National Capital Region
Transportation Planning Board

Metropolitan Washington Council of Governments (COG)
National Capital Region Transportation Planning Board (TPB)

Highway and Transit Networks for the TPB Ver. 2.3.75 Travel Model and Air Quality Conformity Analysis of Visualize 2045 and the FY 2019-2024 TIP

Draft Report

March 15, 2019

777 NORTH CAPITOL STREET NE, SUITE 300, WASHINGTON, DC 20002
MWCOG.ORG/TPB (202) 962-3200

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About the TPB

The National Capital Region Transportation Planning Board (TPB) is the federally designated metropolitan planning organization (MPO) for metropolitan Washington. It is responsible for developing and carrying out a continuing, cooperative, and comprehensive transportation planning process in the metropolitan area. Members of the TPB include representatives of the transportation agencies of the states of Maryland and Virginia and the District of Columbia, 23 local governments, the Washington Metropolitan Area Transit Authority, the Maryland and Virginia General Assemblies, and nonvoting members from the Metropolitan Washington Airports Authority and federal agencies. The TPB is staffed by the Department of Transportation Planning at the Metropolitan Washington Council of Governments (COG).

About COG

The Metropolitan Washington Council of Governments (COG) is an independent, nonprofit association that brings area leaders together to address major regional issues in the District of Columbia, suburban Maryland, and Northern Virginia. COG's membership is comprised of 300 elected officials from 24 local governments, the Maryland and Virginia state legislatures, and U.S. Congress.

About Visualize 2045

Visualize 2045 is the federally required long-range transportation plan for the National Capital Region. It identifies and analyzes all regionally significant transportation investments planned through 2045 to help decision makers and the public "visualize" the region's future. Visualize 2045 is developed by the TPB.

Credits

Director of COG's Department of Transportation Planning (DTP): Kanti Srikanth
Director, Travel Forecasting and Emissions Analysis, DTP: Ronald Milone (retired Oct. 2018)
Report Authors: Meseret Seifu, Ron Milone, and Mark Moran
Contributors: Jim Yin, Wanda Owens, Joseph Davis, Jane Posey, William Bacon, Ray Ngo, Feng Xie, Anant Choudhary, and Sanghyeon Ko
Oversight: COG/TPB Travel Forecasting Subcommittee

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1 Introduction

The National Capital Region Transportation Planning Board (TPB) is the federally designated Metropolitan Planning Organization (MPO) for the Washington, D.C. metropolitan area and is also one of several policy boards that operate at the Metropolitan Washington Council of Governments (COG). The COG/TPB staff develops and maintains, with consultant assistance, a series of regional travel demand forecasting models to support the regional transportation planning process in the Washington, D.C. area. One of the critical inputs to the regional travel demand forecasting model is a series of transportation networks, which represent both the highway (road) system and the transit system in the Washington, D.C. area. Transportation networks depict the highway and transit system for a series of discrete years, typically an existing "base" year and several forecast years. Transportation networks are used in the travel model to formulate impedances (travel times and costs) between origins and destinations. The travel model considers impedances as a basis for estimating the number of person trips that travel between zones and for allocating those person trips among specific modes of travel. Transportation networks also provide a basis upon which the performance of the existing and planned regional transportation system may be evaluated. The TPB Version 2.3.75 travel demand forecasting model is the latest in a series of adopted, regional, production-use travel demand forecasting models that belong to the Version 2.3 family of models.

Transportation networks are prepared with attention to several technical requirements:

- Networks are designed to represent the major transportation facilities and services that are relevant to the regional level of analysis. Thus, many of the smaller scale facilities, such as local roads, are purposefully excluded;
- Networks are designed to conform to a detailed area (or zone) system that is specifically designed for regional modeling. The existing farea system for the Washington, D.C. area consists of 3,722 transportation analysis zones (TAZs);
- Networks are designed to meet the specific technical requirements of the Version 2.3 family of travel demand models. The travel model currently requires network inputs that are used to develop travel highway and transit impedances between zones. The travel model requires modal travel impedances associated with both peak and off-peak operating conditions; and
- Networks are prepared in a format that is compliant with the specific requirements of the software platform that is currently used to apply the model. The Version 2.3 Travel Model is currently implemented with Citilabs Cube software.

Because of the technically specialized nature of the model's transportation networks, substantial staff resources are required to develop and manage these travel model inputs each year. The network development activity is included in the TPB's Unified Planning Work Program (UPWP) under the Travel Forecasting major work activity. Network development includes an annual update of the current-year highway and transit networks with the most up-to-date information, as well as the development of future-year networks that represent the TPB's continuously evolving Long-Range Transportation Plan

(LRTP), currently known as "Visualize 2045," and the Transportation Improvement Program (TIP), which is a six-year subset of the LRTP.

The network development activity also supports other elements of the work program, including Mobile Emissions Planning and Technical Assistance, which encompass subarea and corridor studies conducted by both TPB staff and state/local planning agencies.

This technical report documents the travel demand model transportation networks that were used in the 2018 Air Quality Conformity (AQC) analysis of the Constrained Element of the 2018 update of the TPB's LRTP, known as Visualize 2045, and the FY 2019-2024 Transportation Improvement Program (TIP), which was approved by the TPB on October 17, 2018.

Visualize 2045 includes both a financially constrained element and an aspirational element. The constrained element includes projects that the region's transportation agencies expect to be able to afford between now and 2045, and the aspirational element goes beyond financial constraints. The air quality conformity analysis is conducted for only the financially constrained element, and most references to the Visualize 2045 plan in this document refer to only that component.[1]

As stated earlier, transportation network files are developed in compliance with the adopted travel demand model and its associated software. The currently adopted, production-use TPB travel demand model is known as Generation-2/Version 2.3.75. The travel model uses an area system with 3,722 TAZs and is currently applied using Citilabs Cube software (Version 6.4.1). Transit path-building is accomplished using a module of Cube Voyager called TRNBUILD. Cube Voyager also contains a newer transit path-building module called Public Transport (PT). TPB staff is working to transition from the older transit path builder (TRNBUILD) to the newer transit path builder (PT). One of the features of PT is the ability to trace transit paths graphically, on-screen, over a transit map (TRNBUILD included only text-based reports of transit paths). TPB staff is currently conducting validation and sensitivity tests of the Generation-2/Ver. 2.5 travel model.[2] If the Gen2/Ver. 2.5 model performs equal to or better than the Ver. 2.3 travel model, TPB staff plans to transition to the Ver. 2.5 model. It is hoped that a decision about such a transition can be made by the end of FY 2019.

This report describes the process, technical conventions and specifications associated with the TPB's network-related inputs to the travel model. There are other supporting documents that are directly related to the Visualize 2045, FY 2019-2045 TIP network development process and specifications, including: 1) the air quality conformity Analysis report,[3] which includes a complete listing of all transit

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[1] "Visualize 2045 A Long-Range Transportation Plan for the National Capital Region Air Quality Conformity Analysis," (National Capital Region Transportation Planning Board, Metropolitan Washington Council of Governments, October 17, 2018).

[2] Cambridge Systematics, Inc. and Gallop Corporation, "FY 17 Task Orders," Final Report (Metropolitan Washington Council of Governments, National Capital Region Transportation Planning Board, June 30, 2017), https://www.mwcog.org/file.aspx?&A=YiUe54YhmPVA0q1IahkVpmf4CjB%2fkVfhr3mZDJJ1ACM%3d.

[3] "Visualize 2045 A Long-Range Transportation Plan for the National Capital Region Air Quality Conformity Analysis," (National Capital Region Transportation Planning Board, Metropolitan Washington Council of Governments, October 17, 2018), Appendix B (Project Inputs).

and highway projects assumed in Visualize 2045 and the FY 2019-2024 TIP; and 2) the Version 2.3.75 User's guide,[4] which documents the overall model application process and describes the relationship between specific network files and program steps in the model chain.

The remainder of this chapter provides an overview of the TPB's network development process and its connection with the annual Air Quality Conformity process.

1.1 Air Quality Conformity Process

One of the primary goals of TPB's network development program is to furnish base- and forecast-year highway and transit networks for the Air Quality Conformity Analysis of the financially constrained element of the Visualize 2045 long-range transportation plan and the FY 2019-2024 Transportation Improvement Program (TIP). This analysis is generally undertaken each year to determine whether air pollution from motor vehicles (referred to as "on-road mobile emissions") that use roads represented in the TIP and the LRTP conform to state implementation plans (SIPs) designed to ensure that mobile emissions do not exceed approved emissions budgets regarding prevailing air quality standards set by federal law. The analysis includes the formulation of travel demand forecasts and associated mobile source emissions inventories for a set of milestone years. TPB staff typically collects TIP and LRTP transportation network information from all TPB member jurisdictions, the three state departments of transportation (District of Columbia Department of Transportation [DDOT], Maryland Department of Transportation [MDOT] and Virginia Department of Transportation [VDOT]), the Washington Metropolitan Area Transit Authority (WMATA or Metro), the Maryland Transit Administration (MTA), the Virginia Railway Express (VRE), and other local transit service providers on an annual basis.[5]

The Visualize 2045 air quality conformity schedule is shown in Table 1-1.

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[4] "User's Guide for the COG/TPB Travel Demand Forecasting Model, Version 2.3.75: Volume 1 of 2: Main Report and Appendix A (Flowcharts)" (Washington, D.C.: Metropolitan Washington Council of Governments, National Capital Region Transportation Planning Board, December 5, 2018), https://www.mwcog.org/transportation/data-and-tools/modeling/model-documentation/

[5] Although the modeled area, and thus the transportation networks, include one county in West Virginia (Jefferson Co.), the TPB model networks include only current-year roads in this county, not future-year roads.

Table 1-1 Schedule for Visualize 2045 and FY 2019-2024 TIP

Year	Month	Event
2017	December	Technical Committee reviewed draft Visualize 2045 inputs and draft Scope of Work
		for the Air Quality Conformity Analysis
		Visualize 2045 inputs and draft scope of work released for 30-day public comment period
		TPB briefed on inputs and draft scope of Work
2018	January	MWAQC briefed on inputs and Scope of Work
		Comment period ended
		TPB reviewed comments and approved inputs and draft scope of work
	May	Public Forum on the development of the FY 2019-2024 TIP
	September	Technical Committee reviewed draft Visualize 2045 and conformity analysis
		Draft Visualize 2045 Plan, TIP, and conformity analysis released for 30-day public comment period
		TPB briefed on the draft Visualize 2045 Plan, TIP, and Conformity analysis
	October	MWAQC TAC briefed on the draft Visualize 2045 Plan, TIP, and Conformity analysis
		Comment period ended
		TPB reviewed and responded to comments
		TPB approved Visualize 2045 Plan, TIP, and conformity analysis

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The air quality conformity (AQC) analysis of the Visualize 2045 plan and FY 2019-2024 TIP included the following six networks: 2019, 2021, 2025, 2030, 2040, and 2045.

1.2 Network Development Program Overview

Network development activities are carried out in a way that accommodates the air quality conformity determination schedule. Federal law requires that the LRTP be updated every four years. However, in the Washington, D.C. area, the LRTP has typically been updated on a more frequent basis (such as annually, or every two years), which means that the air quality conformity process has also been conducted on a more frequent basis than the federally required four-year cycle. The Visualize 2045 LRTP, developed in 2018, represents the "quadrennial" update of the Plan. The quadrennial update is considered a major update and includes activities not conducted in other years, such as a complete financial analysis and extensive public outreach.

One of the key objectives of the network development program is to prepare regional network inputs to the travel model in time for travel modeling work to proceed during the spring. The following procedure has typically been followed each year:

1) Pre-existing network inputs developed for the previous year's air quality analysis, and the previous TIP and LRTP, are obtained as a starting point for highway network coding. For example, the Visualize 2045 inputs were built from the previously developed 2016 Constrained Long-Range Plan (CLRP) MDOT and VDOT off-cycle analysis inputs. The TPB's link and node network data are currently stored in a multi-year and multi-modal (highway and transit)

Personal Geodatabase. TPB staff essentially develops a single multi-year database for each TIP and LRTP.[6]

2) The pre-existing highway networks are subject to ongoing review and updates, such as when errors are detected by either TPB staff or external users of the regional travel model. These types of updates are incorporated into the current-year TIP and LRTP network database throughout the year.
3) The transit network "base-year" data is refreshed with each regular LRTP update with the latest schedule information provided by the local operators and provides the starting point for transit coding each year. Most of the transit schedule information is obtained from digital (machine-readable) files, though some agencies do not produce machine-readable schedule information. The base-year transit data generally represent the state of the transit service in effect during the fall, when schedule information is collected by TPB staff. For the air quality analysis of the Visualize 2045, the transit network base year was 2017.
4) The Visualize 2045 plan and FY 2019-2024 TIP network elements (both highway and transit) are collected from the state and local implementing agencies and coded into the network. The coded projects are those considered to be "regionally significant," [7] as defined by the TPB.
5) Other miscellaneous and policy-related network inputs that are not currently stored in the geodatabase are prepared for each milestone year.

Network development activities also address the production of networks required for special project-planning studies, as well as the development of specialized inputs supporting the TPB's Model Development activities. This report focuses on the data and conventions used to construct the Visualize 2045 plan and FY 2019-2024 TIP networks.

1.3 Report Structure

The remainder of this report addresses the structure and conventions of the TPB travel model transportation networks in greater detail. Chapter 2 presents the foundational elements of the TPB's transportation networks, such as the zonal area system underpinning the network and the components of the regional highway network. Chapter 3 describes the individual network files that are prepared for the transportation model and the attributes that are contained in each file. Chapter 4 describes the geodatabase that is currently used to maintain the regional network data. The database has been specially designed to consolidate network-related information within a multi-year and multi-modal framework and in a geographically referenced framework.

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[6] Networks exported from this database should be consistent with each other, whereas networks exported from different geodatabases will not necessarily be consistent with each other, so it is generally not a good idea to mix networks from two different geodatabases.

[7] Memorandum from Jane Posey to TPB Technical Committee, Subject: Defining Regional Significance for Conformity, October 6, 2011.

2 TPB Transportation Network Background

This chapter presents background on the travel model transportation networks that are developed by TPB staff, including a description of the "modeled area," a review of the zone system that underlies the networks, and the time-of-day period definitions that are represented. The basic elements associated with highway and transit networks are described, along with a review of network location (node) numbering. This chapter also presents an overview of the specific travel costs that are developed in the TPB networks and considered in the regional travel model.

2.1 Modeled Area

A map of the TPB modeled area is shown in Figure 2-1. The area covers 6,800 square miles and includes 22 jurisdictions spanning the District of Columbia, Northern Virginia, suburban Maryland, and one county in West Virginia.[8] The modeled area extends well beyond the current TPB member-area, which is shown as the shaded area in Figure 2-1.

2.2 Time-of-Day Considerations

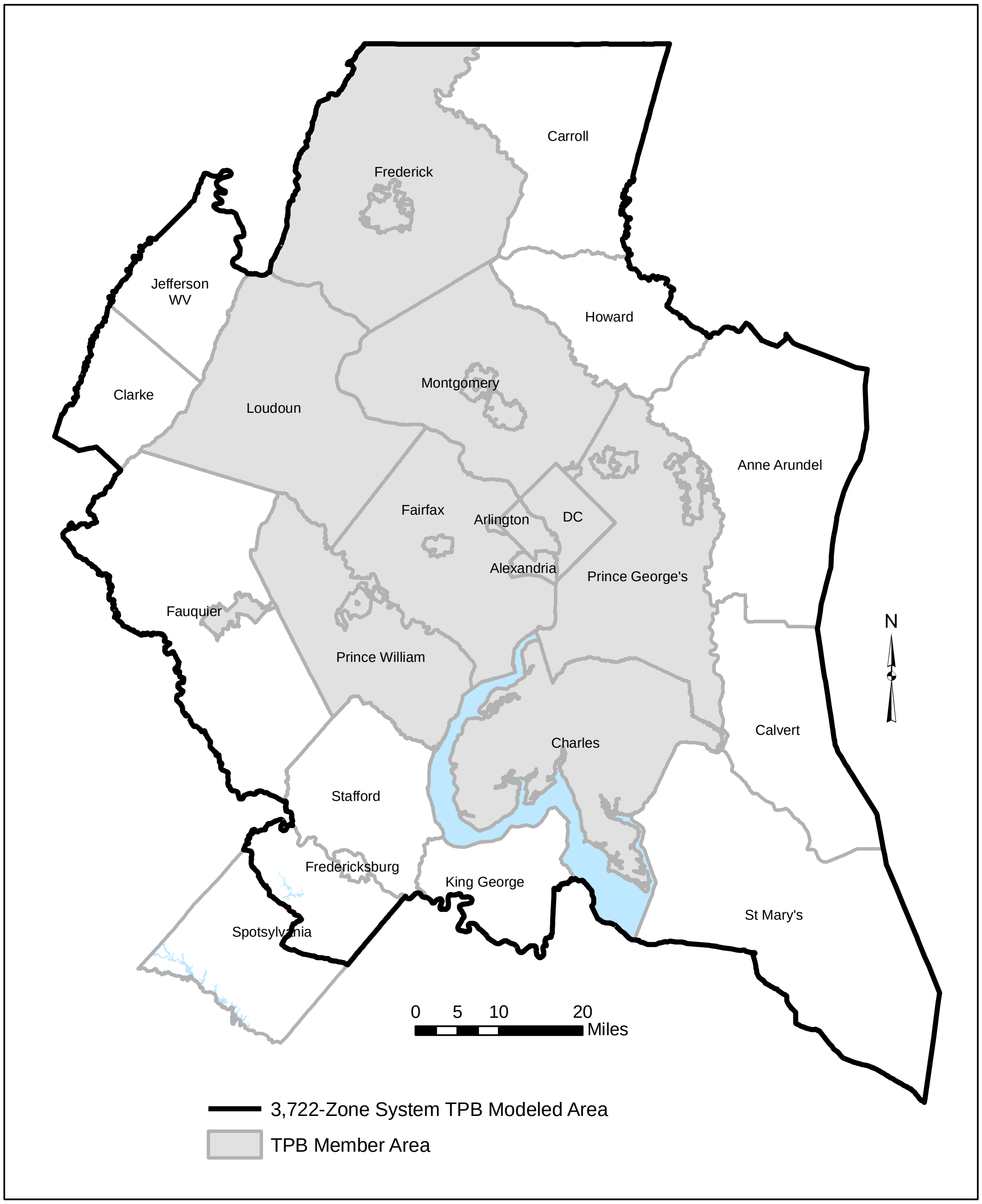
The travel model requires zonal travel times and costs for both peak and off-peak conditions because congestion levels experienced by different travel markets vary substantially over an average weekday. Thus, the travel model networks developed by TPB staff correspond to either peak or off-peak conditions.

Many of the primary highway facilities in the region operate with varying configurations during peak and off-peak hours of the day. Examples of operational changes include:

- HOV priority lanes/facilities: Freeways with diamond lanes or exclusive lanes that are dedicated to HOVs. Many HOV priority lanes operate in the peak-flow direction during peak periods and revert to general purpose lanes during the off-peak hours;
- Facilities with reverse-direction lanes: Several roads operate with varying directional lane configurations during the morning and evening time periods to better serve the peak-flow direction of traffic (e.g., The Theodore Roosevelt Bridge, which has a reversible lane). Some facilities operate entirely in one direction during rush periods and revert to two-way configurations during the off-peak; and
- Some facilities do not change in operation during the day, but are available only to special markets, such as autos only or airport-bound trips.

[8] The term "jurisdiction" includes both counties (e.g., Arlington County) and major cities (e.g., the City of Alexandria and Washington, D.C.). One of the 22 jurisdictions, Spotsylvania County, is only partially included in the modeled study area- the northern portion approximately north of VA 606. All other jurisdictions are fully included in the study area.

Figure 2-1 COG/TPB modeled area – 3,722-zone area system (TPB member area shown in gray)



Note: The TPB Member area also includes the urbanized portion of Fauquier County.

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The following time-period definitions are used for the highway network:

- AM peak period (3 hours: 6:00 AM to 9:00 AM)
- Midday period (5 hours: 10:00 AM to 3:00 PM)
- PM peak period (4 hours: 3:00 PM to 7:00 PM)

- Night/early morning period (11 hours: 7:00 PM to 6:00 AM)

Although traffic assignment is conducted for four time-of-day periods (AM peak period, midday, PM peak period, and nighttime), the trip distribution and mode choice steps operate with travel times and costs developed from the AM peak period and midday period only.[9]

The highway network distinguishes these special operations by using facility-specific attributes that change by time-of-day period. These attributes include directional lanes and codes that enable or disable the use of a specific facility to specific travel markets (e.g., HOV traffic). Highway costs (tolls) on specific facilities are also coded differentially by time-of-day period.

The operational differences reflected in the regional highway networks pertain essentially to high-level facilities (freeways and principal arterials). **While numerous operational differences between time periods exist on minor arterials and collectors, many of these are not reflected in TPB networks. For example, TPB highway networks do not contain information about turn prohibitions or parking restrictions)**, which are below the grain of the regional network.

Like the highway network, the level of transit service in the Washington, D.C. region varies substantially during the average weekday. Consequently, transit networks prepared for the travel model provide a representation of **peak** and **off-peak** service. For each modeled transit route, an average headway (service frequency) and an average run time (time from start of the route to the end of the route) is calculated for the two time-of-day periods. For the calculation of average headways and run times, the **peak period** is represented by the AM peak hour (7:00-7:59 AM) and the **off-peak** period is represented by the five-hour midday period (10:00 AM to 2:59 PM).[10] The AM period definition is reasonably representative of most peak/commuter service but may not be adequate to represent peak-period service operating in the outer reaches of the region. Consequently, the peak frequencies and running times for express bus and local bus service in some "outer" jurisdictions are developed using an earlier peak hour definition which is decidedly more representative of peak conditions. The specific peak hour selected is based on the professional judgment of the network coder.

2.3 Zone Area System

Transportation Analysis Zones (TAZs) represent the basic geographic unit by which regional highway and transit travel flows are estimated by the travel demand model. The TAZ system is important to the overall network design because TAZs delineate the finest level of spatial resolution that can be supported by the land activity inputs, and hence the travel model. Consequently, the highway and transit facilities represented in the regional network are purposefully designed to conform around each TAZ as closely as possible.

The existing modeled area is subdivided into 3,722 TAZs. The zone system includes 3,675 internal TAZs and 47 external stations, which represent points of entry to, and exit from, the modeled area. The

[9] Milone, Moran, and Seifu, "User's Guide for the COG/TPB Travel Demand Forecasting Model, Version 2.3.70: Volume 1 of 2: Main Report and Appendix A (Flowcharts)," chap. 13.
[10] Milone, Moran, and Seifu, chap. 21.

3,722-TAZ system has been in existence since 2009 and has been designed to provide a greater level of resolution in concentrated areas of development known as "activity centers." These concentrated areas were identified by COG's Metropolitan Development Policy Committee in 2007 as a basis for encouraging mixed use development and as an aid for improving the coordination of land use and transportation planning.

The 3,722 TAZ system numbering has been developed on a jurisdictional basis as shown in Table 2-1. The table indicates that the internal TAZs are numbered from 1 to 3675. The external station locations are shown in Figure 2-2 and Figure 2-3. External station numbers are sequenced from 3676 to 3722 and are assigned to highway facilities in a clockwise direction, from Virginia Route 3 station in King George County to US 50/301 (the Chesapeake Bay Bridge) in Anne Arundel County. The table also indicates that 1,278 reserved TAZs are currently available for subzone work. However, changes to the existing TAZ system would require changes to dimensions that are currently specified in application scripts and programs.

The TAZs in Table 2-1 are referred to as "TPB TAZ" to distinguish them from "COG TAZ." In 2008 and 2009, the COG GIS staff developed a new system of TAZs, which had more zones, but did not increase the size of the modeled area. In other words, the new zones were, on average, smaller than the previous zone system, which is useful for better modeling of transit and non-motorized trips. The old zone system had 2,191 TAZs and the new system has 3,722 TAZs. Reviews of the initial 3,722-TAZ system used in the COG Cooperative Forecasting process uncovered some instances where TAZ boundary refinements were needed. The result was that there are now two sets of zones for the 3,722-TAZ area system:

- COG TAZs: For land activity forecasts (COGTAZ3722_TPBMOD)
- TPB TAZs: For transportation modeling (TPBTAZ3722_TPBMOD)[11]

The specific differences between the two area systems are detailed in Table 2-2.

[11] Meseret Seifu, "Review of New Zone System: 3722 Transportation Analysis Zones (TAZ)" (January 22, 2010), 23, http://www.mwcog.org/uploads/committee-documents/Zl5aV1dd20100122152445.pdf.

