership}{Monthly\ vehicle\ revenue\ hours}$$

F. Passengers per hour is a standard measure of transit service productivity[3]. It is calculated using Equation 6. All data is sourced from DRPT (see Section 2.1).

Equation 6: Passengers per mile

$$Passengers\ per\ Mile = \frac{Monthly\ transit\ ridership}{Monthly\ vehicle\ revenue\ miles}$$

1.5 Access to Transit Page

Access to transit tells you how much of a population in a jurisdiction have access to a transit stop or station. Access is defined as being within a quarter mile of a bus stop, half mile of a heavy rail station, or a mile of a commuter rail station. Access to paratransit is calculated as the population within three-fourths of a mile of a fixed route, as required by the Federal Transit Administration[5]. The access calculations are provided in Section 3.2.

The gauges on this page tell you what percentage of each population has access to different modes of public transportation in Northern Virginia. For example, when bus is selected for all jurisdictions, "Total Population with Access to Transit" shows an estimated 62.5% of the population has access to a bus stop.

A. The jurisdiction filter allows a user to look at metrics for a specific jurisdiction or number of jurisdictions (multiple jurisdictions can be selected). Specifically, this filter affects the gauges (C through G) as well as the total population by jurisdiction graph.

B. The transit mode filter allows a user to look at metrics for a specific transit mode. Only one transit mode can be selected at a time on this page. This filter specifically affects the gauges (C through G) as well as the total population by jurisdiction graph (H).

C. The total population with access to transit shows the percentage of all residents in the NVTC region or specific jurisdiction(s) who have access to transit for a particular mode. It is calculated using census data (see Section 2.3) and GTFS data (see Section 2.2). The process is described in Section 3.2. Equation 7 shows how the percentage is calculated.

Equation 7: Percent of total population with transit access

$$Percent\ of\ total\ population\ with\ transit\ access = \frac{Estimated\ population\ with\ transit\ access}{Total\ population} \cdot 100$$

[4] Kittelson & Associates, Inc. et al. 2003. *Transit Cooperative Research Program (TCRP) Report 88: A Guidebook for Developing a Transit Performance-Measurement System*. Washington, DC.

[5] https://www.transit.dot.gov/complementary-paratransit-service-does-requirement-paratransit-service-be-provided-within-three