Table 2-1 Jurisdictional summary of 3,722 TPB TAZ ranges

Jurisdiction	Jur. Code	Beginning TAZ No.	Ending TAZ No.	TAZ/Station Count
District of Columbia	0	1	393	393
Montgomery Co., Md.	1	394	769	376
Prince George's Co., Md.	2	770	1404	635
Arlington Co., Va.	3	1405	1545	141
City of Alexandria, Va.	4	1546	1610	65
Fairfax Co., Va.	5	1611	2159	549
Loudoun Co., Va.	6	2160	2441	282
Prince William Co., Va.	7	2442	2819	378
Frederick Co., Md.	9	2820	2949	130
Howard Co., Md.	10	2950	3017	68
Anne Arundel Co., Md.	11	3018	3116	99
Charles Co., Md.	12	3117	3229	113
Carroll Co., Md.	14	3230	3287	58
Calvert Co., Md	15	3288	3334	47
St. Mary's Co., Md.	16	3335	3409	75
King George Co., Va.	17	3410	3434	25
City of Fredericksburg, Va.	18	3435	3448	14
Stafford Co., Va.	19	3449	3541	93
Spotsylvania Co., Va.	20	3542	3603	62
Fauquier Co., Va.	21	3604	3653	50
Clarke Co., Va.	22	3654	3662	9
Jefferson Co., WVa.	23	3663	3675	13
Total Internal TAZs				3,675
External Stations:		3676	3722	47
Reserved TAZ numbers		3723	5000	1,278

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Note: 13 of the 3675 internal TAZs are unused: 61, 382, 770, 777, 2555, 2629, 3103, 3266, 3267, 3478, 3482, 3495, 3544

Table 2-2 Differences between COG TAZ and TPB TAZ area systems

COG TAZ	Jurisdiction	Issue	TPB TAZ
61	District of Columbia	island/water body	unused TAZ
382	District of Columbia	water body	unused TAZ
770	Prince George's Co., MD	water body	unused TAZ
777	Prince George's Co., MD	water body	unused TAZ
2555	Prince William Co., VA	resolution too fine for regional model	dissolved into TAZ 2554
2629	Prince William Co., VA	resolution too fine for regional model	dissolved into TAZ 2630
3103	Anne Arundel Co., MD	resolution too fine for regional model	unused TAZ
3266	Carroll Co., MD	peninsula/water body	unused TAZ
3267	Carroll Co., MD	water body	unused TAZ
3482	Stafford Co., VA	resolution too fine for regional model	dissolved into TAZ 3489
3478	Stafford Co., VA	resolution too fine for regional model	dissolved into TAZ 3489
3495	Stafford Co., VA	resolution too fine for regional model	dissolved into TAZ 3494
3544	Spotsylvania Co., VA	water body	unused TAZ

Figure 2-2 Location of external stations in the modeled area

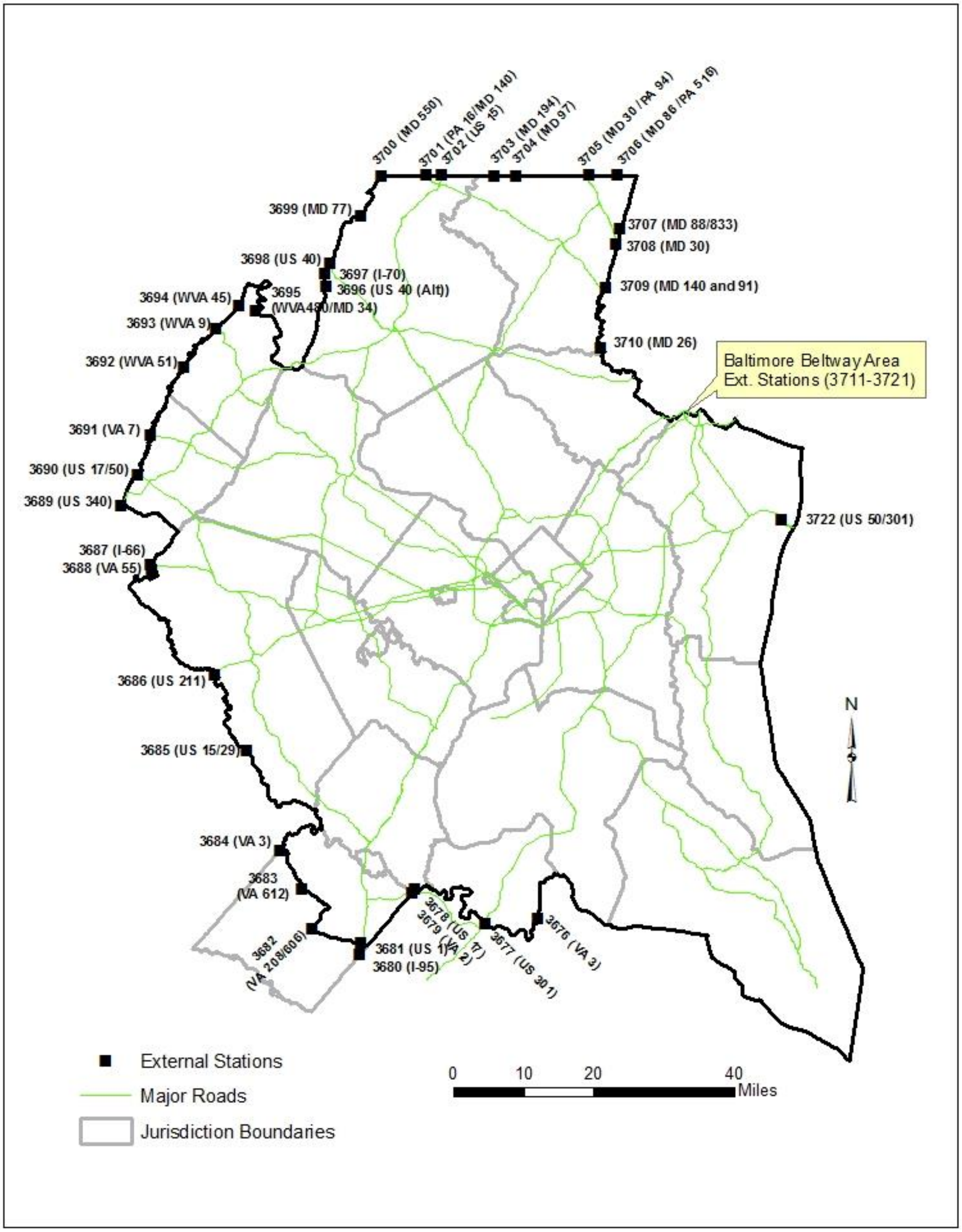
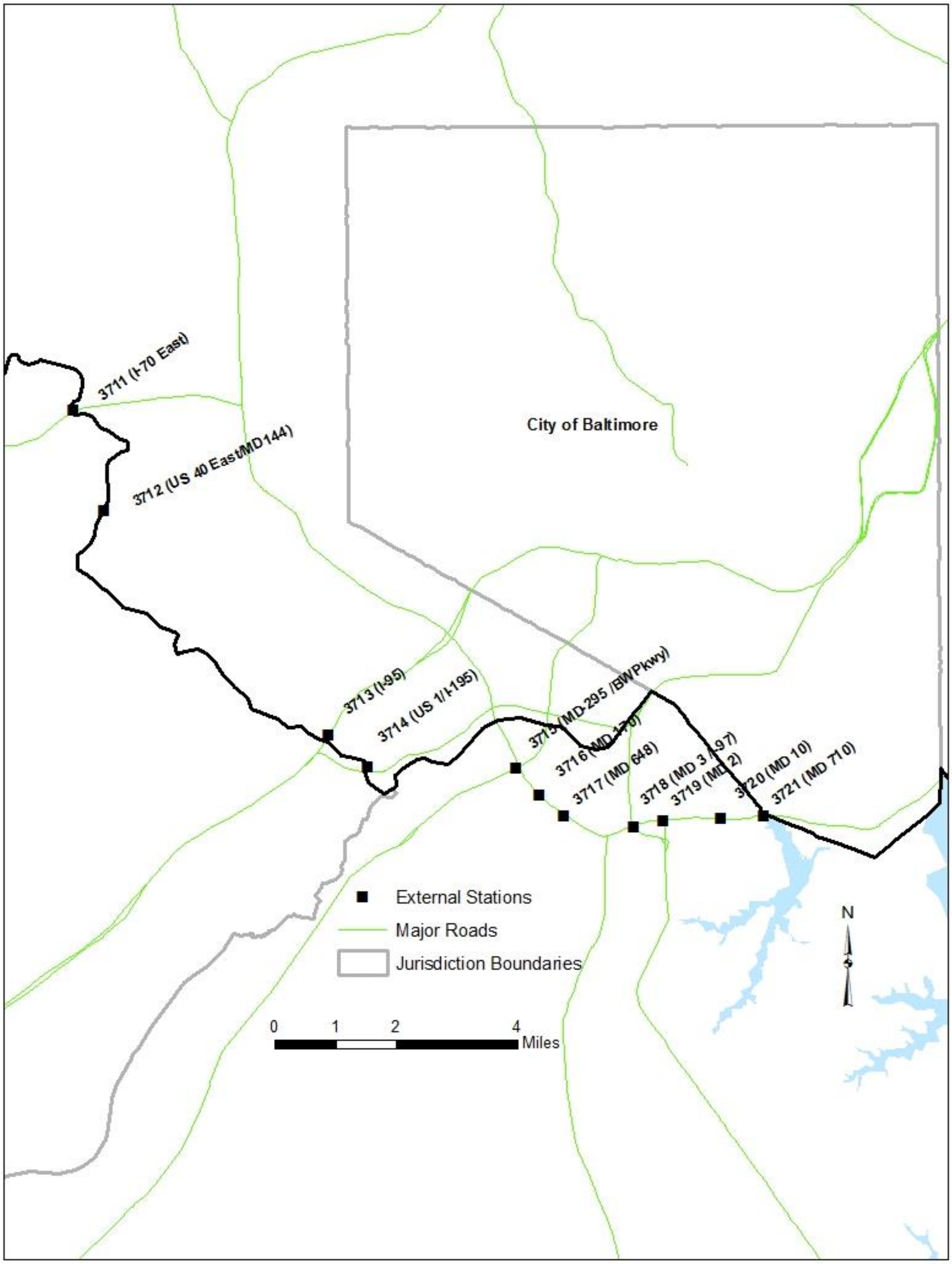


Figure 2-3 Location of external stations in Baltimore Beltway area



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2.4 Highway Network Elements

The transportation networks used by the travel model represent the region's transportation system as a collection of point locations (zone centroids and nodes) and transportation facility segments (links). This relatively simplistic depiction of the system provides the travel model with concise information about roadway connectivity and capacity that exists between zones. The model evaluates demand against the network capacity and subsequently produces level-of-service metrics (times and costs) between zones, which are important variables in the model.

There are several types of nodes and links that are used in the highway networks. These types are listed and described below:

- **Zone Centroids**: Point locations which represent the geographic center of activity of a TAZ. All trips begin and end at zone centroids. Although zones also have boundaries, zone boundaries are not explicitly represented in the transportation network, so all trips travel from one zone centroid to another zone centroid. The travel model represents zone-to-zone travel (inter-zonal travel), but not within-zone travel (intra-zonal travel), since this is below the grain of the model and its associated network.
- **PNR "Dummy" Centroids**: Point locations which represent park-and-ride (PNR) parking lots at Metrorail, commuter rail, and light rail stations. These are components of the highway network that exist so that congested travel times from TAZs to rail PNR lots may be developed in the construction of auto-access links in the transit network.
- **Highway Nodes**: Point locations that represent highway intersections, zonal points-of-access to the highway system, or simply "break points" or "shape points" for links representing highway facilities.
- **Centroid Connector Links**: Segments (or links) between zone centroids and the highway network by which generated traffic may leave or enter the TAZ. These special links represent the physical connection between zonal activity and the highway system based on the underlying localized street system. Centroid connections usually number from one to four links for each TAZ. Traffic "loaded" on centroid connectors is exclusively limited to trips originating or destined to a specific TAZ.
- **PNR Connector Links**: Segments that represent access links between Metrorail/commuter rail/light rail PNR lots and the highway network. Traffic is not "loaded" on these types of links; they are used for the sole purpose of developing congested TAZ-to-PNR travel times.
- **Highway Links**: These represent the major highway segments in the regional network on which regional traffic is "loaded." The segments are comprised of freeway, expressway, arterial, and collector facilities and do not include local streets. Freeway links are usually coded by direction, as two "one-way" links. In contrast, most non-freeway segments are represented as a single "two-way" facility. Freeway ramps are included in the regional network but are not represented as a "cloverleaf." Instead ramps are coarsely represented, and the regional model does not furnish accurate ramp volumes.
- **"Transit Only" Links**: There are two types of transit-only links. The **first** type are links that truly are restricted to only transit vehicles. An example would be a rail link for Metrorail or commuter

rail, or a BRT link that allows only BRT vehicles. This type of transit-only link exists in the transit network. The **second** type of transit-only link exists in the highway network. In general, transit links are not a part of the highway network. However, to develop a transit network, one begins with the highway network as the base, or, more specifically, those links in the highway network that carry bus service. In some cases, bus service may operate on a road segment that is below the grain of the highway network. In these cases, TPB staff adds a transit-only link to the highway network so that bus service can use this link. Since it is transit-only, a transit-only link in the highway network is excluded from the traffic assignment process. Thus, regional traffic is not loaded onto transit-only links in the highway network.

2.5 Transit Network Elements

The transit system contains some components of the highway system described above and consists of additional "point" and "segment" elements that are necessary for transit path building. The TPB transit network consists of a combination of the highway network along with transit-related elements. The transit elements are listed and described below:

- **Rail Stations**: Point locations where travelers may board or alight from fixed-guideway transit service, including Metrorail, commuter rail, light rail, street car, and BRT.
- **Transit PNR Lots**: Park-and-Ride lot point locations. It is assumed that "auto-access" trips originating from TAZ centroids park at these locations, prior to boarding at rail stations or at bus stops (most typically express bus stops). The model also considers Kiss-and-Ride (KNR) access, but KNR access links do not connect to PNR lots; they connect directly to the rail stations.
- **Rail Links**: These represent fixed guideway (Metrorail, commuter rail, light rail, streetcar and BRT) segments that connect rail stations. These are not part of the background highway network. Once TPB staff makes the transition from the TRNBUILD transit path builder to the Public Transport (PT) transit path builder, there will no longer be as much of a distinction between a highway network and a transit network – there will just be a transportation network, containing both highway and transit links in one network.
- **PNR Lot-to-Station Walking Links**: Links representing sidewalks between the PNR lot and the rail station.
- **Bus-to-Station Transfer Links**: Links representing sidewalks between bus stops and rail stations.
- **Walk Access Links**: Walk connections between zone centroids and transit stops accessible from the TAZ.
- **Auto Access Links**: Auto connections between the zone centroid and proximate PNR lots.
- **Sidewalk Links**: All highway links, other than freeways and expressways that are available for accessing transit from a zone centroid or are available for transferring between transit modes.
- **Transit lines/routes**: These are the individual transit routes that are in service during specific time periods. Transit lines are categorized among "modes" which distinguish basic service types (including, for example, Metrorail lines). The "line" files contain general characteristics (mode, average headway, average end-to-end running time, and a one- or two-way indicator) as well as the route delineation, which is expressed as a node string. The route delineation of bus-related modes is defined as a series of highway nodes. Rail related route delineation is defined as a

series of station nodes. In Cube, transit line files are text files. Since we currently use TRNBUILD, the files are in TRNBUILD format and have file extensions of "TB". In the future, we will transition to Public Transport (PT) and, at that time, the files will be in PT format, which will likely be indicated in the file name or the file extension (e.g., MODE1AM.LIN).

Most of the highway and transit network inputs are files that contain attributes of elements listed above. The attributes describe the physical location of nodes and the physical characteristics of links, such as the number of lanes, distance and the facility classification. These are specified in Chapter 3.

2.6 Overview of Network Travel Costs

The Version 2.3.75 Travel Model, like all the other models in the Version 2.3 family of models, requires several traveler out-of-pocket cost inputs. Most of the traveler costs are network-related or path-related elements. All cost inputs are either prepared in constant-year (year-2007) prices (dollars or cents) or are converted to constant-year prices as part of the model application process. The year 2007 is the model "base-year" because that was the year when model calibration data was collected. The travel model currently considers five travel cost components each affecting different varying steps of the travel model:

- Transit related
    - Transit fares
    - Parking costs associated with drive-access to transit (parking at a PNR lot)
- Highway related
    - Highway tolls
    - Parking costs associated with a non-transit trip
    - Other auto operating costs (distance based)

Transit fares are computed within the model stream in terms of current-year prices and are ultimately converted to constant-year prices. PNR-related parking costs are provided for both the peak and off-peak period. These PNR parking costs are stored in the station file (station.dbf). Current-year highway tolls are obtained from the appropriate websites. Future-year tolls are estimated in a semi-automated toll-setting process (see, for example, the current TPB model user's guide). Both PNR parking costs and tolls are coded as input variables in current-year prices.

As suggested by the list above, parking costs for transit trips are handled separately from parking costs associated with auto trips. Parking costs associated with a non-transit trip are calculated using a parking cost model, which is applied with the Cube Voyager script *prefarv23.s*. These parking costs are a function of job density, specifically attraction TAZ employment density. This script also calculates "terminal time," i.e., the time to park and un-park a car.[12] Since these parking costs are calculated with

[12] "User's Guide for the COG/TPB Travel Demand Forecasting Model, Version 2.3.75: Volume 1 of 2: Main Report and Appendix A (Flowcharts)," sec. 21.7.

a parking cost model, the network coder does not have to collect these. Lastly, auto operating costs are computed directly in year-2007 prices, based on a single per-mile parameter.

PNR lot costs are coded as a station node attribute in the network input files in current-year cents. PNR lot costs, like tolls, are used exclusively in the development of rail-related transit paths. PNR lot costs may be altered with "shadow–price" variables that also exist in the station file for calibrating auto access demand at specific rail stations. One could make use of shadow prices to adjust the demand (up or down) at one or more PNR lots, to reflect observed behavior. Shadow prices have not been used in the current travel model but, for more information, see pp. 186-187 of the current travel model user's guide.[13] Also, unlike the other cost components, the PNR lot cost is not considered in the mode choice modeling process.

Highway tolls are coded on a highway network on a link-by-link basis and are specified as either a flat cost or as a per-mile rate. Highway tolls are rather unique cost components in that they affect the construction of highway paths. Most conventional travel models build minimum-impedance paths based on congested travel time. The TPB model builds highway paths based on a generalized cost function that equals the congested travel time plus the travel time equivalent of tolled costs. The monetary toll between zones therefore reflects any toll segments that exist along each minimum generalized cost path.

Zone-to-zone transit fares are computed in a way that mimics WMATA's actual fare policy. The computation involves two steps: 1) the calculation of Metrorail fares between stations using WMATA policy parameters and 2) combining Metrorail fares between stations with bus/commuter rail fares between "Bus Fare Zones" which are entered as an input. Bus Fare Zones are currently 21 "macro areas" of the region that approximate WMATA policy areas and other transit market areas. The transit fares are dependent on minimum perceived time paths between TAZ that include Metrorail defined boarding and alighting stations, if Metrorail use is included within the path.

2.7 Node Numbering System

The various node groups are numbered in the network in a structured way. Structured node numbering is useful because it facilitates network integrity checks and network mapping. It is also important because model application programs reference predefined TAZs and node numbers and node ranges for the purposes of indexing or dimensioning.

An overview of the node numbering system that has been adopted for highway and transit networks on the 3,722-TAZ system is shown in Table 2-3**.** The numbering system allocates nodes from lowest to highest beginning with TAZs, station centroids, station nodes, PNR lot nodes, and finally highway nodes.

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[13] Ray Ngo et al., "User's Guide for the COG/TPB Travel Demand Forecasting Model, Version 2.3.75: Volume 1 of 2: Main Report and Appendix A (Flowcharts)" (Washington, D.C.: Metropolitan Washington Council of Governments, National Capital Region Transportation Planning Board, December 5, 2018), https://www.mwcog.org/transportation/data-and-tools/modeling/model-documentation/.

Table 2-3 TAZ/node numbering system overview

Node Class	Node Type	Beginning TAZ / Node	Ending TAZ / Node	Node Count
TAZ/PNR Centroids	Internal TAZ Centroid	1	3675	3,675
	External Stations:	3676	3722	47
	Reserved TAZ numbers	3723	5000	1,278
	PNR Centroid	5001	7999	2,999
Transit Nodes	Transit Station Nodes	8000	10999	3,000
	Transit PNR Lot Nodes	11000	13999	3,000
	Transit Reserved Nodes	14000	19999	6,000
Highway Network Nodes		20000	54999	35,000

Ref: " I:\ateam\docum\FY15\2014LRTP_Network_Report\NW_Report_Tables\3722TAZ_Master_Node_Table_Jan_2015.xlsx"

The sub-allocation of transit nodes above is further detailed in Table 2-4.

Table 2-4 Node numbering system for transit nodes

Node Type	Beginning TAZ / Node	Ending TAZ / Node	TAZ / Node Count
Metrorail PNR Centroids:	5000	5999	1000
Commuter Rail PNR Centroids:	6000	6999	1000
Light Rail/BRT PNR Centroids:	7000	7999	1000
Metrorail Station Node:	8000	8999	1000
Commuter Rail Station Node:	9000	9999	1000
Light Rail Station Node:	10000	10499	500
BRT Street car Station Node:	10500	10999	500
Metrorail PNR Lot Node:	11000	11999	1000
Commuter PNR Lot Node:	12000	12999	1000
Bus PNR Lot Node:	13000	13999	1000
Reserved Transit Nodes	14000	19999	6000

Ref: "I:\ateam\docum\FY16\2015LRTP_Network_Report\NW_Report_Tables\3722TAZ_Master_Node_Table_Jan_2015.xlsx"

Note: 7000-7999 range is not currently used in the geodatabase.

Highway node numbers are allocated in discrete ranges by jurisdiction, as shown in Table 2-5.

Table 2-5 Allocated highway node ranges by jurisdiction

Jurisdiction	Beginning TAZ / Node	Ending TAZ / Node	Allocated Nodes
District of Columbia	20000	21999	2000
Montgomery Co., Md.	22000	25999	4000
Prince George's Co., Md.	26000	29999	4000
Arlington Co., Va.	30000	31999	2000
City of Alexandria, Va.	32000	33999	2000
Fairfax Co.. Va.	34000	37999	4000
Loudoun Co., Va.	38000	39999	2000
Prince William Co., Va.	40000	41999	2000
Frederick Co., Md.	42000	43999	2000
Howard Co., Md.	44000	45499	1500
Anne Arundel Co., Md.	45500	46999	1500
Charles Co., Md.	47000	47999	1000
Carroll Co., Md.	48000	48999	1000
Calvert Co., Md	49000	49499	500
St. Mary's Co., Md.	49500	49999	500
King George Co., Va.	50000	50499	500
City of Fredericksburg, Va.	50500	50999	500
Stafford Co., Va.	51000	51999	1000
Spotsylvania Co., Va.	52000	52999	1000
Fauquier Co., Va.	53000	53999	1000
Clarke Co., Va.	54000	54499	500
Jefferson Co., WVa.	54500	54999	500
Reserved Nodes	90000	91000	1000

Ref: I:\ateam\docum\FY16\2015LRTP_Network_Report\NW_Report_Tables\3722TAZ_Master_Node_Table_Jan_2015.xlsx

In November 2017, Yuanjun Li, from Montgomery County, asked for an unused node range to be reserved exclusively for Montgomery County studies where more detailed coding is included in the highway networks, to avoid the possibility of using the same node numbers in different locations. The range from 90000-91000 was reserved for that purpose, to be used by Montgomery County staff and consultants.

3 Cube Voyager Network Inputs

Chapter 2 provided a broad overview of the TPB transportation networks in terms or the TAZ system, network elements, and node numbering conventions. This chapter presents more detail on the specific input files that are prepared, which include policy-related inputs as well as infrastructure-related inputs. The input files are presented in four sub-sections: cost deflation inputs, highway network inputs, transit network inputs, and transit fare inputs.

It is important to note that all input filenames used by the TPB travel demand model are assigned generic names, such as "link.dbf." The Version 2.3 family of travel models identifies modeled scenarios using scenario-specific *subdirectories*, each containing generic input *filenames*. While this approach might appear confusing and error-prone, TPB staff has grown comfortable with the application approach for several years. More detail on the TPB's model application may be found in the travel model user's guide.[14]

3.1 Cost Deflation Inputs

The Version 2.3.75 model application includes a procedure that creates an inflation/deflation factor for converting current-year costs into constant-year (year-2007) costs. The factor is used in subsequent steps and applied to highway tolls and transit fares. The cost deflation factor information is stored in a user-prepared parameter file, shown in Figure 3-1. The file contains the historical year-to-year consumer price index (CPI) schedule published by the Bureau of Labor Statistics (BLS). The specific CPI index definition used for deflating modeled transportation costs is defined as "All Urban Consumers/U.S. city average for all items (1982-84=100)." The following link was used to obtain historical CPI data:

https://www.bls.gov/cpi/tables/historical-cpi-u-201712.pdf

The CPI parameter file (Figure 3-1) is updated each year.[15] The file contains a table showing the annual CPI starting from 2007 to the most recent historical year. The table also includes the computed average annual growth rate and the deflation factor implied from the base year to the current year. The deflation rate for converting current year costs is based on the historical rate of inflation defined as the base-year CPI divided by current-year CPI (the most recent year for which annual CPI data is furnished). As shown in the parameter file, the existing deflation factor for the current year (2017) is 0.8459 (or 207.342 divided by 245.120). In the recent past, the CPI has grown about 2% a year, which is indicated as the solid red line in Figure 3-2. TPB travel forecasts generally assume that future cost escalation will follow the historical rate of inflation.