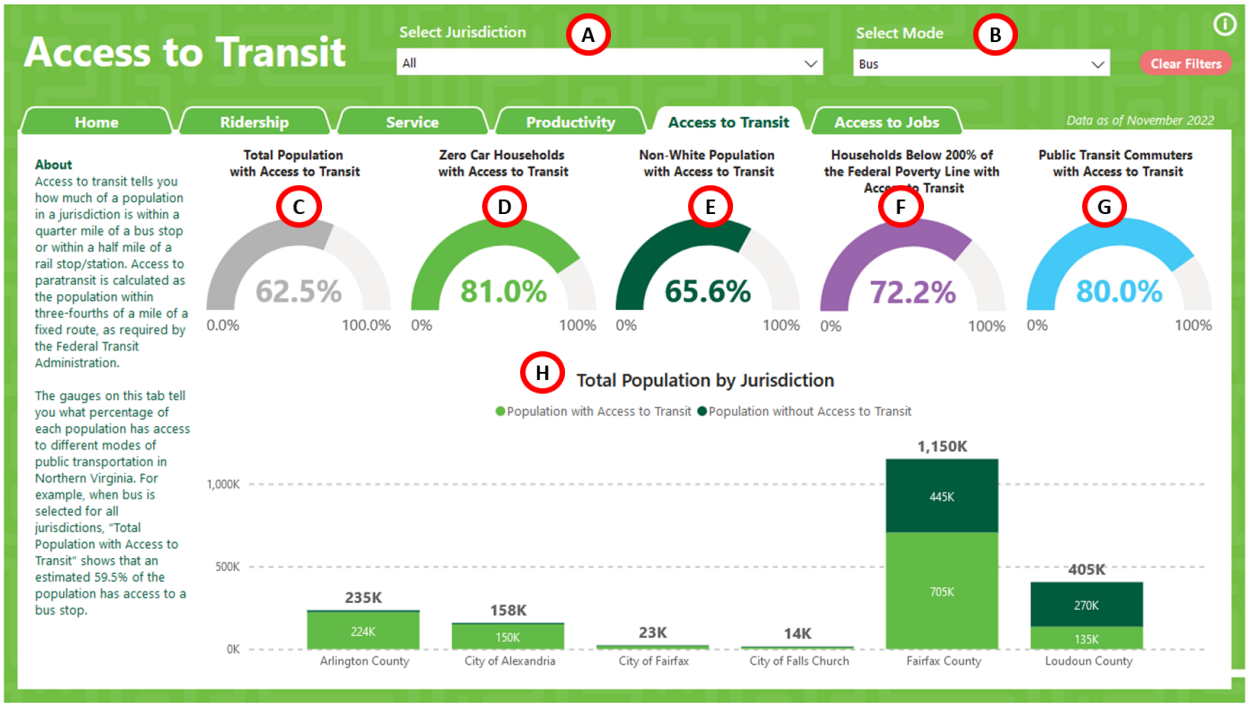

Figure 5: Dashboard transit access page

D. Zero car households with access to transit shows the percentage of all zero car households in the NVTC region or specific jurisdiction(s) who have access to transit for a particular mode. As residents of zero car households have, by definition, no access to a personal vehicle, they may be more reliant on access to transit services. This measure was calculated using census data (see Section 2.3) and GTFS data (see Section 2.2). The process is described in Section 3.2. Equation 8 shows how the percentage is calculated.

Equation 8: Percent of zero car households with transit access

$$Percent\ of\ zero\ car\ households\ with\ transit\ access = \frac{Estimated\ zero\ car\ households\ with\ transit\ access}{Total\ zero\ car\ households} \cdot 100$$

E. Non-white populations with access to transit shows the percentage of non-white populations in the NVTC region or specific jurisdiction(s) who have access to transit for a particular mode. Non-white population access was calculated as people belonging to this population tend to be more likely to use transit services[6,7]. This measure was calculated using census data (see Section 2.3) and GTFS data (see Section 2.2). The process is described in Section 3.2. Equation 9 shows how the percentage is calculated.

Equation 9: Percent of on-white population with transit access

$$Percent\ of\ non\ white\ population\ with\ transit\ access = \frac{Estimated\ non\ white\ population\ with\ transit\ access}{Total\ non\ white\ population} \cdot 100$$

[6] Pucher, J., & Renne, J. L. (2003). Socioeconomics of urban travel. Evidence from the 2001 NHTS. Transportation Quarterly 57(3), 49-77.

[7] Taylor, B. D., & Morris, E. A. (2015). Public transportation objectives and rider demographics: are transit's priorities poor public policy?. Transportation, 42(2), 347-367.

F. Population below 200% of the federal poverty line with access to transit shows the percentage of low-income populations in the NVTC region or specific jurisdiction(s) who have access to transit for a particular mode. Low-income population access was calculated as people belonging to this population tend to be more likely to use transit services5[5,6]. Low-income populations were defined as 200% of the federal poverty line to be consistent with the Metropolitan Washington Council of Governments (MWCOG)[8]. It is also close to other low-income measures used in the region including DRPT[9] (125%- 200% of the federal poverty level), OmniRide[10] (190% of the federal poverty level), and Fairfax County[11] (225% of the federal poverty level). The measure was calculated using census data (see Section 2.3) and GTFS data (see Section 2.2). The process is described in Section 3.2. Equation 10 shows how the percentage is calculated.