[14] chap. 4.

[15] Ray Ngo to Mark Moran, "Update of the CPI Schedule Used in the Version 2.3 Travel Model," Memorandum, February 22, 2018.

Figure 3-1 Cost deflation parameter file (CPI_File.txt)

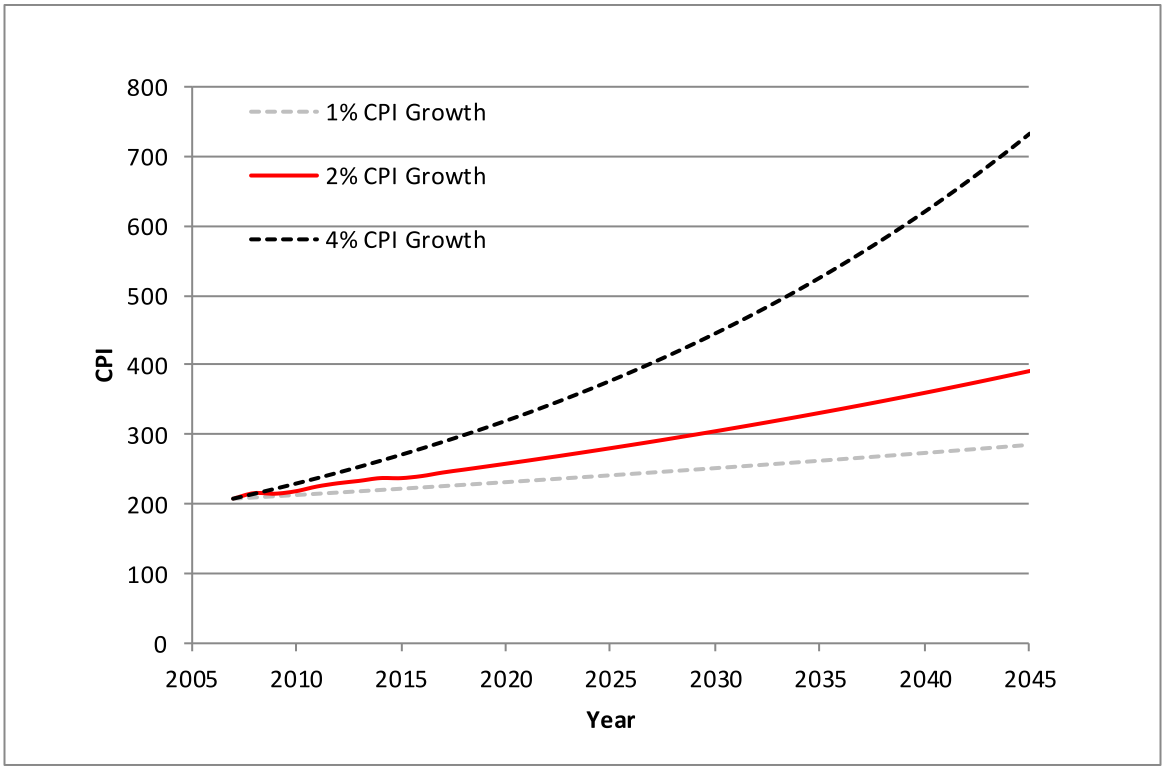
```
;; - MWCOG V2.3 Travel Model - Cost deflation Table
;; - 1/30/2017 - RN
;; Data from BLS / All Urban Consumers (CPI-U) US City Avg.1982-84=100.0
;; http://www.usinflationcalculator.com/inflation/consumer-price-index-and-annual-percent-
changes-from-1913-to-2008

InflationFTR         = 1.0    ; Inflation Assumption (DEFAULT IS 1.0)
Defl_OverRide        = 0.0    ; Deflation Override   (DEFAULT IS 0.0)  If Non-zero it is used as
deflator
                              ; Used as deflator IF NON-ZERO
BaseCPIYear          = 2007   ; Base year of the CPI Table
CurrCPIYear          = 2017   ; Current year on  CPI table below (Year for which complete annual
CPI data is available)
;
;===============================================================
; Establish historic CPI table and Deflation Factor            =
;===============================================================
;
      LOOKUP Name=CPI_Table,
             LOOKUP[1]    = 1,Result = 2,          ;;  CPI index (from US BLS)
             LOOKUP[2]    = 1,Result = 3,          ;;  Compounded Growth Rate From Base Year
             LOOKUP[3]    = 1,Result = 4,          ;;  Deflation Factor
             Interpolate = N, FAIL=0,0,0,list=Y,
          ;;
          ;;               (((YrCPI/BsCPI)^(1/n))-1.0)*100   BsCPI/YrCPI)
          ;;                      Annual_Avg.                Historic Deflation
          ;; YEAR    CPI          Growth_Rate(%)             Factor
          ;; ----   -----        -----------------          -----------
        R=' 2007,  207.342,          0.00,                  1.0000 ', ; <--- BaseCPIYear
          ' 2008,  215.303,          3.84,                  0.9630 ', ;
          ' 2009,  214.537,          1.72,                  0.9665 ', ;
          ' 2010,  218.056,          1.69,                  0.9509 ', ;
          ' 2011,  224.939,          2.06,                  0.9218 ', ;
          ' 2012,  229.594,          2.06,                  0.9031 ', ;
          ' 2013,  232.957,          1.96,                  0.8900 ', ;
          ' 2014,  236.736,          1.91,                  0.8758 ', ;
          ' 2015,  237.017,          1.69,                  0.8748 ', ;
          ' 2016,  240.007,          1.64,                  0.8639 ', ;
          ' 2017,  245.120,          1.69,                  0.8459 '  ; <--- Curr(ent)CPI Year

; --- end of CPI File -----------
; -------------------------------
```

Ref: " Z:\ModelRuns\fy19\CGV2_3_75_Visualize2045_CLRP_Xmittal\2019_Final\Inputs\ CPI_File.txt"

Figure 3-2 Projected CPI escalation at varying annual growth rates

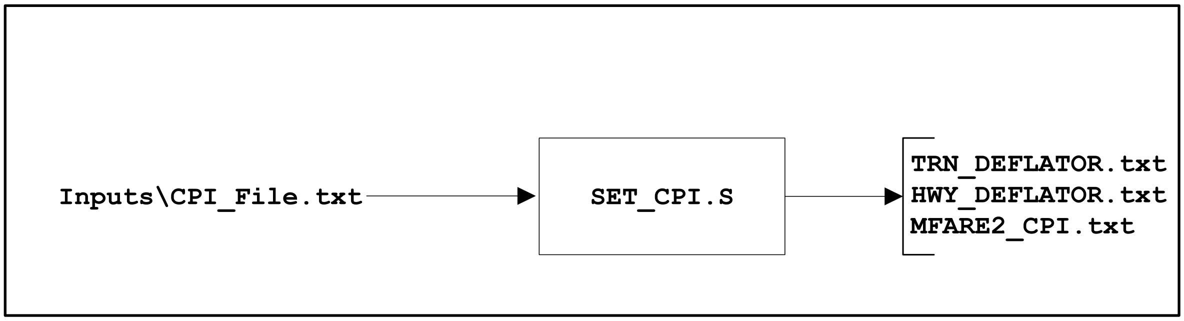


Ref: "I:\ateam\docum\fy19\V2.3.75_Visualize2045NetworkReport\Report Tables\cpi.xlsx"

The InflationFTR variable ("inflation/deflation factor" variable) enables one to investigate varying future cost escalation scenarios. An InflationFTR value of "1.0" implies that future costs will escalate directly with the historical CPI growth rate. The parameter may be changed to, for example, "0.5" to reflect cost growth at one-half of the historical growth rate or to "2.0" to reflect cost growth at twice the historical growth rate, etc. The dashed lines in Figure 3-2 indicate how project cost escalation for these types of scenarios compare with the TPB's default cost escalation assumption.

The CPI_File.txt file is called into the SET_CPI.S script as shown in Figure 3-3. The script writes out two one-line text files containing the deflation factors that are used to convert current year highway and transit costs to constant-year costs in subsequent modeling steps. The MFARE2_CPI.txt file contains summary CPI information.

Figure 3-3 Deflation process in the Version 2.3 Travel Model



3.2 Highway Network Files

A list of user-generated highway network inputs is provided in Table 3-1. The list includes a node file, a link file, a zonal land activity file, and a toll parameter file. The files are read into Cube Voyager scripts and are ultimately converted into a single binary or "built" network file (*.NET). Binary networks are used in the travel model application because they enable the software to process network-related operations more efficiently. The binary network ultimately created from the TPB "network building" process is named *zonehwy.net*. This file is sometimes referred to as an "unloaded network" file because it does not include link volumes resulting from the traffic assignment step.

Table 3-1 also indicates the source of the files. The highway node and link file are developed from a multi-year and multi-modal geodatabase that is discussed in Chapter 4. Other inputs relating to zonal land activity and policy parameters are generated either manually or by off-line procedures.

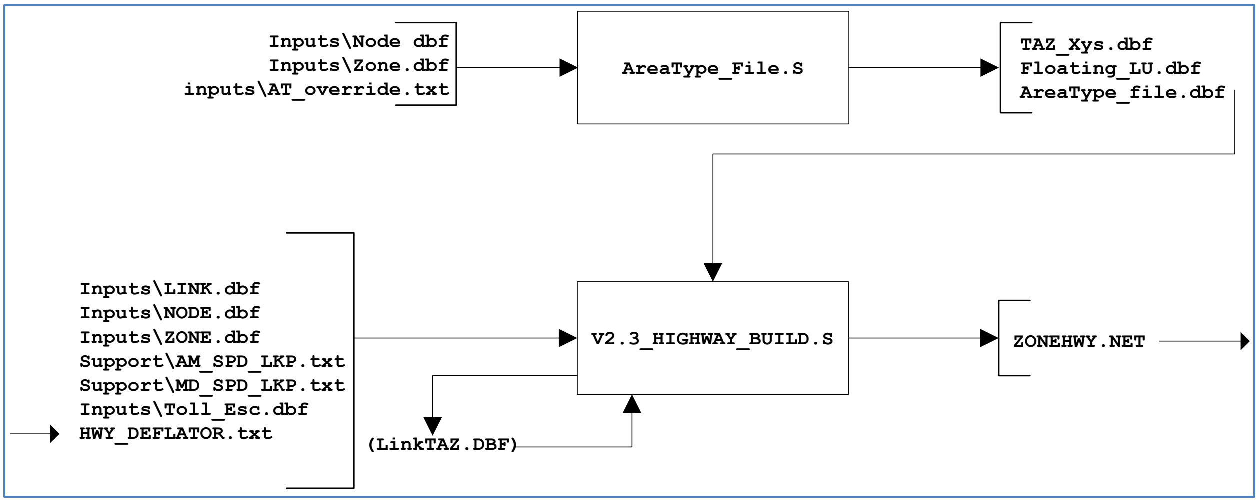
Table 3-1 Listing of highway network input files

Filename	Description	Type	Source
Node.dbf	XY coordinates of nodes in highway network	DBF	Geodatabase
Zone.dbf	Land use/land activity data at zonal level, 3722 TAZ	DBF	Analyst-generated
Link.dbf	Highway network links	DBF	Geodatabase
Toll_Esc.dbf	Toll policy parameters by link "Tollgrp" code	DBF	Analyst-generated

Ref: "I:\ateam\docum\fy14\2013LRTP_Network_Report\v23_inputs_v10.xlsx"

The above files are used in a network building process that is shown in Figure 3-4. The process involves two steps, one that develops zonal area types (AreaType_File.S) and another that "builds" the highway network (V2.3_Highway_Build.S). The inputs files and the two steps are described in the next sections of the report.

Figure 3-4 Highway network building process



3.2.1 Zonal land use

The zone.dbf file contains zonal land activity and other items that are shown in Table 3-2. This file is created from a standard Cube Voyager process that reads a single, standardized, multi-year file from COG's Cooperative Forecasts of land activity, and creates individual (year-by-year) files, that are used by the travel model. The most recent COG Cooperative Forecasts, Round 9.1 land activity was employed in the Visualize 2045 and FY 2019-2024 TIP conformity analysis. The Round 9.1 land activity totals for the modeled region are shown in Table 3-3. Cooperative Forecasts are prepared in five-year increments. If intermediate years are modeled, such as 2019 in the the Visualize 2045 plan analysis, the land activity values are linearly interpolated.

Table 3-2 Format description of the land use file (zone.dbf)

File Name	Variable Name	Description
Zone.dbf	TAZ	TAZ (1-3,722)
	HH	Households
	HHPOP	Household Population
	GQPOP	Group Quarters Population
	TOTPOP	Total Population
	TOTEMP	Total Employment
	INDEMP	Industrial Employment
	RETEMP	Retail Employment
	OFFEMP	Office Employment
	OTHEMP	Other Employment
	JURCODE	Jurisdiction Code (0-23) *0/dc, 1/mtg, 2/pg, 3/alr/, 4/alx,5, ffx, 6/ldn, 7/ pw, 8/(unused), 9/ frd, 10/how, 11/aa, 12/chs, 13/(unused), 14/car, 15/cal, 16/stm, 17/ kg, 18/fbg, 19/stf, 20/spts, 21/fau, 22/clk, 23/jef*
	LANDAREA	Gross Land Area (in sq. miles)
	HHINCIDX	Ratio of zonal HH median income to regional median HH income in tenths (i.e. 10 = 1.0), per 2000 CTPP.
	ADISTTOX	Airline distance to the nearest external station in whole miles.
	TAZXCRD	TAZ X-Coordinates (NAD83-based in whole feet)
	TAZYCRD	TAZ Y-Coordinates (NAD83-based in whole feet)

Before the zone-level land activity data can be used as an input to the travel model, it must undergo an adjustment process, known as the CTPP-based employment adjustment, which ensures that a consistent employment definition is used by all counties and jurisdictions in the modeled area. The reason for this adjustment is that different jurisdictions in the modeled area, which covers DC, Maryland, Virginia, and one county in West Virginia, use different definitions of employment.

Table 3-3 Round 9.1 Cooperative Forecasts regional totals by year

Year	HH	HHPOP	GQPop	TotPop	TotEMP
2010	2,461,971	6,521,805	122,327	6,644,132	3,804,966
2015	2,615,596	6,933,619	134,754	7,068,373	4,027,355
2020	2,787,518	7,351,946	141,277	7,493,223	4,287,262
2025	2,956,878	7,742,742	144,576	7,887,318	4,554,059
2030	3,115,506	8,104,589	146,997	8,251,586	4,806,757
2035	3,249,283	8,419,428	149,075	8,568,503	5,029,637
2040	3,366,633	8,694,838	152,450	8,847,288	5,252,144
2045	3,487,592	8,970,465	153,165	9,123,630	5,454,003

Note: These values include the CTPP-based employment adjustment that ensure that a consistent definition of employment is used across the modeled area.

Ref I:\ateam\mod_inputs\lu\rnd91_taz3722\Processing\RayChecking\ rd91_tpb3722_Processing_RayChecking.xlsx

3.2.2 Highway Link and Node Coordinate Files

The link.dbf file contains the attributes of individual highway segments (links) that comprise the highway network. The link attributes are shown in Table 3-4. A row in this DBF file is uniquely defined by the A-Node/B-Node pair. The link.dbf file describes basic characteristics of individual highway segments including distance, the number of directional lanes by time-of-day period (??LANE), directional user-market enable or disable codes (??LIMIT), and facility type (FTYPE). These highway network link key attributes are described in this section.

Table 3-4 Base highway link file description (link.dbf)

File Name	Variable Name	Description
Link.dbf	A	A-Node
	B	B-Node
	DISTANCE	Link distance (in whole miles w/explicit decimal)
	JUR	Jurisdiction Code (0-23) *0/dc, 1/mtg, 2/pg, 3/alr/, 4/alx,5, ffx, 6/ldn, 7/ pw, 8/(unused), 9/ frd, 10/how, 11/aa, 12/chs, 13/(unused), 14/car, 15/cal, 16/stm, 17/ kg, 18/fbg, 19/stf, 20/spts, 21/fau, 22/clk, 23/jef*
	SCREEN	Screenline Code
	FTYPE	Link Facility Type Code (0-6)
		0/centroids, 1/Freeways, 2/Major Art., 3/Minor Art, 4/ Collector, 5/ Expressway, 6/ Ramp
	TOLL	Toll Value in current year dollars
	TOLLGRP	Toll Group Code
	AMLANE	AM Peak No. of Lanes
	AMLIMIT	AM Peak Limit Code (0-9)
	PMLANE	PM Peak No. of Lanes
	PMLIMIT	PM Peak Limit Code (0-9)
	OPLANE	Off-Peak No. of Lanes
	OPLIMIT	Off-Peak Limit Code (0-9)
	EDGEID	Geometry network link identifier
	LINKID	Logical network link identifier
	NETYEAR	Planning year of network link

File Name	Variable Name	Description
	SHAPE_LENGT	Geometry length of network link (in feet)
	PROJECTID	Project identifier

The highway network node file, node.dbf (Table 3-5), contains the XY coordinates for both TAZs and highway nodes.

Table 3-5 : Highway node file description

File Name	Variable Name	Description
Node.dbf	N	TAZ or Highway Node Number
	X	X - Coordinates (NAD83-based in whole feet)
	Y	Y- Coordinates (NAD83-based in whole feet)

Road attributes that may vary by time of day are represented by two sets of link attributes named <prd>lane and <prd>limit, where <prd> is "AM", "PM", and "OP." The lane attribute describes the number of directional effective through lanes in operation during the period. The limit attribute assigns special market prohibitions that exist during a given time-of-day period. The limit prohibitions indicate 1) whether the directional link is available to traffic during the period or 2) whether the link is available to certain markets only during specific time periods or during the entire day. In many cases, lane coding is related to limit coding. The limit codes currently used by the model are presented in Table 3-6.

Table 3-6: Limit codes

Limit Code	Vehicles Allowed
0	All Vehicles
2	HOV 2+ Occ. Vehicles
3	HOV 3+ Occ. Vehicles
4	All Vehicles, other than trucks
5	Airport Passenger Auto Driver Trips
9	Transit Only

Limit and lane codes are used to reflect changes in directional-lane configurations, a variety of HOV operations, and truck prohibitions (primarily on parkways). Limit coding is also used to identify "Transit Only" links (limit code = 9), which are used to more accurately depict transit route coding relative to zone centroids. These types of links are excluded from the highway assignment process because they are below the grain of both the zone system and the roadways included in the networks.

The third input file to AreaType_File.s (Figure 3-4) is a file that allows one to make an override of an area type value (AT_override.txt). For example, the area-type of the TAZ containing The Pentagon might be calculated as a 3 ("Medium employment density"), but one could override this value with a 1 ("High mixed employment and population density"). More details can be found in the travel model user's guide.

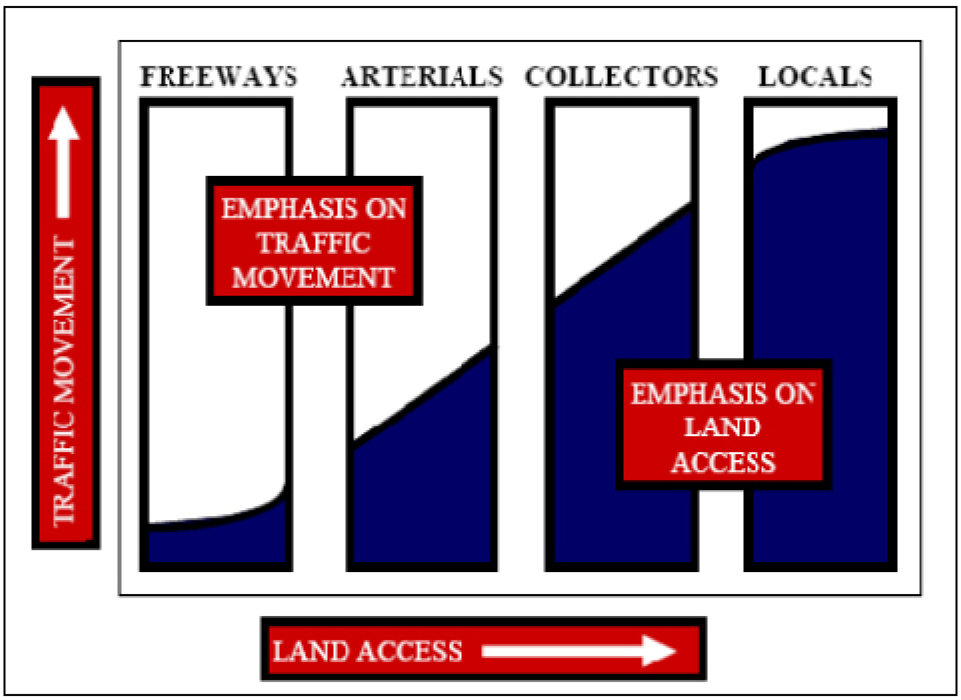
3.2.3 Roadway functional classification and the facility-type variable

Roads/highways are typically classified into a hierarchical system that indicates their design and the type of traffic they are designed to serve. The classic hierarchy is

- Freeways
- Arterials
- Collectors
- Local roads

Higher level roads, such as freeways, have an emphasis on mobility and traffic movement. Lower level roads, such as collectors and local roads, have an emphasis on land access. This continuum is shown graphically in Figure 3-5.

Figure 3-5 Classification of roads and their emphasis on mobility and access



Source: [16]

Figure 3-6 shows examples of the different types of roads.

In COG/TPB highway networks, the facility-type (FTYPE) code is used to designate the hierarchy of road types. Facility-type codes are defined as:

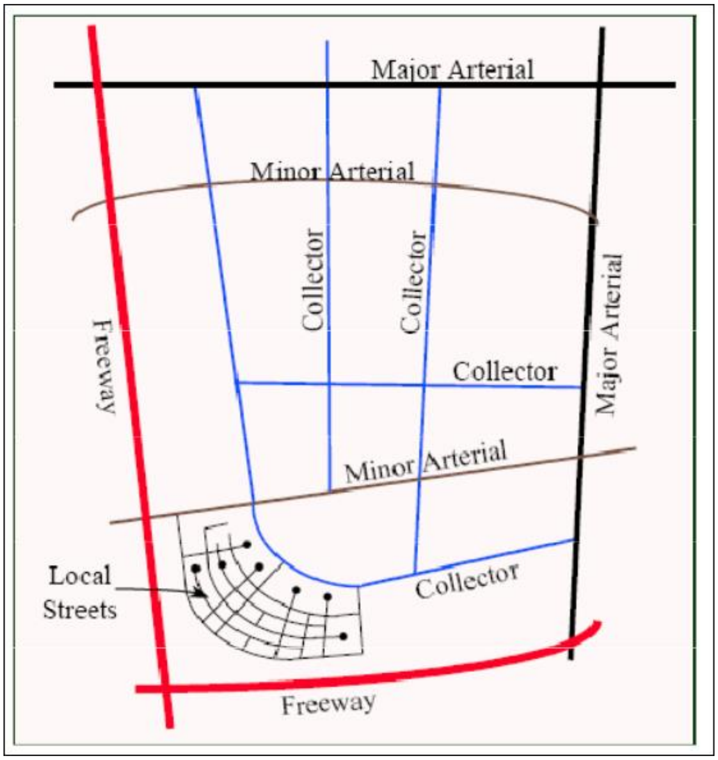
- 0: centroid connectors;
- 1: interstates and freeways;
- 2: major arterials;

[16] BLF Marketing, Wilbur Smith Associates, Inc., and RKG Associates, Inc., "Clarksville SMART GROWTH Plan – 2030: A Blueprint for Progress and Quality … as We Grow to 250,000 Residents" (Clarksville, Tennessee, July 23, 2010), chap. 3, http://www.clarksvillesmartgrowth.com/Sec3-TransportationAnalysis.htm.

- 3: minor arterials;
- 4: collectors;
- 5: parkways and expressways with at-grade intersections; and
- 6: freeway and expressway ramps

The highest-class roads in TPB networks are interstates/freeways (FTYPE=1) and parkways/expressways (FTYPE=5). The lowest-class roads in TPB networks are collectors (FTYPE=4). Note that local roads are not typically part of TPB networks, but each centroid connector represents one or more local roads that are not explicitly represented.

Figure 3-6 Example of different types of roads



Source: [17]

The facility type (FTYPE) attribute is used in conjunction with an area-type indicator (ATYPE) which is used to establish modeled free-flow speeds and hourly capacity.

The federal government has its own classification scheme, called the federal functional classification system.[18] While there is a correlation between TPB facility-type codes and the federal functional classification system, there are numerous exceptions. For example, facilities categorized as freeways in the federal system may be coded as expressways in the TPB network, or expressways in the federal system may be coded as freeways. These types of classification adjustments are ultimately made to

[17] BLF Marketing, Wilbur Smith Associates, Inc., and RKG Associates, Inc., chap. 3.
[18] "Highway Functional Classification Concepts, Criteria and Procedures" (Washington, D.C.: U.S. Department of Transportation, Federal Highway Administration, 2013), https://www.fhwa.dot.gov/planning/processes/statewide/related/highway_functional_classifications/fcauab.pdf.

ensure that the facility use and operation is accurately represented in the travel model. It should also be noted that the "ramp code" (FTYPE=6) was added to the facility code list in FY 2003 to support an EPA requirement associated with estimating emissions specific to ramps. Ramp-type facilities in the TPB networks are associated with the same speed and capacity characteristics as freeway and expressway facilities.