Equation 10: Percent of population below 200% of poverty line with transit access

$$Percent\ below\ 200\%\ of\ povery\ line\ with\ transit\ access = \frac{Estimated\ pop.\ below\ 200\%\ of\ poverty\ line\ with\ transit\ access}{Total\ population\ below\ 200\%\ of\ poverty\ line} \cdot 100$$

G. Transit commuters with access to transit shows the percentage of transit commuters in the NVTC region or specific jurisdiction(s) who have access to transit for a particular mode. Transit commuters are defined as those that identify a mode of transit as their primary method for making home to work trips for the American Community Survey (ACS). This measure was calculated using census data (see Section 2.3) and GTFS data (see Section 2.2). The process is described in Section 3.2. Equation 11 shows how the percentage is calculated.

Equation 11: Percent of transit commuters with transit access

$$Percent\ of\ transit\ commuters\ with\ transit\ access = \frac{Estimated\ transit\ commuters\ with\ transit\ access}{Total\ transit\ commuters} \cdot 100$$

H. The total population by jurisdiction shows approximately the number of people who do and do not have access to transit in each jurisdiction. These data are similar to those used in C but are presented in a different way. The measure was calculated using census data (see Section 2.3) and GTFS data (see Section 2.2). The process is described in Section 3.2.

[8] MWCOG. (2018). Region Forward Progress Reports. https://www.mwcog.org/documents/2018/12/19/region-forward-progress-reports-region-forward/

[9] https://drpt.virginia.gov/media/3477/722_final-application-guidance_trip.pdf

[10] https://omniride.com/omniride/assets/File/OR20_TSP_FullReport_2020-03-23_DRAFT.pdf

[11] https://www.fairfaxcounty.gov/transportation/sites/transportation/files/assets/documents/pdf/btc/december%2014%202021 /item%206%20-%20trip_update_presentationformat.pdf

1.6 Access to Jobs Page

Access to transit tells you how many jobs in a jurisdiction have access to a transit stop or station. Access is defined as being within a quarter mile of a bus stop, half mile of a heavy rail station, or a mile of a commuter rail station. Access to paratransit is calculated as the population within three-fourths of a mile of a fixed route, as required by the Federal Transit Administration. The access calculations are provided in Section 3.2.

Figure 6: Dashboard access to jobs page

A. The jurisdiction filter allows a user to look at metrics for a specific jurisdiction or number of jurisdictions (multiple jurisdictions can be selected).

B. The transit mode filter allows a user to look at metrics for a specific transit mode. Multiple modes can be selected but only one transit mode should be selected to get the total jobs accessible for a specific mode.

C. Transit accessible jobs shows approximately the number of jobs that have access to transit in each jurisdiction. The measure was calculated using MWCOG data (see Section 2.4) and GTFS data (see Section 2.3). The process is described in Section 3.2.

1.7 Definitions Page

The definitions page provides definitions and constraints around terminology and data. There are two main reasons for this page. First, some of the terminology used on this dashboard may be unfamiliar to some people or might need to be clarified. For example, the definition of heavy rail and what constitutes Metro service are both included on this page. Second, transit data can sometimes be updated or changed over time. For example, DRPT performs periodic reviews of its data that sometimes result in data being corrected. Consequently, the definitions page indicates when data was calculated/collected in case there are any discrepancies between dashboard data and source data.