3.2.4 Other link attributes

Modeled link free-flow speeds and capacities are based on the facility type and an area type (ATYPE) variable. The area type identifies, in broad terms, the level of land development around each highway link. The area type variable is not included in the link.dbf file, but rather, is dynamically generated during the highway network building process:

- In the AreaType_File.s script, a "1-mile floating" land use density is computed for each TAZ. The floating density for a given TAZ equals the accumulated land activity of the TAZ, plus the land activity of all proximate TAZs within a one-mile radius, divided by the similarly accumulated land area. Floating population and floating employment figures are computed for each TAZ. The one-mile radius is evaluated based strictly on centroid positioning;
- Each TAZ is assigned an area type (integer) value of 1 to 6 based on the joint population and employment density ranges defined in Table 3-7; The names of the six area types, as well as examples of each type, can be found in Table 3-8.
- The mid-point of each highway link is evaluated against all TAZ centroid positions. Each link is then assigned the area type value associated with the nearest TAZ.

Table 3-7 Area-type codes, from 1 to 7, based on population and employment density

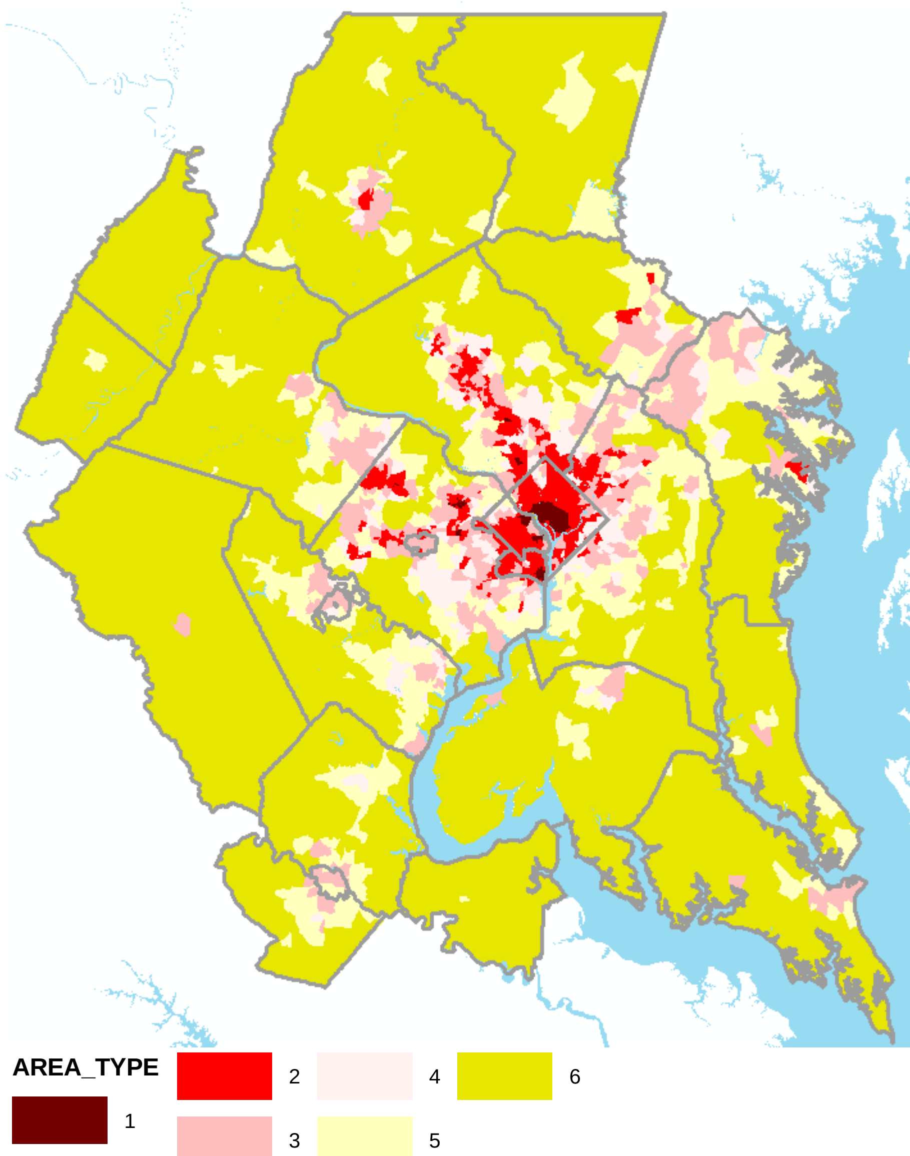
One-Mile “Floating” Population Density (Pop/Sq mi)	One- mile “Floating” Employment Density (Emp/Sq mi)						
	0-100	101-350	351-1,500	1,501-3,550	3,551-13,750	13,751-15,000	15,001+
0-750	6	6	5	3	3	3	2
751-1,500	6	5	5	3	3	3	2
1,501-3,500	6	5	5	3	3	2	2
3,501-6,000	6	4	4	3	2	2	1
6,001-10,000	4	4	4	2	2	2	1
10,000-15,000	4	4	4	2	2	2	1
15,001+	2	2	2	2	2	1	1

Table 3-8 The six area-type codes and examples of each area type

Area Type	Name	Examples
1	High mixed employment and population density	1. Downtown DC, between Georgetown, Florida Ave., and 11th St. NE & SE 2. Old Town Alexandria 3. The Rosslyn/Court House area of Arlington Co. 4. Pentagon City area of Arlington Co. 5. Downtown Bethesda, Maryland 6. Center of Tysons Corner, Virginia
2	Medium/high mixed density	1. Most DC outside the downtown core 2. Most Arlington Co., south of Lee Highway 3. Most Alexandria 4. Areas of Tysons Corner just beyond the center 5. Annapolis, Maryland 6. Downtown Frederick, Maryland 7. Parts of Reston and Herndon, Virginia, along the Dulles Access/Toll Road
3	Medium employment density	1. Parts of upper NW DC near Rock Creek Park 2. Parts of Arlington along Lee Highway 3. National Airport 4. The Pentagon 5. Arlington Cemetery 6. BWI Airport 7. Potomac Mills mall in Woodbridge, Virginia
4	Medium population density	1. Parts of upper NW DC near Rock Creek Park 2. Parts of north Arlington 3. SE DC near the Capitol Heights Metrorail station 4. Chevy Chase, Maryland, near the DC border
5	Low density	1. Area along McArthur Boulevard in DC 2. Upper north Arlington Co. 3. Fort Hunt section of Fairfax Co. 4. Dulles Airport 5. Andrews Air Force Base
6	Rural	1. Great Falls, Virginia 2. Much of Loudoun Co., Virginia 3. Most of Fauquier Co., Virginia 4. Much of Charles, St. Mary's, and Calvert Counties, Maryland 5. Most of Frederick and Carroll Co., Maryland

Note that the Pentagon and Arlington Cemetery are categorized as area type 3 ("medium employment density"). This is due to the use of the one-mile floating density. Some could argue that Arlington Cemetery should be categorized as "rural" (area type 6) and that the Pentagon should be categorized as area type 2 ("medium/high mixed density"). A user of the travel model can, if they so choose, override the calculated area-type values by using an override feature in the model. A map of the six area types can be found in Figure 3-7.

Figure 3-7 Map of the six area types



3.2.5 Toll Parameter File

The modeled area includes several currently existing toll facilities: the Dulles Toll Road, the Dulles Greenway, the Beltway HOT lanes in Virginia, I-95/I-395 (from VA 610 at Garrisonville to Turkeycock Run), I-66 inside the Beltway, the Intercounty Connector (ICC), and the Governor Nice Bridge. Beyond these, Visualize 2045 includes the expansion of the I-95/I-395 HOT lanes to VA 17 (Warrenton Rd- exit 133) to the south, and to the vicinity of Eads Street to the north. It also includes the development of HOT lanes on I-66 outside the Beltway in Virginia, and Electronic Toll Lanes (ETLs) on the entire Beltway in Maryland and on I-270 from the Beltway to Frederick,[19] as shown in Figure 3-8.

[19] Jane Posey to Files, "Visualize 2045 Toll Rates," Memorandum, January 10, 2019

The Washington, D.C. region includes several tolled highway facilities that vary substantially in tolling policy. On some facilities, such as the Dulles Toll Road, the Intercounty Connector (ICC), and the Governor Nice Bridge, toll values are fixed and are not a function of the time of day or day of the week. On other facilities, toll rates can vary throughout the day, either set in advance, with "fixed" tolls that vary by specific times of the day, or set dynamically, as a function of real-time congestion levels. The ICC, between Prince George's County and Montgomery County, is an example of a facility where fixed toll rates vary by hour of the day, according to a schedule that has been set in advance. The high-occupancy/toll (HOT) lanes on I-495, known as the I-495 Express Lanes, are an example of a toll facility where the toll rates are set dynamically, as a function of congestion levels. TPB staff reviews the tolling policy of private and publicly operated facilities each year and strives to produce reasonably representative toll values for each time-of-day period.[20]

There are two cost-related variables in the link.dbf file that allow the user to flexibly specify tolls in the network: the *TOLL* and *TOLLGRP* variables. The **TOLL** variable is a monetary value of the fee charged to traverse the link. The network database contains tolls for each year, up to the current year. This allows the user to produce a year-2019 network, for instance, that would contain the tolls as they were in 2019. For forecast years, the network contains the current year's tolls in current-year cents. **TOLLGRP** is a variable that is used to identify tolling locations in the network. A TOLLGRP code of 1 identifies existing facilities where fixed-rate tolls are collected at specific locations. The Dulles Toll Road (VA 267) is an example of this. A TOLLGRP code of 2 identifies links on the ICC. A TOLLGRP code of 3 or greater identifies links on a variably priced facility, such as the I-495 Express Lanes. The TOLLGRP rates are specified in the toll parameter/escalation file (TOLL_ESC.dbf). Table 3-9 lists the specific variables in the file.

[20] See, for example, Jane Posey to Files, "Visualize 2045 Toll Rates," Memorandum, January 10, 2019.

Figure 3-8 Existing and the Visualize 2045 Plan Managed-lane facilities in the regional highway networks

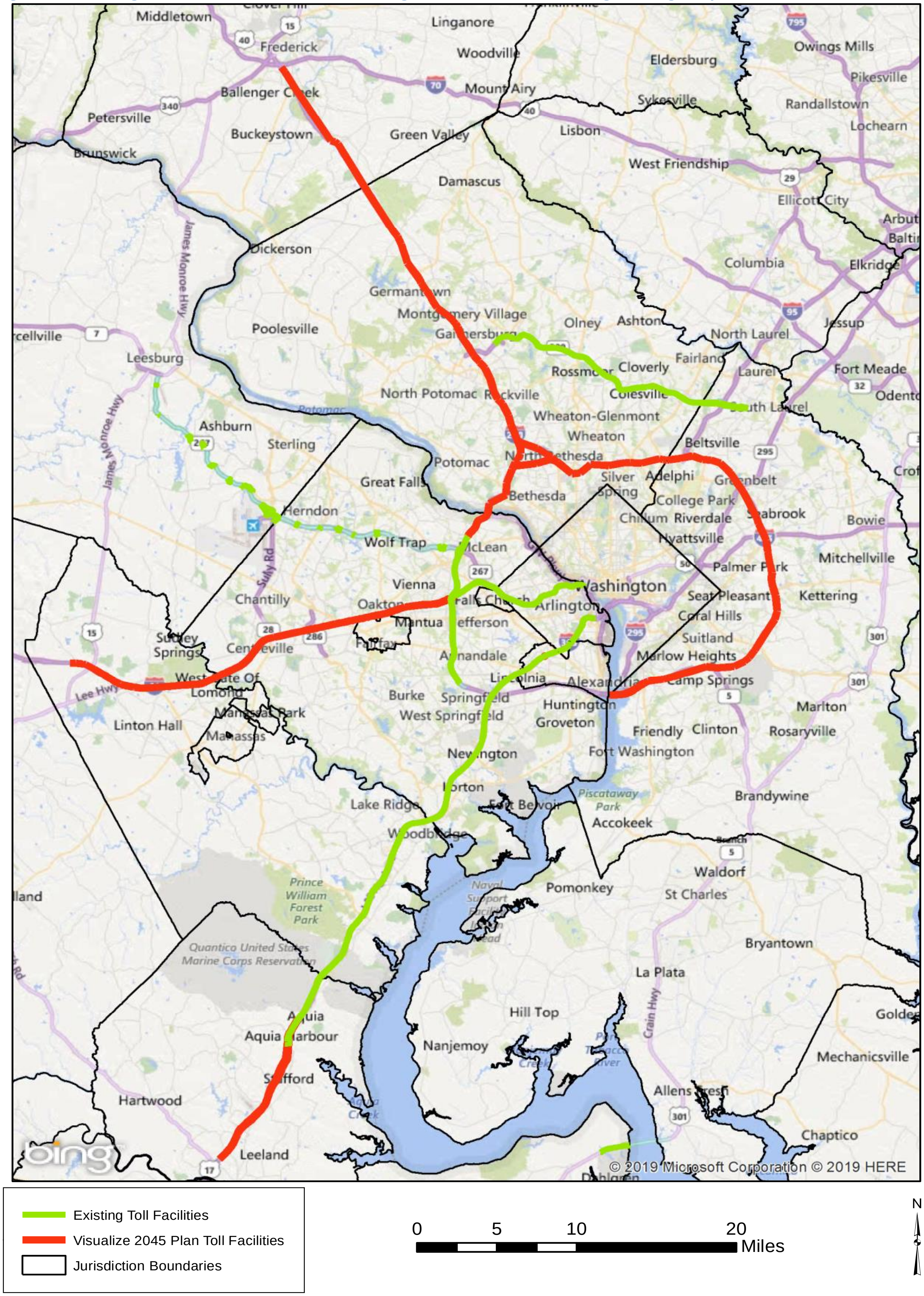


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Table 3-9 Toll parameter file (Toll_esc.dbf)

Variable Name	Description
Tollgrp	Toll group code, 1=existing fixed-toll facility, 2=ICC, 3+= VA/MD HOT or other toll lane
Escfac	Deflation factor override
Dstfac	Distance (per mile)-based toll factor in current-year cents/dollar (optional)
AM_Tftr	AM period Toll factor (no units)
PM_Tftr	PM period toll factor (no units)
OP_Tftr	Off-peak period toll factor (no units)
AT_MIn	Area Type minimum override (optional)
AT_Max	Area Type maximum override (optional)
TollType	*Toll Type (1 = operating in calibration year, 2 = operating after calibration year)*

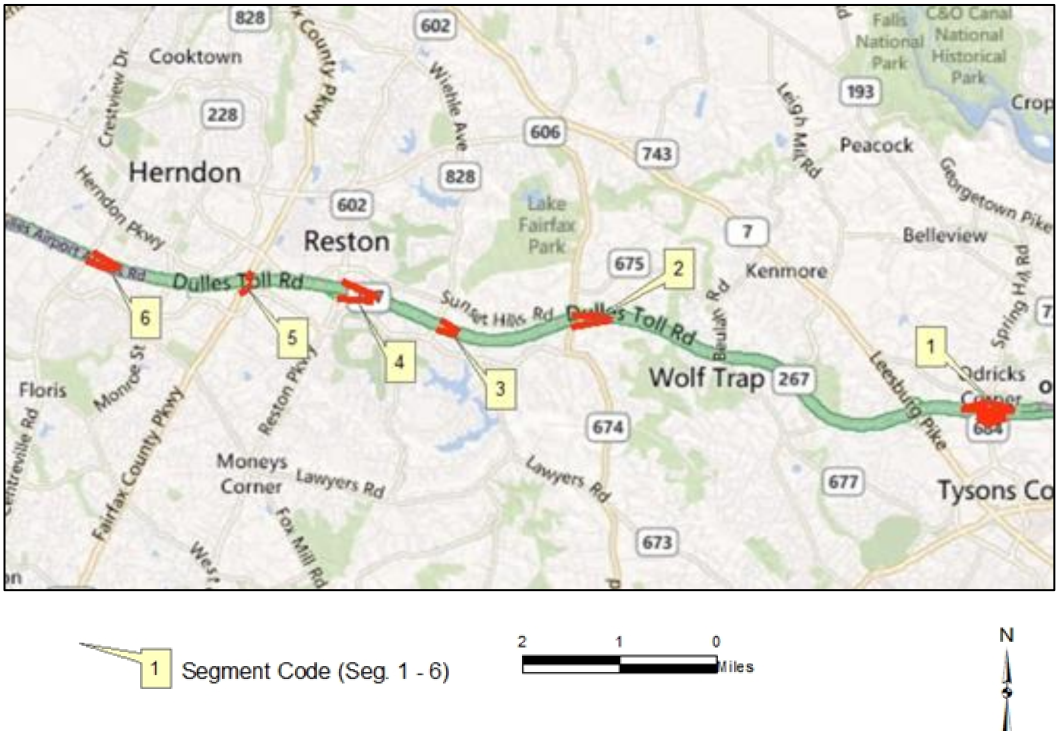
Ref: "I:\ateam\docum\fy19\V2.3.75_Visualize2045NetworkReport\Report Tables \Lst_of NW_Fare_Files.xlsx"

The file contains a base distance-based toll factor (DSTFAC), in cents/mile, and time-period-specific variables (e.g., AM_TFTR and PM_TFTR) that allow one to transform distance-based factors to time-period-specific toll rates. Except for the case where TOLLGRP = 1, the TOLL and TOLLGRP factors should not be invoked together. If the TOLL value of a given link is non-zero and the TOLLGRP value equals zero, the highway network building process automatically imposes a TOLLGRP override value of "1". TOLLGRP codes that are used should therefore be greater than "1."

The highway building process ultimately creates six period-specific toll attributes: AMTOLL, PMTOLL, OPTOLL (tolls by time-of-day on all toll facilities) and AMTOLL_VP, PMTOLL_VP, OPTOLL_VP (tolls by time-of-day on variable priced facilities only).

Figure 3-9 shows tolling locations on the Dulles Toll Road.

Figure 3-9 Dulles Toll Road: Toll facilities locations



The Visualize 2045 plan forecast-year networks reflect year-2018 toll values, as shown in Table 3-10. Note that in this table, the nominal toll rate is fixed at the year-2018 value through 2045, which implies that real tolls (prices) are dropping from 2018 to 2045. In the model, all prices are converted to a common year (2007, the calibration year) and then grown to the modeled year being analyzed. Thus, a year-2018 toll would first be brought to year-2007 prices, then would be grown to the appropriate year being modeled (e.g., 2030). This deflation step is done using the CPI data in CPI_File.txt. As can be seen in Figure 3-1 on p. 26, the deflation year goes only to 2017. That is because, when the CPI file was being developed, data for the entirety of 2018 was not yet available. Thus, when year-2018 tolls are deflated, they are deflated using the year-2017 deflation value (0.8459). In the future, one could consider using a current-year CPI value (in this example, 2018) that relies on only a subset of the year (since the CPI file is generally developed in the middle of the “current year.” So, in conclusion, as currently implemented, both a year-2018 toll and a year-2018 toll of $1.00 would be deflated to a year-2007 toll of $0.85.

Table 3-10 Dulles Toll Road (VA 267): Toll links

Segment	A	B	Location	Direction	Toll Values (in 2018 cents) 2018
1	35130	35133	Main Toll Plaza-Rt 684 Interchange (LOV)	Inbound	250
	35136	35129	Main Toll Plaza-Rt 684 Interchange (LOV)	Outbound	250
	35430	36657	Greensboro Dr at Tyco Rd	Inbound	100
	36657	35129	Greensboro Dr at Tyco Rd	Outbound	100
	35130	35132	Spring Hill Road- Off Ramp	Inbound	100
	35132	35133	Spring Hill Road- On Ramp	Inbound	100
	35136	35131	Spring Hill Road- Off Ramp	Outbound	100
	35131	35129	Spring Hill Road- On Ramp	Outbound	100
2	35097	35096	Rt 674 (Hunter Mill Road) - On Ramp	Inbound	100
	35194	35095	Rt 674 (Hunter Mill Road) - Off Ramp	Outbound	100
3	35101	35100	Rt 828 (Wiehle Avenue)- On Ramp	Inbound	100
	35196	35099	Rt 828 (Wiehle Avenue)- Off Ramp	Outbound	100
4	35105	35104	Rt 602 (Reston Pkwy)-On Ramp	Inbound	100
	35198	35103	Rt 602 (Reston Pkwy)-Off Ramp	Outbound	100
5	35287	35291	Rt 7100 (Fairfax Co. Pkwy)- On Ramp	Inbound	100
	35289	35286	Rt 7100 (Fairfax Co. Pkwy)- Off Ramp	Outbound	100
6	35109	35108	Rt 228 (Centreville Road) -On Ramp	Inbound	100
	35200	35107	Rt 228 (Centreville Road) -Off Ramp	Outbound	100

Note: Toll rates effective January 1, 2014. Year 2018 toll values are used for all forecast years.

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The 14-mile Dulles Greenway connects to the Dulles Toll Road at Route 28 (at Dulles International Airport), and extends west to Route 15 at Leesburg, as shown in Figure 3-10 and Figure 3-11. Dulles Greenway tolls (shown in Table 3-11, for segments 1-4, and, Table 3-12, for segments 5-8) are coded in highway networks **based on a weighted average of the cash rates, E-ZPass rates, and congestion-management tolling**. Survey data indicate that the E-ZPass markets account for roughly three-fourths of users and that about half the travel occurs during the times when the congestion-management tolls are in effect. The main toll facility is represented west of the Route 28 (Sully Road) interchange with a weighted toll of $6.15 in 2018 and beyond. A weighted toll of $5.15 in 2018 and beyond is used for all westbound and eastbound on-ramps at Routes 28, 606, and 607. A weighted toll of $4.35 in 2018 and beyond is coded for all westbound and eastbound on-ramps at Routes 772, Claiborne Parkway, and Belmont Ridge Road. A weighted toll of $3.40 in 2018 and beyond is coded for all on-ramps at Route 653. No toll is charged at the future Battlefield Parkway interchange.