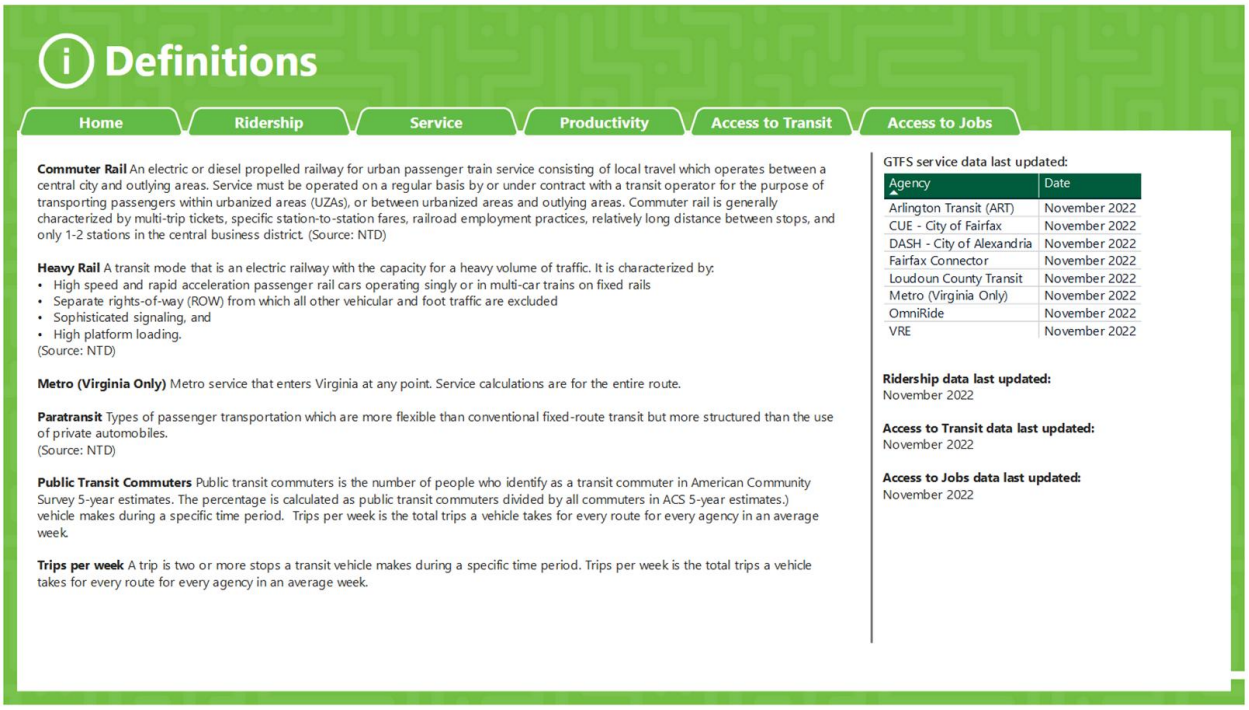

Figure 7: Definitions page

2.0 Data

This section summarizes the different types of data used to develop the dashboard. All data described are publicly available.

2.1 Virginia Department of Rail and Public Transportation (DRPT) Ridership and Service Data

DRPT collects monthly data from transit providers in Virginia including Unlinked Passenger Trips (UPT), Vehicle Revenue Hours (VRH) and Vehicle Revenue Miles (VRM)[12]. Table 1 below provides DRPT's data definitions. All three metrics are reported for every transit mode including bus, paratransit, commuter rail, and heavy rail. Data is only available from July 2018 onwards, the beginning of Virginia's fiscal year 2019[13].

Table 1: DRPT required performance metrics (2022 DRPT Purple Book)

Metric	Description
Unlinked Passenger Trips (UPT)	Number of passengers who board public transportation vehicles, regardless of whether a passenger is transferring from another transit vehicle.
Vehicle Revenue Hours (VRH)	Hours traveled by revenue vehicles (buses, vans, railcars, etc.) while in revenue service.
Vehicle Revenue Miles (VRM)	Miles traveled by revenue vehicles while in revenue service.

DRPT requires transit agencies provide backup documentation to support all reported metrics. DRPT program managers formally review and validate these data using this documentation at least once a year. Program managers also perform ad hoc reviews of performance data on an as-needed basis as part of their quarterly grant meetings with transit agencies.

2.2 General Transit Feed Specification (GTFS)

Originally developed by Google, GTFS[14] is a standard data format for transit schedules. Transit agencies use GTFS to feed scheduled data into applications like Google Maps, Apple Maps and transit apps. The data include everything that is needed to know when and where transit will be available, including the specific location of transit stops, the timing and sequence of transit trips, the number of trips for each transit route and the days of the week each transit route operates. Figure 7 shows some of the data that may be available in GTFS files[15]. Gray boxes indicate different text files while the white boxes indicate different columns of data that could be used within each text file.

[12] https://olga.drpt.virginia.gov/Documents/forms/FY23%20Grant%20Administration%20Procedures%20(Purple%20Book).pdf

[13] Washington Metropolitan Area Transit Authority VRM and VRH data only began collection from July 2022 onwards

[14] https://developers.google.com/transit/gtfs

[15] There is some flexibility in how GTFS files can be structured and design.

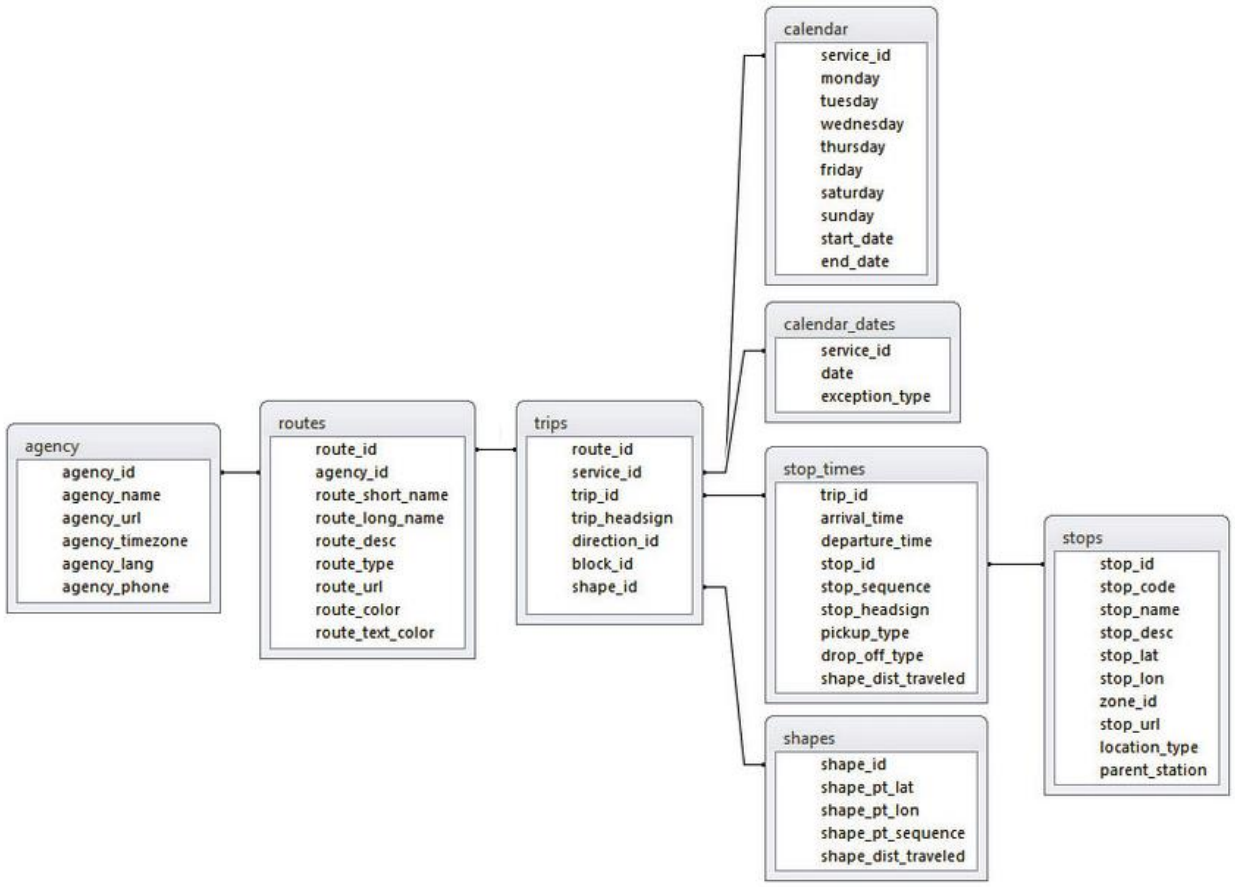

Figure 8: GTFS data schematic[16]