Figure 3-10 Dulles Greenway: Toll facilities locations (Map 1 of 2)

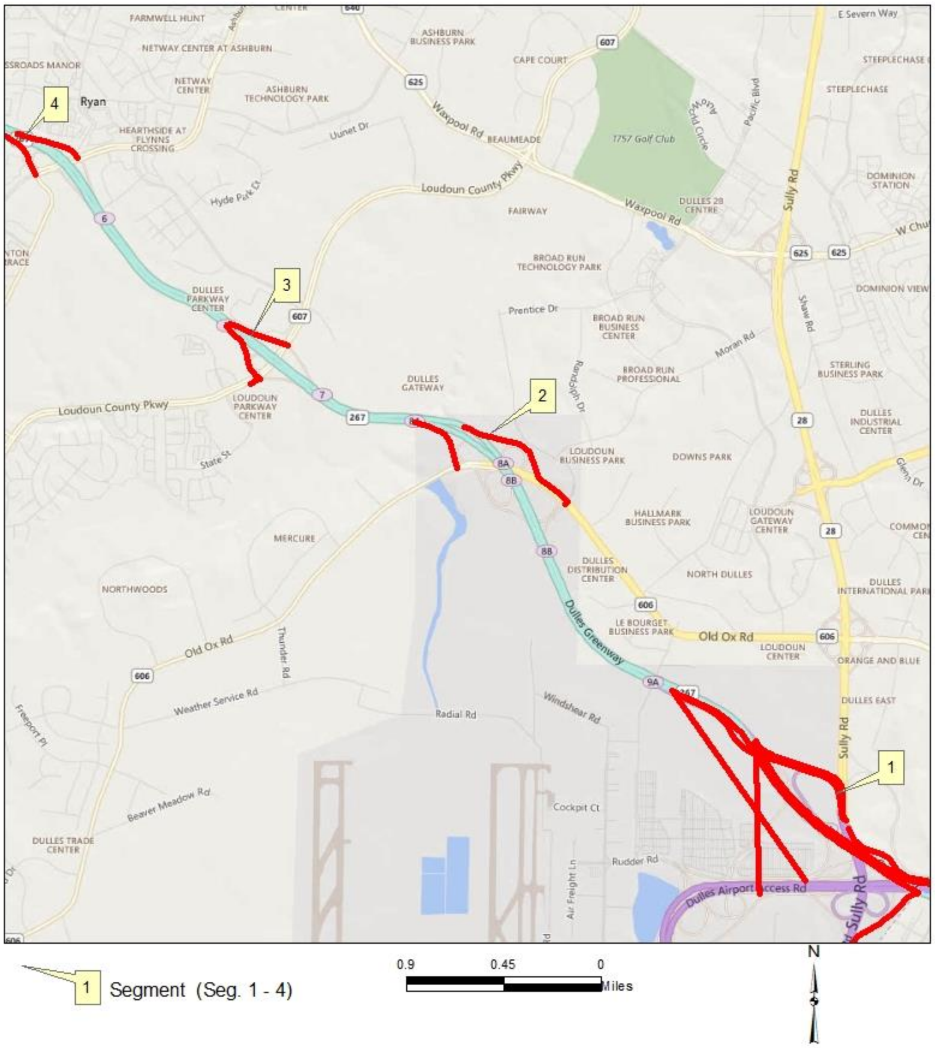

Table 3-11 Dulles Greenway Toll inks (Segments 1-4)

					Toll Values (in 2018 cents)
Seg	**Anode**	**Bnode**	**Location**	**Direction**	**2018**
1	38046	38098	Rt. 28	Outbound	615
	38266	34810	Rt. 28	Inbound	615
	38025	34810	Rt. 28 Toll Plaza on- Ramp	Inbound	100
	38046	38018	Rt. 28 Toll Plaza off- Ramp	Outbound	100
	38064	38098	Rt. 28 to Dulles Greenway on-Ramp	Outbound	515
	38266	38064	Dulles Greenway to Rt. 28 off-Ramp	Inbound	515
	38043	38098	Airport Access road to Dulles Greenway on- Ramp	Outbound	515
	38266	38047	Dulles Greenway to Airport Access road off Ramp	Inbound	515
2	38029	38271	Rt 606 (Old Ox Road) on-Ramp	Outbound	515
	38272	38273	Rt 606 (Old Ox Road) off-Ramp	Inbound	515
3	38100	38276	Rt 607 (Loudoun Co. Pkwy) on-Ramp	Outbound	515
	38277	38278	Rt 607 (Loudoun Co. Pkwy) off-Ramp	Inbound	515
4	38065	38281	Rt 772 (Old Ryan Rd) on-Ramp	Outbound	435
	38282	38283	Rt 772 (Old Ryan Rd) off-Ramp	Inbound	435

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Figure 3-11 Dulles Greenway: Toll facilities locations (Map 2 of 2)

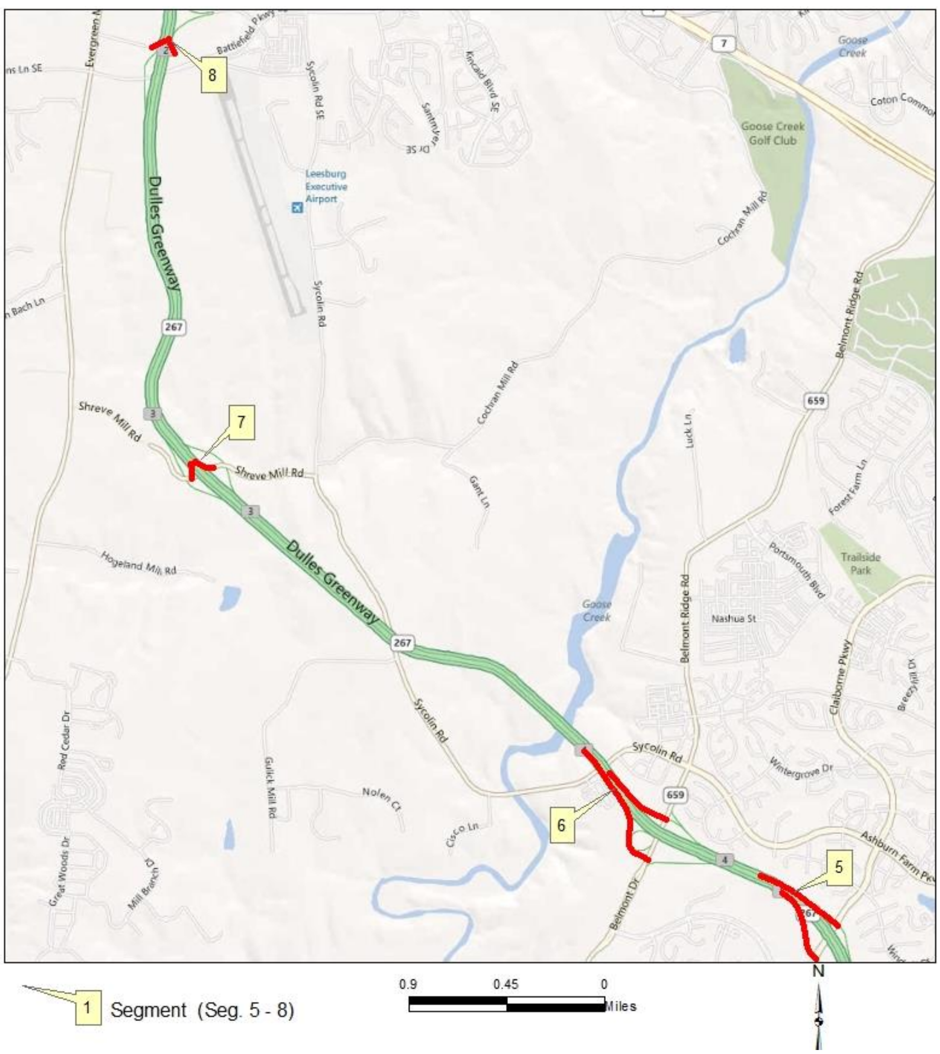

Table 3-12 Dulles Greenway Toll inks (Segments 5-8)

					Toll Values (in 2018 cents)
Seg	**Anode**	**Bnode**	**Location**	**Direction**	**2018**
5	38069	38289	Claiborn Pkwy on-Ramp	Outbound	435
	38290	38291	Claiborn Pkwy off-Ramp	Inbound	435
6	38070	38294	Belmont Ridge Road on-Ramp	Outbound	435
	38295	38296	Belmont Ridge Road off-Ramp	Inbound	435
7	38071	38299	Shreve Mill Road on-Ramp	Outbound	340
	38300	38301	Shreve Mill Road off-Ramp	Inbound	340
8	38072	38304	Battlefield Pkwy on-Ramp	Outbound	na
	38305	38306	Battlefield Pkwy off-Ramp	Inbound	na

Note: Toll rates effective March 2018. Year 2018 toll values are used for all forecast years.

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Table 3-13 shows that a weighted (E-ZPass vs. cash) toll of $2.41 is coded on the Harry W. Nice Bridge, in both directions, on the forecast-year network links.

Table 3-13 Harry W. Nice Bridge toll links

				Toll Values (in 2018 cents)
A	**B**	**Location**	**Direction**	**2018**
50002	50001	Virginia - Maryland	Inbound	241
50001	50002	Maryland - Virginia	Outbound	241

Note: Toll rates effective July 1, 2015. Year 2018 toll values are used for all forecast years.

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Starting in 2012, the Intercounty Connector (ICC) in Maryland was included in all networks representing the year 2012 and beyond. The toll rates used in the Visualize 2045 plan for the ICC are effective as of July 2015.[21] HOT lane operations on I-95/I-395 between Turkeycock Run in Fairfax County and VA 610 (Garrisonville Road) in Stafford County are included in all networks representing 2015 and beyond. The Visualize 2045 plan includes the expansion of the I-95/I-395 HOT lanes to VA 17 (Warrenton Rd- exit 133) to the south in all networks representing 2025 and beyond. The I-395 HOV lanes from Turkeycock Run to Eads Street convert to HOT in 2019. HOV/HOT lanes on I-95 between VA 610 and VA 17 in Spotsylvania County are in all networks representing 2025 and beyond. On I-495 (Capital Beltway) in Virginia HOT lane operations are included as follows:

- Beginning in 2013: From Hemming Avenue to south of Old Dominion Drive;
- Beginning in 2025: From south of Old Dominion Drive to the George Washington Parkway;

[21] Jane Posey to Files, "Visualize 2045 Toll Rates," Memorandum, January 10, 2019

- Beginning in 2025: From the George Washington Parkway to the American Legion Bridge.

The HOV lanes on I-66 inside the Beltway converted to HOT lanes in 2017. HOT lanes on I-66 outside the Beltway to University Boulevard are included in all networks starting in 2021, and from University Boulevard to 1.2 miles west of US 15 in 2040.

As discussed earlier in this chapter, in the COG/TPB highway networks, the toll group variable (TOLLGRP) indicates the type of tolling on the facility. TOLLGRP code 1 is assigned for existing fixed-rate tolled facilities (Dulles Toll Road, Dulles Greenway, and the Harry W. Nice Bridge). The ICC in Maryland is modeled as TOLLGRP code 2 with fixed toll values of 22 cents/mile during peak periods and 17 cents/mile during off-peak periods (in 2018 cents). For all other tolled facilities, the TOLLGRP code varies and is used to develop variably priced tolls.

For the variably-priced ETL and HOT-lane facilities, the links in each segment of I-270, the Beltway in Maryland and Virginia, I-95/I-395, and I-66 are coded with a unique TOLLGRP variable. The network link toll value (TOLL) is left blank and the toll facility type variable (TOLLGRP) is used to access lookup tables of fixed fees and per-mile rates. The tolls vary based on the level of congestion. Table 3-14 shows years 2019 and 2021 end-to-end tolls and average toll rates by time of day, and by direction in 2017 dollars. This summary process was developed by Feng Xie and documented by Sanghyeon Ko.[22]

Table 3-14 Toll Summaries: Year 2019 and 2021 (Visualize 2045 plan)

HOT lane Facilities	Distance	2019						2021					
		AM		PM		MD		AM		PM		MD	
	in miles	Toll	Rate	Toll	Rate	Toll	Rate	Toll	Rate	Toll	Rate	Toll	Rate
Beltway													
Old Dominion Dr to Springfield	10.22	2.04	0.20	2.70	0.26	1.53	0.15	2.04	0.20	3.61	0.35	1.53	0.15
Springfield to Old Dominion Dr	10.28	3.01	0.29	2.17	0.21	1.54	0.15	3.22	0.31	2.40	0.23	1.54	0.15
I-95													
Southern limit of I-95 to Edsall Rd.	28.35	20.27	0.71	N/A	N/A	4.25	0.15	20.89	0.74	N/A	N/A	4.25	0.15
Edsall Rd. to Southern limit of I-95	28.72	N/A	N/A	10.47	0.36	4.31	0.15	N/A	N/A	10.77	0.38	4.31	0.15
I-66 Inside the Beltway (for 2017 and Beyond)													
Roosevelt Bridge to Capital Beltway	9.08	N/A	N/A	8.42	0.93	N/A	N/A	N/A	N/A	7.62	0.84	N/A	N/A
Capital Beltway to Roosevelt Bridge	9.33	7.96	0.85	N/A	N/A	N/A	N/A	6.23	0.67	N/A	N/A	N/A	N/A
I-66 Outside the Beltway (for 2025 and Beyond)													
Capital Beltway to West Terminus	21.62	N/A						4.32	0.20	7.83	0.36	3.24	0.15
West Terminus to Capital Beltway	21.91							14.87	0.68	4.19	0.19	3.14	0.14

Note: All tolls are expressed in 2018 dollars and toll rates are measured in dollar per mile.

Ref: "I:\ateam\docum\fy19\V2.3.75_Visualize2045NetworkReport\Report Tables\ Toll_Suimmaries_V2.3.75.xlsx"

[22] Sanghyeon Ko to Mark S. Moran, Feng Xie, and Anant Choudhary, "Cheat Sheet for Developing Toll Summary Tables Using Cube," Memorandum, January 11, 2019.

Starting in the year 2017, I-66 inside the Capital Beltway (from US Rt. 29 in Rosslyn to I-495) was converted from an HOV facility to a HOT-lane facility. Vehicles traveling in the peak period and peak direction with two or more occupants can use the facility for free, but others must pay a toll. When I-66 HOT lanes outside the Beltway open, the occupancy requirement inside the Beltway will increase from two to three or more to avoid the toll. In 2040, VDOT plans to make I-66 inside the Beltway HOV3+ in both directions in the peak periods.

Starting in the year 2021, I-66 outside the Capital Beltway (from I-495 to west of US Rt. 15 in Prince William County, 25 miles) will be converted to 3 general-purpose lanes (plus auxiliary lanes in some segments) and 2 HOT lanes in each direction, with tolling 24/7.

Table 3-15 shows toll information for years 2025 and 2030.

Table 3-15 Toll Summaries: Year 2025 and 2030 (Visualize 2045 plan)

		2025						2030					
HOT lane Facilities	Distance	AM		PM		MD		AM		PM		MD	
	in miles	Toll	Rate	Toll	Rate	Toll	Rate	Toll	Rate	Toll	Rate	Toll	Rate
Beltway (VA)													
American Legion Bridge to Springfield	12.31	3.23	0.26	5.64	0.46	1.85	0.15	2.90	0.24	5.78	0.47	1.85	0.15
Springfield to American Legion Bridge	12.36	4.38	0.35	3.10	0.25	1.85	0.15	5.73	0.46	3.55	0.29	1.85	0.15
I-95													
Southern limit of I-95 to 14th St. Bridge	44.64	34.79	0.78	N/A	N/A	6.70	0.15	46.81	1.05	N/A	N/A	6.70	0.15
14th St. Bridge to Southern limit of I-95	45.32	N/A	N/A	21.15	0.47	6.80	0.15	N/A	N/A	29.14	N/A	6.80	N/A
I-66 Inside the Beltway (for 2017 and Beyond)													
Roosevelt Bridge to Capital Beltway	9.08	N/A	N/A	7.45	0.82	N/A	N/A	N/A	N/A	7.50	N/A	N/A	N/A
Capital Beltway to Roosevelt Bridge	9.33	6.63	0.71	N/A	N/A	N/A	N/A	6.99	0.75	N/A	N/A	N/A	N/A
I-66 Outside the Beltway (for 2025 and Beyond)													
Capital Beltway to West Terminus	21.62	4.32	0.20	8.98	0.42	3.24	0.15	4.32	0.20	10.41	0.48	3.24	0.15
West Terminus to Capital Beltway	21.37	17.78	0.83	4.27	0.20	3.21	0.15	21.74	1.02	4.27	0.20	3.21	0.15
Beltway (MD - ETL)													
American Legion to Woodrow Wilson Bridge	41.52	8.30	0.20	12.60	0.30	6.23	0.15	8.30	0.20	14.47	0.35	6.23	0.15
Woodrow Wilson to American Legion Bridge	41.65	15.70	0.38	8.96	0.22	6.25	0.15	17.49	0.42	9.50	0.23	6.25	0.15
I-270 (MD - ETL)													
Frederick to Spur (VA side)	31.33	38.39	1.23	6.27	0.20	4.70	0.15	46.89	1.50	6.27	0.20	4.70	0.15
Frederick to Spur (MD side)	32.37	37.92	1.17	6.47	0.20	4.85	0.15	46.21	1.43	6.47	0.20	4.85	0.15
Spur (VA side) to Frederick	30.91	6.18	0.20	20.94	0.68	4.64	0.15	6.18	0.20	25.73	0.83	4.64	0.15
Spur (MD side) to Frederick	31.90	6.38	0.20	20.38	0.64	4.78	0.15	6.38	0.20	25.18	0.79	4.78	0.15

Note: All tolls are expressed in 2018 dollars and toll rates are measured in dollar per mile.

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Table 3-16 shows toll information for years 2040 and 2045

Table 3-16 Toll Summaries: Year 2040 and 2045 (Visualize 2045 plan)

		2040						2045					
	Distance	AM		PM		MD		AM		PM		MD	
	in miles	Toll	Rate	Toll	Rate	Toll	Rate	Toll	Rate	Toll	Rate	Toll	Rate
Beltway (VA)													
American Legion Bridge to Springfield	12.31	4.29	0.35	7.03	0.57	1.85	0.15	5.22	0.42	7.98	0.65	1.85	0.15
Springfield to American Legion Bridge	12.36	7.67	0.62	4.42	0.36	1.85	0.15	9.05	0.73	4.84	0.39	1.85	0.15
I-95 & I-395													
Southern limit of I-95 to 14th St. Bridge	44.64	60.97	1.37	N/A	N/A	6.70	0.15	67.24	1.51	N/A	N/A	6.70	0.15
14th St. Bridge to Southern limit of I-95	45.32	N/A	N/A	40.99	0.90	6.80	0.15	N/A	N/A	47.09	1.04	6.80	0.15
I-66 Inside the Beltway (for 2017 and Beyond)													
Roosevelt Bridge to Capital Beltway	9.08	1.82	0.20	7.63	0.84	N/A	N/A	1.82	0.20	8.31	0.92	N/A	N/A
Capital Beltway to Roosevelt Bridge	9.33	9.01	0.97	1.87	0.20	N/A	N/A	9.99	1.07	1.95	0.21	N/A	N/A
I-66 Outside the Beltway (for 2025 and Beyond)													
Capital Beltway to West Terminus	26.23	5.25	0.20	15.77	0.60	3.93	0.15	5.25	0.20	17.51	0.67	3.93	0.15
West Terminus to Capital Beltway	25.98	24.90	0.96	5.20	0.20	3.90	0.15	26.44	1.02	5.20	0.20	3.90	0.15
Beltway (MD - ETL)													
American Legion to Woodrow Wilson Bridge	41.52	8.30	0.20	17.80	0.43	6.23	0.15	8.30	0.20	20.44	0.49	6.23	0.15
Woodrow Wilson to American Legion Bridge	41.65	20.80	0.50	11.18	0.27	6.25	0.15	22.36	0.54	10.83	0.26	6.25	0.15
I-270 (MD - ETL)													
Frederick to Spur (VA side)	31.33	59.59	1.90	6.27	0.20	4.70	0.15	64.67	2.06	6.27	0.20	4.70	0.15
Frederick to Spur (MD side)	32.37	58.60	1.81	6.47	0.20	4.85	0.15	63.68	1.97	6.47	0.20	4.85	0.15
Spur (VA side) to Frederick	30.91	6.18	0.20	34.46	1.11	4.64	0.15	6.18	0.20	38.51	1.25	4.64	0.15
Spur (MD side) to Frederick	31.90	6.38	0.20	33.90	1.06	4.78	0.15	6.38	0.20	38.06	1.19	4.78	0.15
Note: All tolls are expressed in 2018 dollars and toll rates are measured in dollar per mile.													

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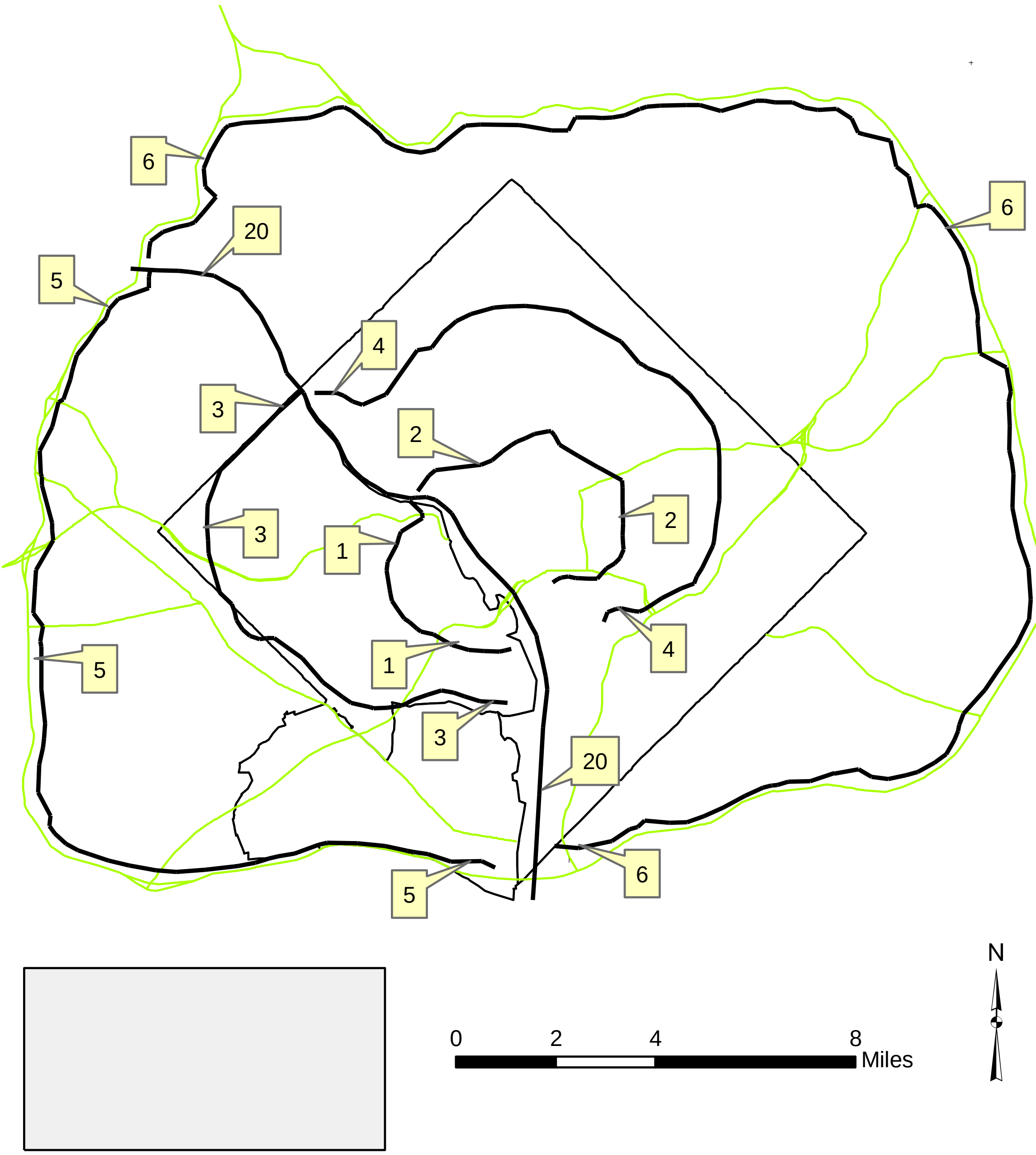
Note about coding the number of lanes on HOV and HOT-lane facilities: On some roads, such as HOV and HOT-lane facilities, the number of lanes available for use varies by the time of day. Unfortunately, there is a mismatch between the four time-of-day periods used in the traffic assignment and the times of day when operational changes occur to these facilities. Thus, when TPB staff is coding such facilities, it is necessary to make simplifying assumptions. Thus, for years or segments where the facility is 2 lanes, TPB staff codes 1 lane northbound and 1 lane southbound during the off-peak periods to best replicate the capacity of the facility. Similarly, for model years or segments where the facility is 3 lanes, TPB staff codes 2 lanes northbound and 2 lanes southbound. Although this is not precise, it is a compromise that must be made, and should be reasonable for regional modeling purposes, due to the mismatch between the four time-of-day periods used in the traffic assignment and the times of day when operational changes occur to these facilities.

3.2.6 Highway Network Screenlines

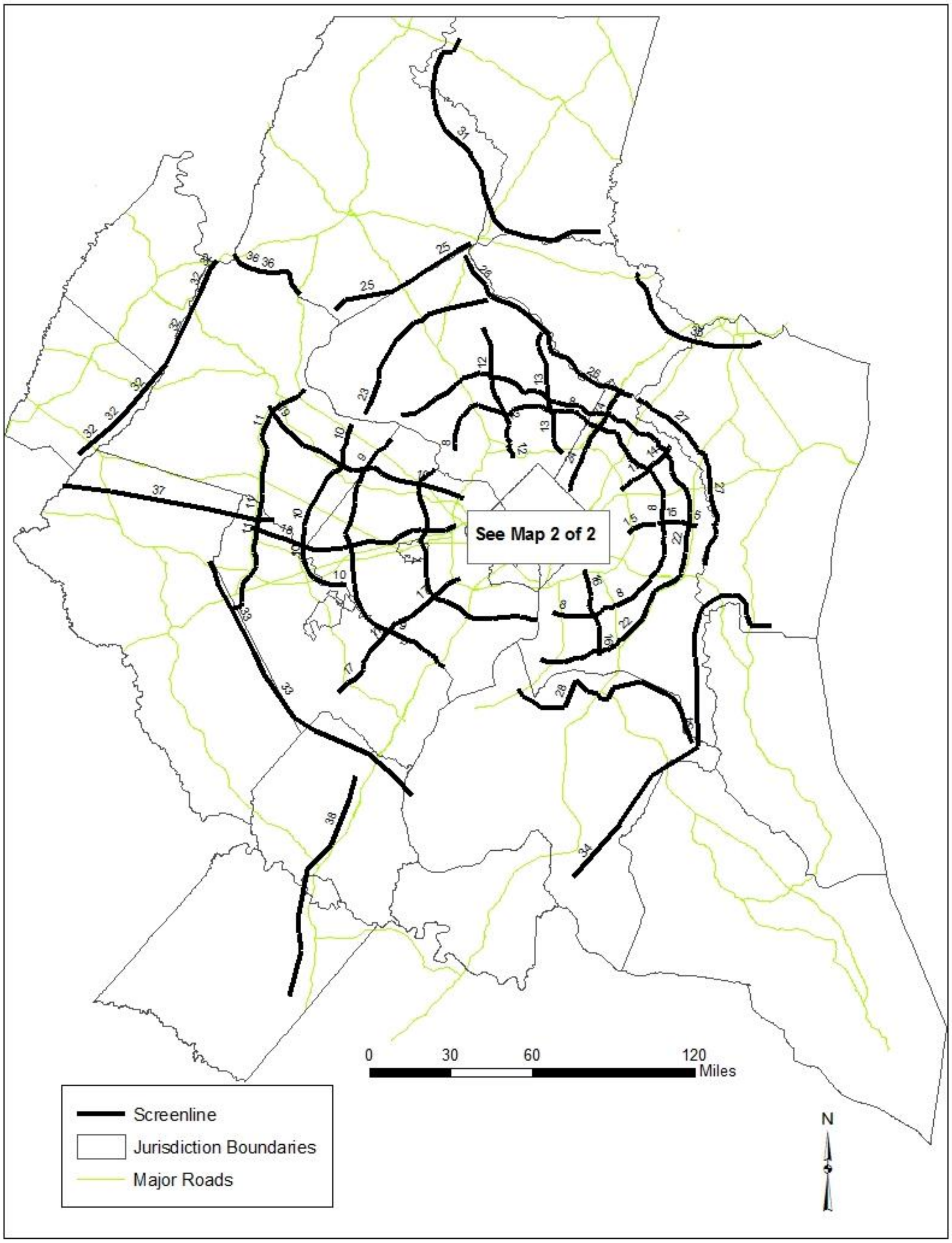
The network includes an attribute (SCREEN) that identifies 36 screenlines/cutlines, which are used for model summary or validation purposes.[23] The screenline locations are shown in Figure 3-12 and Figure 3-13.

Figure 3-12 Highway Network screenlines: Inside the Beltway



[23] The screen variable includes codes from 1 to 38, but the numbers 21 and 30 are unused

Figure 3-13 Highway network screenlines: Outside the Beltway



Ref.: I:\ateam\docum\fy14\2013LRTP_Network_Report\2013LRTP_NW_Rept_Tables\ Updated_Screenline_Map.jpg

3.2.7 Visualize 2045 plan Highway Statistics

A summary of directional lane miles for the AM peak period is shown in Table 3-17.[24] In the 2019 highway network, there were over 23,000 AM lane miles. By 2045, this number is predicted to increase by almost 1,600, which is 7%, regionally. Prince George's Co. and Fairfax Co. are predicted to have the largest increase in AM lane miles from 2019 to 2045 – 400 and 310 miles, respectively – though this is not surprising since these counties are the largest jurisdictions in the region, in terms of lane miles. The District of Columbia is the only jurisdiction that is predicted to have decline in the AM lane miles from 2019 to 2045, but the decrease is very small (much less than 1 percent).

[24] Computation of AM lane miles **excludes** TAZ centroid connectors (FTYPE=0) and transit-only links (AMLIMIT=9) in the highway network.

Table 3-17 AM lane-miles for the Visualize 2045 highway networks

Jurisdiction Code	Jurisdiction	2019	2021	2025	2030	2040	2045	Diff 2045-2019	Ratio 2045/2019
0	District of Columbia	1,390	1,392	1,387	1,387	1,387	1,387	-3	1.00
1	Montgomery Co., Md.	2,661	2,673	2,891	2,886	2,896	2,906	245	1.09
2	Prince Georges Co., Md.	3,017	3,156	3,355	3,364	3,372	3,417	400	1.13
3	Arlington Co., Va.	517	521	521	521	522	522	5	1.01
4	City of Alexandria, Va.	329	329	330	330	330	330	1	1.00
5	Fairfax Co., Va.	3,315	3,377	3,523	3,562	3,625	3,625	310	1.09
6	Loudoun Co., Va.	1,695	1,715	1,777	1,784	1,815	1,815	120	1.07
7	Prince William Co., Va.	1,498	1,502	1,534	1,546	1,649	1,650	152	1.10
9	Frederick Co., Md.	1,668	1,681	1,714	1,724	1,737	1,743	75	1.04
10	Howard Co., Md.	967	989	999	1,006	1,006	1,006	40	1.04
11	Anne Arundel Co., Md.	1,369	1,371	1,387	1,398	1,411	1,411	42	1.03
12	Charles Co., Md.	853	853	859	859	859	896	44	1.05
14	Carroll Co., Md.	576	576	607	607	624	624	48	1.08
15	Calvert Co., Md	367	367	367	367	377	377	9	1.03
16	St. Mary's Co., Md.	455	455	455	455	461	461	6	1.01
17	King George Co., Va.	254	254	254	254	254	254	0	1.00
18	City of Fredericksburg, Va.	79	83	83	96	96	97	17	1.22
19	Stafford Co., Va.	587	595	616	622	626	632	45	1.08
20	Spotsylvania Co., Va.	443	443	449	455	459	462	19	1.04
21	Fauquier Co., Va.	795	795	795	795	795	795	0	1.00
22	Clark Co., Va.	161	161	161	161	161	161	0	1.00
23	Jefferson Co., WVa.	278	278	278	278	278	278	0	1.00
		23,271	**23,564**	**24,342**	**24,456**	**24,739**	**24,848**	**1,577**	**1.07**

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Note: TAZ connectors (FTYPE=0) and transit-only links (AMLIMIT=9) are **excluded.**

3.3 Transit Network Files

The transit network consists of transportation infrastructure, represented via nodes and links, plus the transit service that runs over that infrastructure. The transportation infrastructure includes the highway network, which is used by buses, and transit-only infrastructure, such as transit stations and rail links. The input files used to construct the transit networks are listed in Table 3-18.

Table 3-18 Listing of transit network input files

Filename	Description	Type	Source
Station.dbf	Station file: Metrorail, Comm.Rail, LRT stations/PNR lots & bus PNR lots	DBF	Geodatabase
AreaWalk.txt	Used to calculate zonal percent walk to transit values	Text	Travel Model-generated
met_node.tb	Metrorail stations	Text	Geodatabase
com_node.tb	Commuter rail stations	Text	Geodatabase
lrt_node.tb	LRT stations/stops	Text	Geodatabase
new_node.tb	BRT/streetcar stations/stops	Text	Geodatabase
met_pnrn.tb	Metrorail PNR lots	Text	Geodatabase
com_pnrn.tb	Commuter rail PNR lots	Text	Geodatabase
bus_pnrn.tb	Bus PNR lots	Text	Geodatabase
lrt_pnrn.tb	LRT PNR lots	Text	Geodatabase
new_pnrn.tb	BRT/streetcar PNR lots	Text	Geodatabase
met_link.tb	Metrorail links	Text	Geodatabase
com_link.tb	Commuter rail links	Text	Geodatabase
lrt_link.tb	LRT links	Text	Geodatabase
new_link.tb	BRT/streetcar links	Text	Geodatabase
met_bus.tb	Transfer link (walk) between Metrorail station and bus stop	Text	Geodatabase
com_bus.tb	Transfer link (walk) between commuter rail station and bus & LRT stop	Text	Geodatabase
lrt_bus.tb	Transfer link (walk) between LRT station and bus stop	Text	Geodatabase
new_bus.tb	Transfer link (walk) between BRT/streetcar stop and bus stop	Text	Geodatabase
MODE1AM…,MODE10AM.tb	AM transit line files	Text	Geodatabase
MODE1OP…,MODE10OP.tb	Off-peak transit line files	Text	Geodatabase

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The input files are intended to serve as extensions to the highway network, which provides the infrastructure for bus and rail service. The table indicates that all the transit link, node and line/route elements, and station file are produced directly from the geodatabase, with one exception: the AreaWalk.txt file which contains zonal walk-to-transit market areas. The Ver. 2.3.75 travel model includes an automated/integrated transit walkshed process. The process is run using a Python/ArcPy script and does not require manual intervention from the user. Before discussing the individual input files, the next section discusses transit and non-transit mode codes used in the transit network.

3.3.1 Transit and Non-Transit Mode Codes

The transit network consists of various types of transit services and transit vehicles. For example, a bus typically operates on a road in mixed traffic (i.e., with private vehicles, such as cars and trucks). But a bus can also operate as bus rapid transit (BRT), meaning that it may use a combination of normal roads (mixed traffic) and bus-only links/segments (separate right of way). Similarly, there are many rail transit modes that operate now, or will operate in the future, in the Washington, D.C. area, such as Metrorail, commuter rail, light rail transit (LRT) and streetcar. In terms of network coding, we currently differentiate the following six transit modes:

- Local bus (LB)
- Commuter/Express bus (CB)
- Metrorail (MR)
- Commuter rail (CR)
- Light rail transit (LRT)
- Bus rapid transit (BRT) and streetcar (SR)

The last mode, BRT and streetcar, is designated for transit service that travels on a *combination* of separate right of way (where the vehicles are not mixed with other traffic) and regular streets (where the vehicles are mixed with other traffic). By contrast, the LRT mode is designed to be used for transit service that travels *predominantly* on its own right of way (hence, it is not encumbered by other traffic). Historically, the coding practice by COG/TPB staff has been to distinguish three separate categories for both local and express bus service:

- Metrobus
- Non-Metrobus, inner jurisdictions (referred to as “other primary”)
- Non-Metrobus, outer jurisdictions (referred to as “other secondary”)

This results in the ten transit modes shown in Table 3-19.

Table 3-19 Transit mode codes

Mode Code	Mode Description
1	Local bus: Metrobus (also includes DC Circulator bus)
2	Express bus: Metrobus
3	Metrorail
4	Commuter rail
5	Light rail
6	Local bus: Other primary service (inner jurisdictions)
7	Express bus: Other primary service (inner jurisdictions)
8	Local bus: Other secondary service (outer jurisdictions)
9	Express bus: Other secondary service (outer jurisdictions)
10	BRT/streetcar

The transit path-builder, TRNBUILD, can combine average headways (frequencies) and run times (time from start to finish of the route), when two or more transit lines share the same link, via a technique known as "line combining." The line combining can result in new, equivalent average headways and run time, but "TRNBUILD's line-combining process combines only lines with the same mode."[25] For this reason, and especially as COG/TPB staff transitions from TRNBUILD to Public Transport (PT), staff may choose to consolidate some of the current 10 mode codes into fewer mode code designations.

There are currently about 28 transit agencies represented in the transit networks used by the TPB travel demand forecasting model, as shown in Table 3-20. For each transit agency, this table shows the agency abbreviations, the main services offered by each agency, and the modes of travel offered. So, for example, in terms of services, WMATA offers Metrorail, Metrobus, Metroway, and REX. In terms of modes, WMATA has heavy rail (HR), local bus (LB), express/commuter bus (CB), and Bus Rapid Transit (BRT: Metroway). The lists of services and modes are for both the current time and the future. So, for example, Fairfax Co. DOT is listed as offering BRT, because it is one of the future services that is modeled in the transit network (US 1 BRT). As noted below the table, if the transit agency is part of the National Transit Database (NTD), the 2017 annual ridership is shown in this table. However, it is not always clear which transit services are included in the NTD ridership totals. For example, in the case of WMATA, the NTD total includes Metrorail and Metrobus, but it is not clear to us if the NTD value includes Metroway and REX.

Table 3-21 provides an equivalency between transit modes and transit services.

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[25] Citilabs, Inc., "Cube Voyager Reference Guide, Version 6.4.1" (Citilabs, Inc., September 30, 2015), 1004.

Table 3-20 Transit agencies in the Washington, D.C. area (TPB modeled area)

	Agency	Abbrev.	3-Letter Code	2-Letter Code	Services (Current and Future)	Modes (Current and Future)	City/County	State	Incl. in TPB Model?	Incl. in NTD Database?	2017 Annual Trips	5 digit NTD ID
1	Washington Metropolitan Area Transit Authority	WMATA	WMA	WM	Metrorail, Metrobus, Metroway, REX	HR, LB, CB, BRT	Multiple	Multiple	y	y	347,960,762	30030
2	District Department of Transportation	DDOT	DCT	DC	DC Circulator, DC Streetcar	LB, SR	Washington	DC	y	y	4,946,911	30112
3	Maryland Transit Administration	MTA	MTA	MT	MARC Commuter Rail, MTA bus, MTA Commuter, Lee Coaches, St. Mary's Transit System, Corridor Cities Transitway (CCT), Purple Line LRT	CR, LB, CB, BRT	Multiple	MD	y	y	9,174,765	30034
4	Amtrak	Amtrak	AMT	AM	Amtrak (operates some MARC commuter rail service)	CR	Multiple	Multiple	y	n		
5	Potomac and Rappahannock Transportation Commission	PRTC	PRT	PR	Virginia Railway Express (VRE), OminRide, OmniLink	CR, CB	Multiple	VA	y	y	3,874,333	30070
6	Northern Virginia Transportation Commission	NVTC	NVT	NV	Virginia Railway Express (VRE)	CR	Multiple	VA	y	y	4,683,000	30073
7	Montgomery Co. Dept. of Transporta., Div. of Transit Svcs	MCDOT	MCT	MC	Ride-On	LB	Montgomery Co.	MD	y	y	22,479,212	30051
8	Fairfax Co. Dept. of Transportation	FFXDOT	FFX	FC	Fairfax Connector, US 1 BRT, Tysons Circulator	LB, BRT	Fairfax Co.	VA	y	y	8,463,046	30068
9	Prince George's Co.	PGCO	PGC	PG	TheBus	LB	Prince George's Co.	MD	y	y	3,009,610	30085
10	Arlington Co.	ART	ART	AR	Arlington Transit (ART)	LB	Arlington Co.	VA	y	y	3,356,638	30080
11	Alexandria Transit Company	ALEX	ALX	AL	DASH Bus	LB	Alexandria	VA	y	n		
12	City of Fairfax	CUE	CUE	CU	City-University-Energysaver (CUE) Bus	LB	City of Fairfax	VA	y	y	630,694	30058
13	TransIT Services of Frederick County	TransIT	FRM	FM	TransIT	LB	Frederick Co.	MD	y	y	601,324	30072
14	Loudoun County	LCTrans	LCT	LC	Loudoun Co. Commuter Bus (LC Transit)	CB	Loudoun Co.	VA	y	y	1,721,175	30081
15	Annapolis Department of Transportation	ANDOT	ANN	AN	Annapolis Transit	LB	Annapolis	MD	y	y	0	30040
16	Howard Transit	HT	HOW	HT	Howard Transit	LB	Howard Co.	MD	y	y	832,065	30048
17	Columbia Transit System	COLUM	COL	CO		LB	Columbia	MD	y	n		
18	FREDericksburg Regional Transit (FRED)	FRED	FRD	FV	FRED	LB	Fredericksburg	VA	y	y	0	30079
19	Carroll Transit System	CARR	CAR	CA		LB	Carroll Co.	MD	y	y	0	30092
20	City of Winchester	WinTran	WNT	WN	WinTran	LB	Winchester	VA	y	y	0	30099
21	Martz Group	NCW	NCW	NC	National Coach Works of Virginia, MTA Commuter	CB	Multiple	Multiple	y	y	89,283	30103
22	Metropolitan Washington Airports Authority	MWAA	MWA	MW	Washington Flyer	SB	Multiple	VA	y	n		
23	Anne Arundel County	AAR	AAR	AA		LB	Anne Arundel Co.	MD	y	y	243,377	30129
24	Calvert County, Maryland	CALV	CAL	CL	Calvert Co. Bus	LB	Calvert Co.	MD	y	n		
25	Regional Transportation Agency of Central Maryland (RTA)	RTA	RTM	RM	City of Laurel Bus	LB	Multiple	MD	y	n		
26	City of Bethesda	BethCirc	BEC	BC	Bethesda Circulator	LB	Bethesda	MD	y	n		
27	Transportation Association of Greater Springfield (TAGS)	TAGS	TAG	TG	TAGS (along with WMATA)	LB	Springfield	VA	y	n		
28	Charles Co.	CHAR	CHS	CH	Vango	SB	Charles Co.	MD	y	y	858,324	30088

Modes

Rail modes: heavy rail (HR), commuter rail (CR), light rail (LRT), and streetcar (SR)

Bus modes: local bus (LB), commuter/express bus (CB), Bus Rapid Transit (BRT), shuttle bus (SB)

If the transit agency is part of the National Transit Database (NTD), the 2017 annual ridership is shown in this table. However, it is not always clear which transit services are included in the NTD ridership totals. For example, in the case of WMATA, the NTD total includes Metrorail and Metrobus, but it is not clear if it includes Metroway and REX.

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Table 3-21 Equivalency between transit modes and transit service

Mode No.	Mode Description	Abbreviation/ Prefix	Transit Service
1	Local Metrobus	"WM01 - 97, A - Z"	WMATA (DC, Alex., Falls Church, & MTG, PG, ARL, FFX Counties)
		"DC"	District of Columbia Circulator
2	Express Metrobus	"WM05 - 29"	WMATA (ARL, ALEX, FFX)
		"REX"	WMATA (FFX. Co.)
3	Metrorail	"WMRED"	RED Line
		"WMBLU"	BLUE Line
		"WMGRN"	GREEN Line
		"WMORN"	ORANGE Line
		"WMYEL"	YELLOW Line
		"WMSILV"	SILVER Line
4	Commuter Rail	"VFRED"	Frederick Line (VRE)
		"VMAS"	Manassas Line (VRE)
		"MBR"	Brunswick Line (MARC)
		"MCAM"	Camden Line (MARC)
		"MP"	Penn Line (MARC)
		"MFRED"	Frederick City Line (MARC)
		"AMTK"	Amtrak Service
5	Light Rail	"PURPLE"	Purple Line -MTA (Bethesda -New Carrollton)
6	Other Primary - Local Bus	"ART"	Arlington County Bus (ART)
		"DAT"	City of Alexandria Bus (DASH)
		"F"	Fairfax County Bus
		"GO"	Prince Georges County Bus (TheBus)
		"RO"	Montgomery Co. Ride-On Bus
		"SG"	Fairfax City Bus (CUE)
		"TYSL"	Tyson's Circulator
7	Other Primary - Express Bus	"DAT"	City of Alexandria Bus (DASH)
		"F"	Fairfax County Bus
8	Other Secondary - Local Bus	"ANN"	City Of Annapolis Bus
		"CCATS"	Carroll County Bus
		"CC"	Calvert County Bus
		"FT"	Frederick County Bus
		"HT"	Howard County Bus
		"L"	City of Laurel Bus
		"LT"	Loudoun County Local Bus
		"OL"	OMNI-LINK (PrinceWilliam Co. Local)
		"VF"	Fredericksburg, Va (VRE Bus)
		"VG"	Charles County Bus (VanGO)
		"ST"	St Mary's County Bus
9	Other Secondary - Express Bus	"LC"	Lee Coaches Commuter Bus
		"LCS"	Loudoun Co. Commuter Bus
		"LINK"	Washington Flyer- Dulles/WFC (MWAA)
		"MT"	Maryland MTA Bus (Frederick, Howard, Anne Arundel,
			Calvert, St Mary's, & Charles counties)
		"OR"	OMNI-RIDE (Prince William Co. Commuter Bus)
		"PQ"	Quicks Commuter Bus (Fredericksburg, Spotsylvania & Stafford Counties)
		"SDC"	Nat'l Coach/Martz Bus (Fredericksburg, Spotsylvania & Stafford Co's)
10	BRT/ Streetcar	"MWAY"	US 1 (Alexandria, Arlington) Metroway BRT
		"DCST"	DC Streetcar
		"US1BRT"	US 1 (Fairfax) BRT
		"CCTBRT"	Corridor Cities Transit Way
		"VIERSBRT"	Between Rockville Metrorail and Wheaton Metro Station
		"29BRT"	Silver Spring Transit Center to Burtonsville
		"355BRT"	Between Clarksburg Outlets and Rockville Metro
		"NHBRT"	New Hampshire Ave- Colesville PNR-Takoma Metro
		"NBETHBRT"	North Bethesda Transitway
		"RANDBRT"	Randolph Road BRT

Ref: " I:\ateam\docum\fy19\V2.3.75_Visualize2045NetworkReport\Report Tables\Transit_NetWrk_Mode_Codes.xlsx"

According to the rules of TRNBUILD, a transit path includes both transit and non-transit links. The transit links would include any movement on a transit vehicle, and these transit links would be categorized by the 10 transit modes previously mentioned. The non-transit links in a transit path are associated with accessing the transit service, transferring between transit services (especially those represented by different mode codes), and egressing from the transit service. In TRNBUILD vernacular, non-transit links are also called “support” links. Transit path-building and assignment are conducted in production/attraction format, so a transit path goes from a production zone to an attraction zone. At the production end of a transit trip, it is assumed that one will access the transit service via one of two modes: walking or driving. Walking includes biking. At the attraction end of a transit trip, it is assumed that there is only one egress mode: walking. This assumes that people do not egress from the transit system via car. Again, biking is considered part of walking. Also, transfers need to be made, such as from a rail station to a bus stop, and from a park-and-ride (PNR) lot to the associated transit stop. The five current mode codes use for these “non-transit” links are shown in Table 3-22.

Table 3-22 Non-transit mode codes used in TRNBUILD

Mode Code	Mode Description
11	Drive-access to transit
12	Transfer link between rail and bus (walk)
13	Sidewalk link (walk)
14	(Unused)
15	Transfer link between park-and-ride (PNR) lot and transit stop (walk)
16	Walk access to/egress from transit

3.3.2 Rail Station File

The “station file” (station.dbf) contains information about Metrorail stations, commuter rail stations, light rail stations, bus rapid transit stations/stops, streetcar stations/stops, express-bus bus stops, and park-and-ride (PNR) lots that serve these stations/stops. The variables included in the station file are shown in Table 3-23.

As mentioned in the previous section, there are 10 transit mode codes and five non-transit mode codes. The station file uses its own “mode code,” which is a letter, instead of a number, as shown in Table 3-23. The station file also includes an access distance code (“NCT”), which controls the number, extent, and directionality of PNR/KNR access links generated for each parking lot. The acceptable values for the access distance code are shown in Table 3-24.

Table 3-23 Variables in the transit station file (Station.dbf)

Name	Type	Field Description
SEQNO	N	Sequence Number
MM	C	Mode Code (M=Metrorail, C=Commuter rail, B=Bus, L=Light rail, N= BRT/streetcar)
NCT	N	Access distance code (1, 2, 3, 0, 9, 8) (See Table 3-24)
STAPARK	C	Does the station have a park-and-ride lot? (Y=yes; blank=no)
STAUSE	C	Is the station in use for the given year? (Y=yes; blank=no)
SNAME	C	Station Name/PNR lot name
STAC	N	Station centroid number (5001-7999), also known as a park-and-ride (PNR) lot centroid or a dummy PNR centroid"
STAZ	N	For the purposes of path building, the TAZ (1-3722) that represents the location of the station PNR lot. Usually the closest TAZ to the PNR lot.
STAT	N	Station Node (8000-8999, 9000-9999, 10000-10999)
STAP	N	Station park-and-ride (PNR) node number (11000-13999)
STAN1	N	Station bus node #1 (used to generate a station-to-bus-node connector)
STAN2	N	Station bus node #2 (used to generate a station-to-bus-node connector)
STAN3	N	Station bus node #3 (used to generate a station-to-bus-node connector)
STAN4	N	Station bus node #4 (used to generate a station-to-bus-node connector)
STAPCAP	N	Parking capacity (number of spaces at the PNR lot)
STAX	N	X coordinate of station/PNR lot (MD State Plane, NAD83, feet)
STAY	N	Y coordinate of station/PNR lot (MD State Plane, NAD83, feet)
STAPKCOST	N	Peak period parking cost (daily cost, cents)
STAOPCOST	N	Off-peak parking cost (hourly cost, cents)
STAPKSHAD	N	Peak-period shadow price **(currently not used)**
STAOPSHAD	N	Off-peak-period shadow price **(currently not used)**
FIRSTYR	N	Year of Station/PNR lot Opening (unused by scripts, but used as metadata)
STA_CEND	N	Project ID (Metadata)
	C	Scenario name, or left blank (Metadata)
	C	Comments, if any, regarding the file, since file cannot accept comment lines preceding the data lines

Notes: The SEQNO variable does not correspond to the station node (STAT), and, unlike the STAT, cannot be assumed to stay the same over time.

Source: Jain, M. (2010, October). MWCOG network coding guide for Nested Logit Model (First draft: September 20, 2007; Updated February 2008 and October 2010). Memorandum.

Table 3-24 Transit access distance codes (NCT)

Access Dist. Code	Interpretation
1	End-of-the-line station (e.g., Shady Grove Metro)
2	Intermediate station (e.g., Rockville Metro)
3	PNR close to a CBD (e.g., Rhode Island Ave. Metro, Fort Totten)
0	Only KNR-access links generated (e.g., Braddock Road, National Airport, Clarendon)
9	Metrorail sta. in use, but no PNR/KNR access (e.g., Dupont Circle, Farragut North, Metro Ctr.)
8	Pentagon Metro Sta., allows for very long KNR links, to represent "slugging" (informal carpool)

Table 3-25 shows the designated ranges for station centroids and station nodes associated with Metrorail, commuter rail, LRT, and BRT/streetcar.