2.3 Census Data

American Community Survey (ACS) 5-year estimates were used wherever census data was needed. 5-year estimates represent data collected over a period of time, in this case, five years[16]. These data provide population, demographic, household, and commuting data across the United States. There are two primary advantages to using ACS 5-year estimates over other data sources:

1. "The primary advantage of using multiyear estimates is the increased statistical reliability of the data for less populated areas and small population subgroups."[17]
2. Data is available more frequently than Decennial Census data which is only collected every ten years

Although the data is available more frequently than Decennial Census data, the five-year range of the estimate means that year-over-year trends are not observable. This means it is not possible to observe differences between 2019 and 2020, for example. ACS 1-year estimates have this capability but these

[16] Kunama, Narumon, Mudtana Worapan, Santi Phithakkitnukoon, and Merkebe Demissie. (2017). "GTFS-VIZ: Tool for preprocessing and visualizing GTFS data." In *Proceedings of the 2017 ACM International Joint Conference on Pervasive and Ubiquitous Computing and Proceedings of the 2017 ACM International Symposium on Wearable Computers*, pp. 388-396.

[17] https://www.census.gov/data/developers/data-sets/acs-5year.html

estimates are not suitable for smaller geographic areas, including City of Fairfax and City of Falls Church. As ACS 1-year estimates exclude two of NVTC's jurisdictions, they are not appropriate in most cases for NVTC.

Data was procured from multiple different data tables[18]. Some variables (e.g., total zero car households) were not readily available in existing tables and had to be calculated. Table 2 summarizes all census tables used and, where needed, how different tables were used to calculate certain needed demographics.

Table 2: Census tables for demographics

Variable	Census Table	Definition
Total Population	B01003 001	Total Population
Total Commuters	B08301 001	Means Of Transportation To Work: Total
Total Transit Commuters	B08301 010	Means Of Transportation To Work: Public Transportation (Excluding Taxicab)
Poverty Ratio Total	C17002 001	Ratio of Income to Poverty Level in the Past 12 Months: Total
Poverty Ratio Over 200 percent	C17002 008	Ratio of Income to Poverty Level in the Past 12 Months: 2.00 and Over
Poverty Ratio Under 200 percent	C17002 001 - C17002 008	Poverty Ratio Over 200 percent subtracted from Poverty Ratio Total
Zero car households (rental occupied)	B25044 008	Tenure by Vehicles Available: Renter Occupied: No Vehicle Available
Zero car households (owner occupied)	B25044 003	Tenure by Vehicles Available: Owner Occupied: No Vehicle Available
Total zero car households	B25044 003 + B25044 008	Zero car households (rental occupied) added to Zero car households (owner occupied)
White population	B02001 002	Race: White Alone
Non-white population	B01003 001 - B02001 002	White Population subtracted from Total Population

For the purposes of the work shown, 2016-2020 ACS 5-year estimates. These are the latest available data and will be updated as new data is released. The calculations were all performed at the census tract level. Although more granular data is available, the census tract level was chosen due to the large number of calculations performed for this dashboard and the faster running time census tract calculations offer compared to finer geographic scales.

2.4 Metropolitan Washington Council of Governments (MWCOG) Employment Data

Part of MWCOG's work includes forecasting population, employment and households in the greater Washington, DC region, including NVTC jurisdictions[19]. MWCOG provides regional employment estimates for small geographic areas called transportation analysis zones (TAZs).