Table 3-25 Station centroid and station node range by mode

Mode	Mode Code	Station Centroid Range	Station Node Range
Metrorail (Mode 3)	M	5000-5999	8000-8999
Commuter rail (Mode 4)	C	6000-6999	9000-9999
Light rail transit (Mode 5) Bus rapid transit/streetcar (Mode 10)	L N	Not used Not used	10000-10499 10500-10999
Bus (Modes 1, 2, 6-9)	B	Not used	Not used

3.3.3 Walk- and Drive-Access to Transit

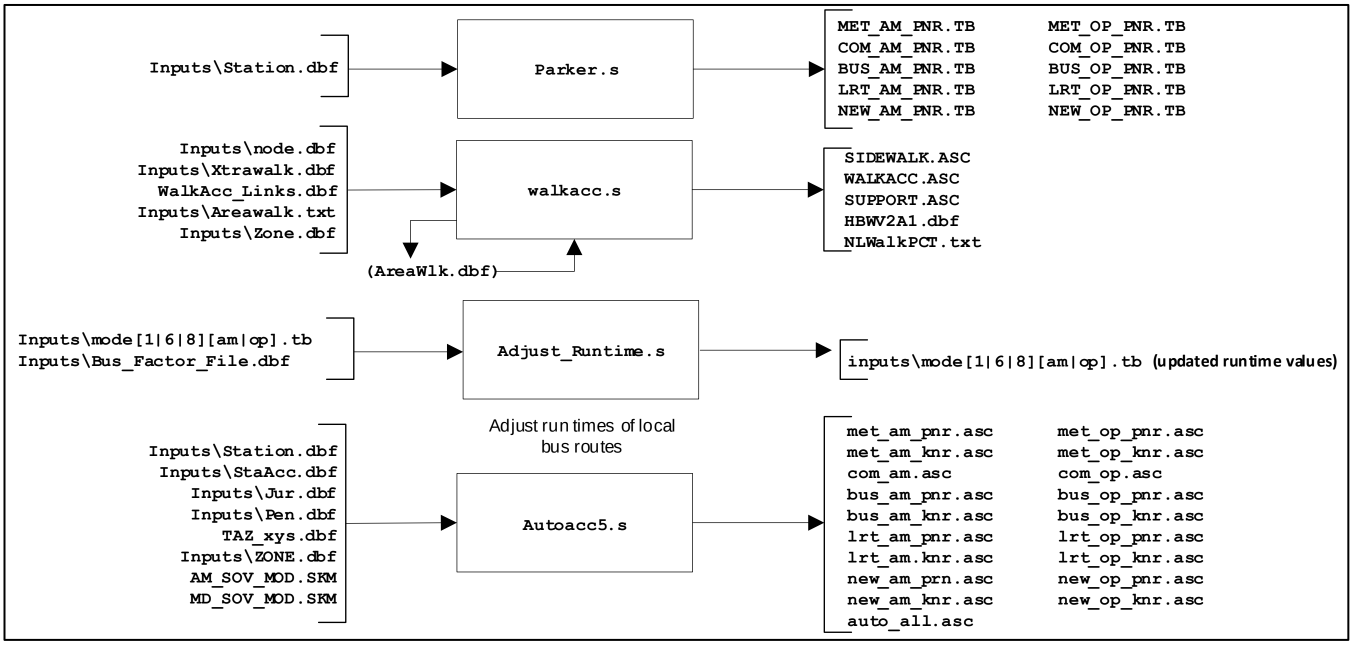
As stated earlier, transit path-building and assignment are conducted in production/attraction format, so a transit path is constructed from a production zone to an attraction zone. At the production end of a transit trip, it is assumed that one will access the transit service via one of two modes: walking or driving. Walking includes biking. At the attraction end of a transit trip, it is assumed that there is only one egress mode: walking. This assumes that people do not egress from the transit system via car.

A series of Cube Voyager scripts are used as part of the transit network building process to enable automatic generation of transit access and transfer links, including zonal walk access links, PNR lot-to-rail station links, and auto access links (TAZ-to-station links). These are non-transit modes that are used to access transit and transfer between transit services and have transit mode codes of 11-16 as shown in Table 3-22. Further details can be found in Chapter 21 of the Version 2.3.75 model User's Guide, which discusses the automatic generation of transit access, auto-access links, and walk-access links.

As shown in Figure 3-14, there are three Cube Voyager scripts that are used for developing access links:

- WALKACC.S: Used to develop zonal walk-access links
- AUTOACC5.S: Used to generate zonal drive-access links
- PARKER.S: Used to generate walk connections between PNR lots and rail stations

Figure 3-14 Process for developing walk-access and drive-access links



As noted in the Version 2.3.75 Travel Model user's guide, the automated approach for generating these links has greatly streamlined the transit network coding process. All three of these programs were originally developed as stand-alone Fortran programs developed by AECOM Consult. TPB staff converted these three Fortran programs to Cube Voyager scripts.

WALKACC.S requires the following input files:

- Node.dbf: A file with the X and Y coordinates of all the transit stop nodes
- Xtrawalk.dbf: A file with extra/user-specified walk links, which can be used in cases where the background highway network lacks sufficient detail to provide adequate walk access (it is assumed that one can walk on all highway links, except freeways, expressways, and ramps).
- WalkAcc_Links.dbf: A list of highway links that can be used for generating walk-access links (developed by MODNET.S)
- Areawalk.txt: A file containing information needed to calculate the zonal percent-walk-to-transit (PWT) values. An excerpt from this file can be found in Figure 3-15. This file contains the following variables:
    - **TAZID**: TAZ number.
    - **TAZAREA**: Area of the TAZ in square miles.
    - **MTLRTSHR**: Area of the TAZ (sq. mi.) within a short (0.5 mile) walk of Metrorail or LRT service
    - **MTLRTLNG**: Area of the TAZ (sq. mi.) within a long (1.0 mile) walk of Metrorail or LRT service
    - **ALLPKSHR**: Area of the TAZ (sq. mi.) within a short (0.5 mile) walk of any transit service (including Metrorail and LRT) in the AM peak period

- **ALLPKLNG**: Area of the TAZ (sq. mi.) within a long (1 mile) walk of any transit service (including Metrorail and LRT) in the AM peak period
- **ALLOPSHR**: Area of the TAZ (sq. mi.) within a short (0.5 mile) walk of any transit service (including Metrorail and LRT) in the **off-peak** period
- **ALLOPLNG**: Area of the TAZ (sq. mi.) within a long (1 mile) walk of any transit service (including Metrorail and LRT) in the **off-peak** period

- Zone.dbf: Standard zonal attribute input file.
- HBWV2A1.dbf: A file with zonal information that is both created by WALKACC.S and then later read into WALKACC.S.

This file need not be sorted by TAZ (as can be seen in Figure 3-15).

Figure 3-15 An excerpt from the AreaWalk.txt file

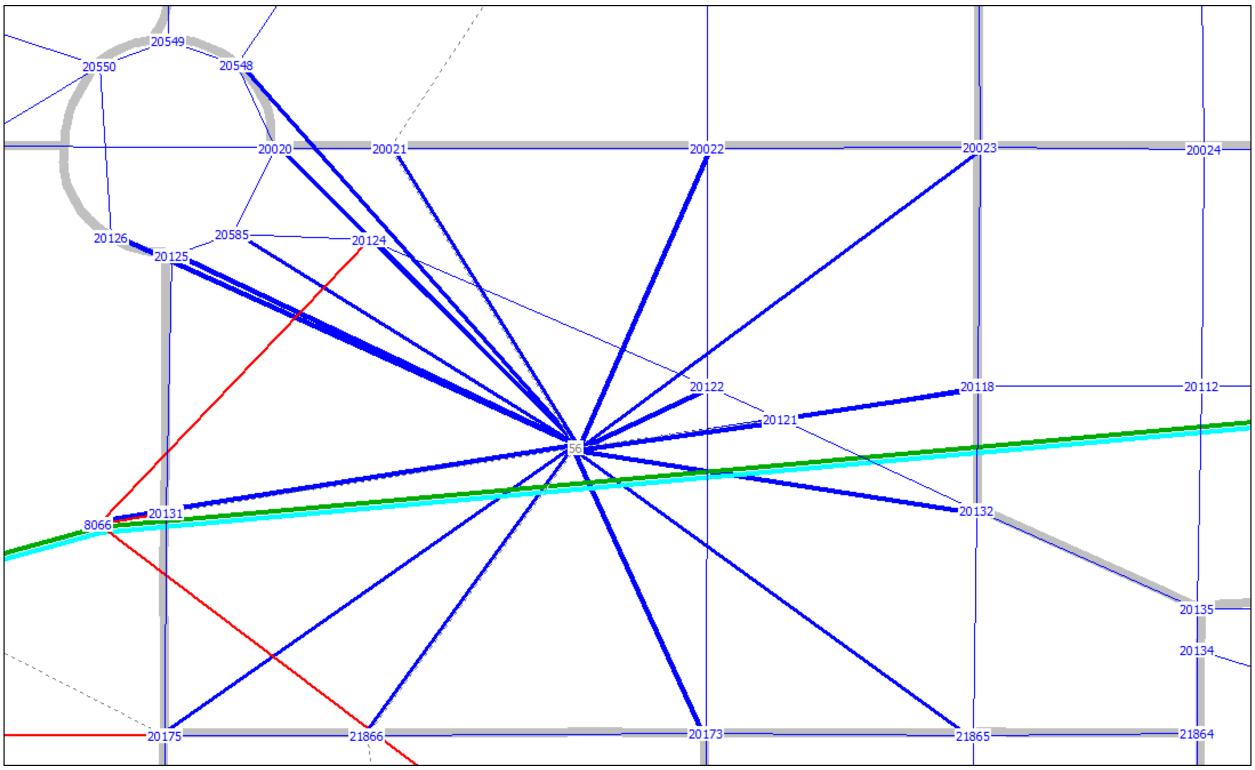
TAZID	TAZ_AREA	MTLRTSHR	MTLRTLNG	ALLPKSHR	ALLPKLNG	ALLOPSHR	ALLOPLNG
2633	0.0540	0.0000	0.0000	0.0540	0.0540	0.0540	0.0540
2634	0.1897	0.0000	0.0000	0.1897	0.1897	0.1897	0.1897
2635	0.6364	0.0000	0.0000	0.4804	0.6364	0.4804	0.6364
2636	0.4917	0.0000	0.0000	0.4917	0.4917	0.4917	0.4917
2637	1.2188	0.0000	0.0000	1.2188	1.2188	1.1620	1.2188
2638	0.6354	0.0000	0.0000	0.4923	0.6354	0.5544	0.6354
2639	0.6991	0.0000	0.0000	0.4743	0.6991	0.4743	0.6991
2640	0.0593	0.0000	0.0000	0.0593	0.0593	0.0593	0.0593
259	0.6207	0.3757	0.6183	0.4934	0.6207	0.4891	0.6207
260	0.4965	0.0000	0.0303	0.4232	0.4965	0.4232	0.4965
1788	1.4192	0.0000	0.0000	0.5475	1.1463	0.5475	1.1463
1789	0.2863	0.0000	0.0412	0.2863	0.2863	0.2863	0.2863
1790	0.3237	0.0000	0.0537	0.3237	0.3237	0.3237	0.3237
1791	0.2910	0.0000	0.0000	0.2661	0.2910	0.2661	0.2910
1792	0.1824	0.0000	0.0029	0.1824	0.1824	0.1824	0.1824
1793	0.1622	0.0000	0.0000	0.1622	0.1622	0.1622	0.1622
1794	0.1026	0.0000	0.0000	0.1026	0.1026	0.1026	0.1026
1795	0.1574	0.0000	0.0000	0.1574	0.1574	0.1574	0.1574
1796	0.9296	0.0000	0.0000	0.9296	0.9296	0.9296	0.9296
1797	0.3545	0.0000	0.0000	0.3545	0.3545	0.3545	0.3545
1798	0.9034	0.0000	0.0083	0.8868	0.9034	0.8868	0.9034
1799	0.3016	0.0000	0.0000	0.3012	0.3016	0.3012	0.3016

The principal output files from WalkAcc.S are

- sidewalk.asc: Sidewalk links.
- walkacc.asc: Walk-access/walk-egress links.
- support.asc: Non-transit/support links.

Figure 3-16 shows walk access/egress links (mode 16) in TAZ 56, which is east of Foggy Bottom Metrorail Station. The thick, dark blue links, in the starburst shape, are the walk access/egress links for one zone (TAZ 56). The thin, dark blue segments are road links. The red links are transit-only links, and the thick, light blue and green links are the Metrorail links (Metrorail's Orange/Blue Line).

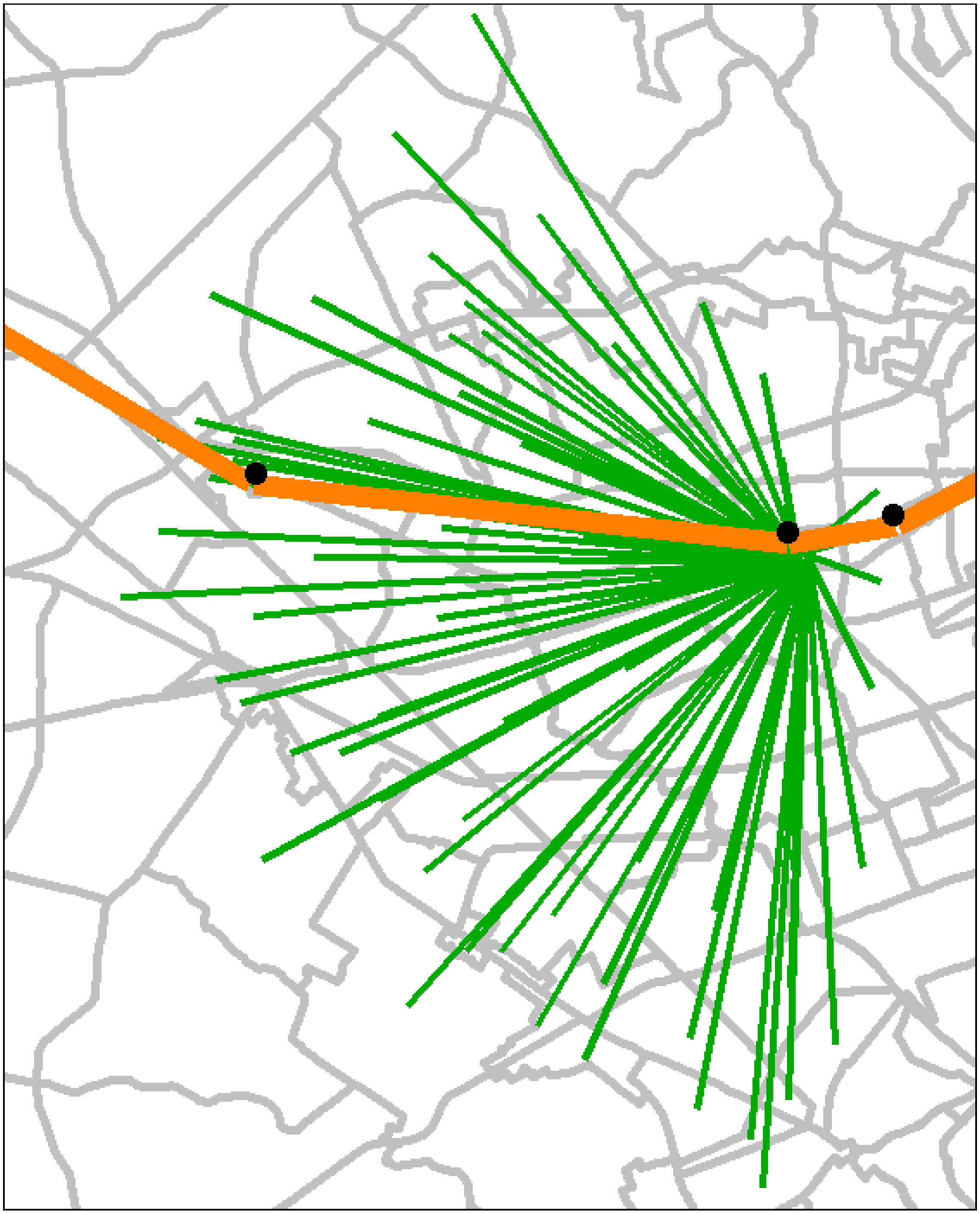
Figure 3-16 Walk access/egress links in TAZ 56, east of Foggy Bottom Metrorail Station



Ref: "L:\modelRuns\fy14\Ver2.3.52_Conformity2013LRTP_Xmittal\2010_Final\zonehwy.net"; "support_mode16_taz56.asc" "MODE3AM.TB"

AutoAcc5.s requires the eight input files shown in Figure 3-14. Figure 3-17 shows an example of the drive-access links (mode 11) associated with the Ballston Metrorail Station park-and-ride (PNR) lot. The lot is located just to the south of the station, which appears as a black dot on the orange line representing Metrorail's Orange Line. Notice that the star-burst shape of the auto access links is not a simple circle, but rather has a directional orientation, reflecting the fact the people have less tendency to back-track when looking for parking at the production end of their trip.

Figure 3-17 Drive-access links associated with the Ballston Metrorail Station PNR lot



Ref: "L:\modelRuns\fy14\Ver2.3.52_Conformity2013LRTP_Xmittal\2010_Final\zonehwy.net"; "MODE3AM.TB" "auto_all_ballston_knr.asc" "auto_all_ballston_pnr.asc" "support.asc"

3.3.4 Station Coordinate Files

The files in Table 3-18 that end with "_node.tb" are the station coordinate files:

- Met_node.tb: Metrorail stations
- Com_node.tb: Commuter rail stations
- LRT_node.tb: LRT stations/stops
- New_node.tb: BRT and/or streetcar stations/stops

These files come directly from the geodatabase. The file extension of "TB" indicates "TRNBUILD" and was introduced by COG/TPB staff a number of years ago to differentiate the files from those formatted for the previous transit path builder, TRNPTH ("TP"). An excerpt from the Metrorail station coordinate file (met_node.tb) can be seen in Figure 3-18. Coordinates are Maryland State Plane, NAD 1983, in feet.

Figure 3-18 Excerpt from the Metrorail station coordinate file (met_node.tb)

```
XY NODE=  8001 X=   1265599 Y=    529193     ;;Shady Grove
XY NODE=  8002 X=   1270639 Y=    516540     ;;Rockville
XY NODE=  8003 X=   1278225 Y=    508218     ;;Twinbrook
XY NODE=  8004 X=   1280517 Y=    503088     ;;White Flint
XY NODE=  8005 X=   1282829 Y=    496367     ;;Grosvenor
XY NODE=  8006 X=   1284767 Y=    485106     ;;Medical Center
XY NODE=  8007 X=   1285560 Y=    479782     ;;Bethesda
XY NODE=  8008 X=   1288003 Y=    471196     ;;Friendship Heights
XY NODE=  8009 X=   1289640 Y=    466682     ;;Tenleytown
XY NODE=  8010 X=   1294409 Y=    464951     ;;Van Ness-UDC
XY NODE=  8011 X=   1295608 Y=    462324     ;;Cleveland Park
XY NODE=  8012 X=   1297352 Y=    458473     ;;Woodley Park-Zoo
XY NODE=  8013 X=   1299822 Y=    453020     ;;Dupont Circle
XY NODE=  8014 X=   1301030 Y=    450307     ;;Farragut North
XY NODE=  8015 X=   1304332 Y=    448558     ;;Metro Center
XY NODE=  8016 X=   1306089 Y=    448606     ;;Gallery Place
XY NODE=  8017 X=   1307581 Y=    447814     ;;Judiciary Square
XY NODE=  8018 X=   1310220 Y=    448408     ;;Union Station
XY NODE=  8019 X=   1313230 Y=    456638     ;;Rhode Island Ave
XY NODE=  8020 X=   1313751 Y=    461393     ;;Brookland-CUA
XY NODE=  8021 X=   1311788 Y=    467989     ;;Fort Totten
XY NODE=  8022 X=   1307186 Y=    476758     ;;Takoma
```

3.3.5 Transit Parking Lot Coordinate Files

The files in Table 3-18 that end with "_pnrn.tb" are the transit parking lot coordinate files:

- met_pnrn.tb: Metrorail PNR lot coordinates
- com_pnrn.tb: Commuter rail PNR lot coordinates
- bus_pnrn.tb: Bus PNR lot coordinates
- lrt_pnrn.tb: LRT PNR lot coordinates

- new_pnrn.tb: BRT and/or streetcar PNR lot coordinates

An excerpt from the Metrorail PNR lot coordinate file (met_pnrn.tb) can be seen in Figure 3-19. Coordinates are Maryland State Plane, NAD 1983, in feet.

Figure 3-19 An excerpt of the Metrorail PNR lot coordinate file (met_pnrn.tb)

```
XY NODE= 11001 X=   1265315 Y=    529089    ;;Shady Grove
XY NODE= 11002 X=   1270959 Y=    516684    ;;Rockville
XY NODE= 11003 X=   1278613 Y=    508435    ;;Twinbrook
XY NODE= 11004 X=   1281327 Y=    503024    ;;White Flint
XY NODE= 11005 X=   1283249 Y=    496139    ;;Grosvenor
XY NODE= 11007 X=   1285562 Y=    479783    ;;Bethesda
XY NODE= 11019 X=   1313784 Y=    456689    ;;Rhode Island Ave
XY NODE= 11021 X=   1311284 Y=    468649    ;;Fort Totten
XY NODE= 11023 X=   1303903 Y=    483450    ;;Silver Spring
XY NODE= 11024 X=   1299517 Y=    491425    ;;Forest Glen
XY NODE= 11025 X=   1297560 Y=    499796    ;;Wheaton
XY NODE= 11026 X=   1297615 Y=    508431    ;;Glenmont
XY NODE= 11027 X=   1338527 Y=    489633    ;;Greenbelt
XY NODE= 11028 X=   1332678 Y=    476884    ;;College Park
XY NODE= 11029 X=   1324845 Y=    472917    ;;PG Plaza
XY NODE= 11030 X=   1321380 Y=    469383    ;;West Hyattsville
XY NODE= 11040 X=   1313758 Y=    436270    ;;Anacostia
XY NODE= 11042 X=   1319454 Y=    427220    ;;Southern Avenue
```

3.3.6 Rail Links

The files in Table 3-18 that end with "_link. tb" are the rail link files:

- met_link.tb
- com_link.tb
- lrt_link.tb
- new_link.tb

An excerpt of the Metrorail rail link file (met_link.tb) is shown in Figure 3-20. The first record of the file is for the rail link (tracks) between Shady Grove Metrorail Station (8001) and Rockville Metrorail Station (8002). Metrorail is mode code 3 and this segment of track has a distance of 2.61 miles. The speed coded for each rail link is a function of the rail link distance.

Figure 3-20 An excerpt of the Metrorail rail link file (met_link.tb)

```
LINK NODES=  8001-  8002 MODES= 03 DIST=  261 ONEWAY= N  SPEED= 40.05
LINK NODES=  8002-  8003 MODES= 03 DIST=  213 ONEWAY= N  SPEED= 40.20
LINK NODES=  8003-  8004 MODES= 03 DIST=  109 ONEWAY= N  SPEED= 22.00
LINK NODES=  8004-  8005 MODES= 03 DIST=  135 ONEWAY= N  SPEED= 41.40
LINK NODES=  8005-  8006 MODES= 03 DIST=  219 ONEWAY= N  SPEED= 44.60
LINK NODES=  8006-  8007 MODES= 03 DIST=  102 ONEWAY= N  SPEED= 31.50
LINK NODES=  8007-  8008 MODES= 03 DIST=  170 ONEWAY= N  SPEED= 34.40
LINK NODES=  8008-  8009 MODES= 03 DIST=   91 ONEWAY= N  SPEED= 23.40
LINK NODES=  8009-  8010 MODES= 03 DIST=  109 ONEWAY= N  SPEED= 33.30
LINK NODES=  8010-  8011 MODES= 03 DIST=   55 ONEWAY= N  SPEED= 18.90
LINK NODES=  8011-  8012 MODES= 03 DIST=   80 ONEWAY= N  SPEED= 21.30
LINK NODES=  8012-  8013 MODES= 03 DIST=  115 ONEWAY= N  SPEED= 35.70
LINK NODES=  8013-  8014 MODES= 03 DIST=   56 ONEWAY= N  SPEED= 15.30
LINK NODES=  8014-  8015 MODES= 03 DIST=   79 ONEWAY= N  SPEED= 22.20
LINK NODES=  8015-  8016 MODES= 03 DIST=   33 ONEWAY= N  SPEED= 17.40
LINK NODES=  8015-  8068 MODES= 03 DIST=   46 ONEWAY= N  SPEED= 24.60
```

3.3.7 Transfer Links

Non-transit links, or support links, include links to access the transit system, to egress from the transit system, and to transfer between transit routes. Transfer links are used to transfer between a rail mode (mode codes 3, 4, 5, and 10) and a non-rail mode (mode codes 1, 2, 6, 7, 8, and 9), such as from Metrorail to bus. Under current coding conventions, these rail-to-non-rail transit transfer links are designated mode code 12. There are four transfer link files:

- met_bus.tb
- com_bus.tb
- lrt_bus.tb
- new_bus.tb

An excerpt from the file containing transfer links between Metrorail stations and bus stops is shown in Figure 3-21.