MWCOG Round 9.2 Cooperative Forecasting 2020 Employment estimates were used for all calculations.

[18] Census tables can be explored here: https://www.socialexplorer.com/data/ACS2020_5yr/metadata/?ds=ACS20_5yr

[19] https://www.mwcog.org/documents/2021/12/02/cooperative-forecasts-employment-population-and-household-forecasts-by-transportation-analysis-zone-cooperative-forecast-demographics-housing-population/

3.0 Methodologies

Many of the calculations used in creating the dashboard are included in the descriptions of each dashboard page in Section 1.0. However, there are some calculations that require a little more explanation. This section provides additional detail for calculations that are a little more complicated and require more than one step.

3.1 Ridership and Service Recovery

Transit ridership and service is given as an index to calendar year 2019 (CY 19). This is calculated as follows:

1. Average total transit ridership from January 2019 through December 2019
2. Divide monthly ridership by the averaged number from step 1
3. Multiply the values from step 2 by 100 to get a percentage

Indexing to CY 19, a full year of pre-pandemic transit ridership and service, demonstrates how ridership and service is recovering compared to pre-pandemic ridership levels. For example, the calculation for ridership in September 2021 is 40%, meaning that ridership for that month is 40% of the pre-pandemic average. Achieving 100% means ridership has fully recovered.

3.2 Access Calculations

Census and GTFS data can be used to estimate the number of people and households that have access[20] to a transit stop or station. By using different census variables, demographics and characteristics of populations with access to transit can be estimated. The step-by-step process for doing this is described below:

1. Plot transit stops/stations (from GTFS data) as points
2. Create a buffer around the stops/stations
    a. ¼ mile for bus stops
    b. ½ mile for heavy rail
    c. ¾ mile for paratransit[21]
    d. 1 mile for commuter rail
3. Join buffers together if:
    a. Estimating populations at a transit system level
    b. Estimating populations at a route level
4. Plot census data

[20] Standard transit practice assumes transit is accessible within ¼ mile of transit stops for lower frequency services, like local bus, and ½ mile of transit stops for higher frequency services, like rail.

[21] Under Department of Transportation (DOT) Americans with Disabilities Act (ADA) regulations at 49 C.F.R. Section 37.131(a)(1)(i), transit entities must "provide complementary paratransit service to origins and destinations within corridors with a width of three-fourths of a mile on each side of each fixed route." https://www.transit.dot.gov/complementary-paratransit-service-does-requirement-paratransit-service-be-provided-within-three

5. Use spatially weighted areal interpolation[22] to estimate the number of people from the census data who might fall within the transit buffers

This process can be repeated using MWCOG job data to estimate the number of jobs that are accessible to transit stations.

There are two caveats to this process. First, it assumes individuals are spread evenly among geographic areas. While this is certainly not the case the assumption has to be made as there are no data sources at the individual level. This measure is thus an approximation. Second, the calculation shows access to transit stops or stations but does not account for when transit service operates. If a bus stops running at 9 p.m., having access to a bus stop at 10 p.m. does not mean someone has access to the bus service. However, this kind of approximation still provides an indication of where there is transit service coverage.

[22] "Areal weighted interpolation is the simplest approach to estimating population values for overlapping polygons. It makes a significant and important assumption - that individuals are spread out evenly within the source features. This assumption quickly breaks down in the real world - areas that have commercial developments mixed in with residential housing, for example, or neighborhoods with a large city park. We do not always have access to this type of contextual data, however, and so areal weighted interpolation remains a popular choice." https://cran.r-project.org/web/packages/areal/vignettes/areal-weighted-interpolation.html

Appendix A: Document Change Log

Data	Name	Description of Change
10/31/2022	X. Harmony	Document created
12/13/2022	X. Harmony	Update screenshots and descriptions in preparation for public