Figure 3-21 An excerpt from the file (met_bus.tb) containing transfer links (mode 12) between Metrorail stations and bus stops

```
SUPPORT N=  8001- 22395 ONEWAY= N  MODES= 12 DIST =    1 SPEED =   3
SUPPORT N=  8001- 22397 ONEWAY= N  MODES= 12 DIST =    1 SPEED =   3
SUPPORT N=  8002-  9005 ONEWAY= N  MODES= 12 DIST =    1 SPEED =   3
SUPPORT N=  8002- 22351 ONEWAY= N  MODES= 12 DIST =    1 SPEED =   3
SUPPORT N=  8002- 22370 ONEWAY= N  MODES= 12 DIST =    1 SPEED =   3
SUPPORT N=  8003- 22344 ONEWAY= N  MODES= 12 DIST =    1 SPEED =   3
SUPPORT N=  8003- 22672 ONEWAY= N  MODES= 12 DIST =    1 SPEED =   3
SUPPORT N=  8004- 22332 ONEWAY= N  MODES= 12 DIST =    1 SPEED =   3
SUPPORT N=  8004- 22670 ONEWAY= N  MODES= 12 DIST =    1 SPEED =   3
SUPPORT N=  8005- 22327 ONEWAY= N  MODES= 12 DIST =    1 SPEED =   3
SUPPORT N=  8006- 22054 ONEWAY= N  MODES= 12 DIST =    1 SPEED =   3
SUPPORT N=  8007- 22048 ONEWAY= N  MODES= 12 DIST =    1 SPEED =   3
SUPPORT N=  8008- 22864 ONEWAY= N  MODES= 12 DIST =    1 SPEED =   3
SUPPORT N=  8009- 20718 ONEWAY= N  MODES= 12 DIST =    1 SPEED =   3
SUPPORT N=  8010- 20753 ONEWAY= N  MODES= 12 DIST =    1 SPEED =   3
SUPPORT N=  8011- 20756 ONEWAY= N  MODES= 12 DIST =    1 SPEED =   3
SUPPORT N=  8012- 20763 ONEWAY= N  MODES= 12 DIST =    1 SPEED =   3
SUPPORT N=  8013- 20503 ONEWAY= N  MODES= 12 DIST =    1 SPEED =   3
```

The station file, mentioned earlier, contains up to four “bus” nodes for each rail station. “Bus node” means any transit node near the rail station that should be connected with the rail station. So, for example, for the Rockville Metrorail Station (8002), the first “bus” node (STAN1) is 9005, which is not a bus stop, but rather a commuter rail station (the Rockville MARC station). The pairing of each rail station and its associated “bus” nodes forms the transfer links that are found in the transfer link files.

3.3.8 Transit Line/Route Files

The AM Peak and Off-Peak transit line files are text files that contain operational information about individual transit lines/routes, including the average headway (frequency) for the time-of-day period, the average scheduled running time for the time-of-day period, and the route itinerary, which are the nodes through which the transit passes. Transit routes can be designated one-way or two-way. Figure 3-22 shows an example of a transit line file in TRNBUILD format for Mode 1 (local bus: Metrobus and DC Connector). The TPB transit networks currently designate ten mode codes as listed in Table 3-19 and Table 3-21.

Figure 3-22 Example of a transit line/route file in TRNBUILD (TB) format

```
;$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
;$    Scenario-----> base       *
;$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
;* * * * * * * * * * * * * * * * * * * * * * * * * * * *
;*          DC Circulator       *
;* * * * * * * * * * * * * * * * * * * * * * * * * * * *
LINE NAME="DC98",
OWNER="DC Circulator;NW 14TH ST & NW K ST;CALVERT ST NW & LANIER PL NW;2015;base",
ONEWAY= Y,MODE= 01,FREQ[1]= 10,RUNTIME= 30,
          N=  20072 -20426 -20425 -20424 -20423  21831 -20448 -20446 -20445,
              21746 -20413  21745  21822  21819  21744 -20371  21826 -20919,
             -20826 -20827 -20833  20829 -20605  20653  20652  21523 -20651,
              20650

;$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
;$    Scenario-----> base       *
;$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
;* * * * * * * * * * * * * * * * * * * * * * * * * * * *
;*          DC Circulator       *
;* * * * * * * * * * * * * * * * * * * * * * * * * * * *
LINE NAME="DC98S",
OWNER="DC Circulator;CONNECTICUT AVE & 24TH ST;NW 14TH ST & NW I ST ;2015;base",
ONEWAY= Y,MODE= 01,FREQ[1]= 10,RUNTIME= 35,
          N=  20650 -20651  21523  20652  20653 -20605  20829 -20833 -20827,
             -20826 -20919  21826 -20371  21744  21819  21822  21745 -20413,
              21746 -20445 -20407 -21766  21814  20406  20405 -20403 -20435,
             -20434 -20433  21631  20400 -20399 -20398 -20105  20104  20072
```

Ref: M:\fy17\CGV2_3_66_Conformity2016LRTP_Xmittal\2016_Base\Inputs\MODE1AM.TB

The average headways reflect the frequency of service, defined by the number of buses or rail cars that operate per hour per period (AM or off peak). The coded headways are subject to a maximum of 60 minutes during both AM peak and off-peak periods. Running time is defined as the average scheduled end-to-end route time in minutes during the given time-of-day period.

As was mentioned on page 56, in the path building process, transit routes that share the same mode code and share the same links can be combined, using TRNBUILD's line combination procedures, such that the traveler experiences a new combined headway and runtime for the set of common routes.

A transit line file is divided into a series of transit lines/routes. For example, Figure 3-22 shows two bus routes for the DC Circulator: the 98 and the 98 South. Each route in the file begins with "header" information. The header section of any transit route in a transit line file is described in Table 3-26.

Table 3-26 Header section for each transit route in a transit line file

File Name	Variable Name	Description
Mode<No. ><per>.tb	LINE NAME	Abbreviation of transit service provider name
	OWNER	The OWNER variable is currently being used to store five fields, which are separated by semicolons: 1. Transit operator 2. Origin 3. Destination 4. Year represented 5. Scenario
	ONEWAY	Y/N (Y= Yes and N=No)
	MODE	Transit mode codes (1 - 10)
	FREQ[1]	Average time between successive arrivals (or departures) of transit vehicles on a given route for the period (AM or OP). Also known as average headway.
	RUNTIME	Average time (in min) for the transit vehicle to go from the start to the finish of its route, for the given period (AM or OP)

Key: <No.> 1-10
<per> = AM (AM peak period) or OP (off-peak period), see pp. 2-3 to 2-4.

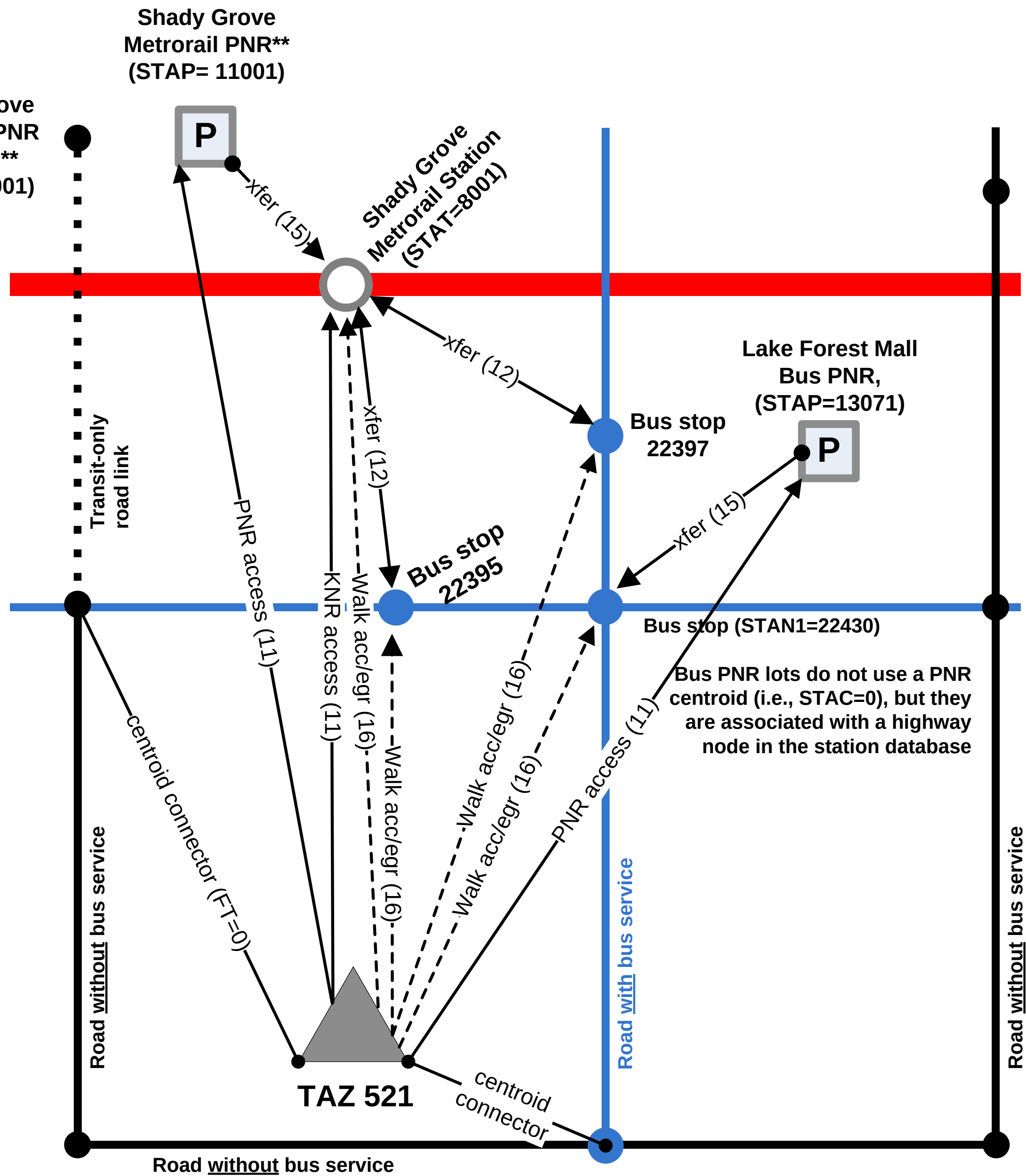
After the route header information, there is a node itinerary, which is a list through which the route passes.

The file extension of “TB” in the names of the line files (also sometimes called “mode files”) indicates “TRNBUILD” and was introduced by COG/TPB staff several years ago to differentiate the files from those formatted for the previous transit path builder, TRNPTH (“TP”). A more standard file extension for these types of files is “LIN,” which stands for transit line/route.

3.3.9 Example of network coding

Figure 3-23 shows a diagram that illustrates the existing MWCOG/TRNBUILD convention for network coding around rail stations (Metro or commuter rail), park-and-ride lots, and bus service.

Figure 3-23 Existing MWCOG/TRNBUILD convention for network coding around rail stations, park-and-ride lots, and bus service



Ref: "I:\ateam\docum\fy14\2013LRTP_Network_Report\network_coding_station_diagr_mwcog_trnbuild.vsd"

In Figure 3-23, numbers in parentheses are mode codes. For example, mode code 11 is drive access to transit, which can be either drive and park (PNR) or drive and drop off ("kiss and ride," KNR). Mode code 16 is for walk access or egress links. Two types of transfer links are shown in the diagram:

- Mode 12: Transfer between a rail mode and a non-rail transit mode (walk)
- Mode 15: Transfer between a PNR lot and the rail station (walk)

Also, the PNR node and the dummy PNR node are stored in the background highway network.

3.3.10 Transit route summaries

This section of the report presents transit route summaries. The network years available were discussed on Page 8 (essentially, 2019, 2021, 2025, 2030, 2040, and 2045).

Summaries of the AM peak period Metrorail routes are shown in Table 3-27. Note that Table 3-27 does not show data for 2040 or 2045, since the Metrorail data for these two years was the same as that for 2030. The table lists COG/TPB's transit route name, origin and destination stations, average headways, average run-times, line distances, and average line speed for service during the AM peak hour and Off-peak period. Table 3-28 presents the same information, but for the off-peak period. Note that the Red Line has two different routes:

- Red Line A: From Shady Grove (end of the line) to Glenmont (end of the line)
- Red Line B: From Grosvenor to Silver Spring

This is reflected in the route names, e.g., Red-A and Red-B. Note: Some routes are denoted "A" even though there is only one of them, such as Green Line A ("Grn-A").

Table 3-27 AM peak-period Metrorail line summary by year: 2019, 2021, 2025, and 2030

Transit Route Name	Transit Yr.	Origin	Destination	Hdwy	RT (mins.)	Dist. (mi)	Spd (mph)
WMBLUA	2019	FRANCONIA/SPRINGFIELD	LARGO TWN CTR	8	64	30	28
WMGRNA	2019	GREENBELT	BRANCH AVE	8	47	23	29
WMORNA	2019	VIENNA	NEW CARROLLTON	8	57	26	27
WMREDA	2019	SHADY GROVE METRO	GLENMONT METRO	8	65	32	30
WMREDB	2019	SILVER SPRING METRO	GROSVENOR METRO	8	44	19	26
WMYELA	2019	MT VERNON SQ/7TH ST-CONVENTION	HUNTINGTON AV METRO	8	25	10	24
WMSILV	2019	Wiehle	LARGO	8	75	32	26
WMBLUA	2021	FRANCONIA/SPRINGFIELD	LARGO TWN CTR	8	66	30	27
WMGRNA	2021	GREENBELT	BRANCH AVE	8	47	23	29
WMORNA	2021	VIENNA	NEW CARROLLTON	8	57	26	27
WMREDA	2021	SHADY GROVE METRO	GLENMONT METRO	8	65	32	30
WMREDB	2021	SILVER SPRING METRO	GROSVENOR METRO	8	44	19	26
WMYELA	2021	MT VERNON SQ/7TH ST-CONVENTION	HUNTINGTON AV METRO	8	27	10	22
WMSILV	2021	VA 772	LARGO	8	90	43	29
WMBLUA	2025	FRANCONIA/SPRINGFIELD	LARGO TWN CTR	8	66	30	27
WMGRNA	2025	GREENBELT	BRANCH AVE	8	47	23	29
WMORNA	2025	VIENNA	NEW CARROLLTON	8	57	26	27
WMREDA	2025	SHADY GROVE METRO	GLENMONT METRO	8	65	32	30
WMREDB	2025	SILVER SPRING METRO	GROSVENOR METRO	8	44	19	26
WMYELA	2025	MT VERNON SQ/7TH ST-CONVENTION	HUNTINGTON AV METRO	8	27	11	24
WMSILV	2025	VA 772	LARGO	8	90	43	29
WMBLUA	2030	FRANCONIA/SPRINGFIELD	LARGO TWN CTR	12	66	30	27
WMYELB	2030	FRANCONIA/SPRINGFIELD	GREENBELT	12	60	29	29
WMGRNA	2030	GREENBELT	BRANCH AVE	6	47	23	29
WMORNA	2030	VIENNA	NEW CARROLLTON	6	57	26	27
WMREDA	2030	SHADY GROVE METRO	GLENMONT METRO	6	65	32	30
WMREDB	2030	SILVER SPRING METRO	GROSVENOR METRO	6	44	19	26
WMYELA	2030	MT VERNON SQ/7TH ST-CONVENTION	HUNTINGTON AV METRO	6	27	11	24
WMSILV	2030	VA 772	LARGO	6	90	43	29

Note: AM peak period is from 7:00 – 7:59 AM. Years 2040 and 2045 Metrorail data is the same as 2030.

Ref: " I:\ateam\docum\fy19\V2.3.75_Visualize2045NetworkReport\Report Tables\ V2375_Visualize2045_Met_Com_BRT_Files_ Updated_Chkd.xlsx"

Source: Visualize 2045 plan and FY 2019-2024 TIP

Table 3-28 Off-peak period Metrorail line summary by year: 2019, 2021, 2025, and 2030

Transit Route Name	Transit Yr.	Origin	Destination	Hdwy	RT (mins.)	Dist. (mi)	Spd (mph)
WMBLUA	2019	FRANCONIA/SPRINGFIELD	LARGO TWN CTR	12	64	30	28
WMGRNA	2019	GREENBELT	BRANCH AVE	12	47	23	29
WMORNA	2019	VIENNA	NEW CARROLLTON	12	57	32	34
WMREDB	2019	SILVER SPRING METRO	GROSVENOR METRO	12	43	26	36
WMYELA	2019	FT	HUNTINGTON	12	36	19	32
WMSILV	2019	Wiehle	LARGO	12	75	15	12
WMREDA	2019	SHADY GROVE METRO	GLENMONT METRO	12	63	32	30
WMBLUA	2021	FRANCONIA/SPRINGFIELD	LARGO TWN CTR	12	66	30	27
WMGRNA	2021	GREENBELT	BRANCH AVE	12	47	23	29
WMORNA	2021	VIENNA	NEW CARROLLTON	12	57	26	27
WMREDB	2021	SILVER SPRING METRO	GROSVENOR METRO	12	43	19	27
WMYELA	2021	FT	HUNTINGTON	12	38	15	24
WMSILV	2021	VA 772	LARGO	12	90	43	29
WMREDA	2021	SHADY GROVE METRO	GLENMONT METRO	12	63	32	30
WMBLUA	2025	FRANCONIA/SPRINGFIELD	LARGO TWN CTR	12	66	30	27
WMGRNA	2025	GREENBELT	BRANCH AVE	12	47	23	29
WMORNA	2025	VIENNA	NEW CARROLLTON	12	57	26	27
WMREDB	2025	SILVER SPRING METRO	GROSVENOR METRO	12	43	19	27
WMYELA	2025	FT TOTTEN	HUNTINGTON	12	38	15	24
WMSILV	2025	VA 772	LARGO	12	90	43	29
WMREDA	2025	SHADY GROVE METRO	GLENMONT METRO	12	63	32	30
WMBLUA	2030	FRANCONIA/SPRINGFIELD	LARGO TWN CTR	12	66	30	27
WMGRNA	2030	GREENBELT	BRANCH AVE	12	47	23	29
WMORNA	2030	VIENNA	NEW CARROLLTON	12	57	26	27
WMREDB	2030	SILVER SPRING METRO	GROSVENOR METRO	12	43	19	27
WMYELA	2030	FT TOTTEN	HUNTINGTON	12	38	15	24
WMSILV	2030	VA 772	LARGO	12	90	43	29
WMREDA	2030	SHADY GROVE METRO	GLENMONT METRO	12	63	32	30

Note: Off-peak period is from 10:00 AM- 2:59 PM

Ref: " I:\ateam\docum\fy19\V2.3.75_Visualize2045NetworkReport\Report Tables\ V2375_Visualize2045_Met_Com_BRT_Files_ Updated_Chkd.xlsx"

Source: Visualize 2045 plan and FY 2019-2024 TIP

Line summaries for commuter rail are shown in Table 3-29 and Table 3-30. Table 3-29 covers the AM peak period and Table 3-30 covers the off-peak period for years 2019, 2021, 2025 and 2030 (and implicitly 2040 and 2045, since these years are the same as 2030).

Line summaries for light rail and BRT/ Streetcar are shown in Table 3-31 and Table 3-32. Table 3-31 covers the AM peak period summaries and Table 3-32 covers the off-peak period summaries for all the Visualize 2045 plan AQC analysis forecast years (2019, 2021, 2025, 2030, 2040, and 2045). Unlike the Metrorail and Commuter rail summaries years 2040 and 2045 are not the same as 2030 (new service providers are shown in a shade of gray in Table 3-31 and Table 3-32).

Table 3-29 AM peak-period commuter rail summary by year: 2019, 2021, 2025 and 2030

Transit Route Name	Transit Year	Origin	Destination	Hdwy	RT(mins.)	Dis.(mi)	Spd(mph)
AMTK86I	2019	Spotsylvania	UNION STATION VRE	60	81	60	44
MBR876	2019	BRUNSWICK STATION	UNION STATION	60	95	50	32
MBR878	2019	Duffields WVA	Union Station	60	111	62	34
MCAM847	2019	DORSEY	UNION STATION	60	54	25	28
MCAM840	2019	UNION STATION	DORSEY	60	47	25	32
MP407511	2019	BWI	UNION STATION	30	44	30	41
MBR892	2019	FREDERICK	UNION	60	111	56	30
MCAM845	2019	DORSEY	Washington-Union	60	50	25	30
MP404	2019	Washington-Union	BWI	60	32	30	56
MP502	2019	UNION STATION	BWI	60	35	30	51
MP409	2019	BWI	UNION STATION	60	34	30	53
VMAS321	2019	Washington-Union Station	Broad Run	60	77	36	28
VMASS1I	2019	BROAD RUN AIRPORT VRE	UNION STATION	30	79	36	27
VFRED1I	2019	Spotsylvania	Washington-Union Station	30	106	60	34
AMTK86I	2021	Spotsylvania	UNION STATION VRE	60	81	60	44
MCAM840	2021	UNION STATION	DORSEY	60	47	25	32
MBR876	2021	BRUNSWICK STATION	UNION STATION	60	95	50	32
MBR878	2021	Duffields WVA	Union Station	60	111	62	34
MCAM847	2021	DORSEY	UNION STATION	60	54	25	28
MP407511	2021	BWI	UNION STATION	30	44	30	41
MBR892	2021	FREDERICK	UNION	60	111	56	30
MCAM845	2021	DORSEY	Washington-Union	60	50	25	30
MP404	2021	Washington-Union	BWI	60	32	30	56
MP502	2021	UNION STATION	BWI	60	35	30	51
MP409	2021	BWI	UNION STATION	60	34	30	53
VMAS321	2021	Washington-Union Station	Broad Run	60	77	36	28
VMASS1I	2021	BROAD RUN AIRPORT VRE	UNION STATION	20	79	36	27
VFRED1I	2021	Spotsylvania	Washington-Union Station	20	106	60	34
AMTK86I	2025	Fredericksburg	UNION STATION VRE	60	81	60	44
MCAM840	2025	UNION STATION	DORSEY	60	47	25	32
MBR876	2025	BRUNSWICK STATION	UNION STATION	60	95	50	32
MBR878	2025	Duffields WVA	Union Station	60	111	62	34
MCAM847	2025	DORSEY	UNION STATION	60	54	25	28
MP407511	2025	BWI	UNION STATION	30	44	30	41
MBR892	2025	FREDERICK	UNION	60	111	56	30
MCAM845	2025	DORSEY	Washington-Union	60	50	25	30
MP404	2025	Washington-Union	BWI	60	32	30	56
MP502	2025	UNION STATION	BWI	60	35	30	51
MP409	2025	BWI	UNION STATION	60	34	30	53
VMAS321	2025	Washington-Union Station	Broad Run	60	77	36	28
VMASS1I	2025	BROAD RUN AIRPORT VRE	UNION STATION	20	79	36	27
VFRED1I	2025	Spotsylvania	Washington-Union Station	20	106	60	34
AMTK86I	2030	Fredericksburg	UNION STATION VRE	60	81	60	44
MCAM840	2030	UNION STATION	DORSEY	60	47	25	32
MBR876	2030	BRUNSWICK STATION	UNION STATION	60	95	50	32
MBR878	2030	Duffields WVA	Union Station	60	111	62	34
MCAM847	2030	DORSEY	UNION STATION	60	54	25	28
MP407511	2030	BWI	UNION STATION	30	44	30	41
MBR892	2030	FREDERICK	UNION	60	111	56	30
MCAM845	2030	DORSEY	Washington-Union	60	50	25	30
MP404	2030	Washington-Union	BWI	60	32	30	56
MP502	2030	UNION STATION	BWI	60	35	30	51
MP409	2030	BWI	UNION STATION	60	34	30	53
MCAMNEW	2030	UNION STATION	DORSEY	60	47	25	32
MBRNEW1	2030	BRUNSWICK STATION	UNION STATION	60	95	50	32
MBRNEW2	2030	UNION STATION	BRUNSWICK STATION	60	94	50	32
MPENNEW	2030	BWI	UNION STATION	60	36	30	50
VMAS321	2030	Washington-Union Station	Broad Run	60	77	36	28
VMASS1I	2030	BROAD RUN AIRPORT VRE	UNION STATION	20	79	36	27
VFRED1I	2030	Spotsylvania	Washington-Union Station	20	106	60	34

Note: AM peak period is from 6:00 – 6:59 AM. Years 2040 and 2045 commuter rail data is the same as 2030.

Ref: " I:\ateam\docum\fy19\V2.3.75_Visualize2045NetworkReport\Report TablesV2375_Visualize2045_Met_Com_BRT_Files_ Updated_Chkd.xlsx"

Source: Visualize 2045 plan and FY 2019-2024 TIP

Table 3-30 Off-peak-period commuter rail summary by year: 2019, 2021, 2025, and 2030

Transit Route Name	Transit Year	Origin	Destination	Hdwy	RT(mins.)	Dis.(mi)	Spd(mph)
AMTK94I	2019	Spotsylvania	Washington-Union Station	60	97	60	37
AMTK95O	2019	UNION STATION VRE	Fredericksburg	60	72	60	50
AMTK176	2019	MANASSAS	UNION STATION	60	61	33	32
MBR871	2019	UNION STATION	BRUNSWICK STATION	60	94	50	32
MPEN1I	2019	BWI	UNION STATION	60	40	30	45
MPEN1O	2019	UNION STATION	BWI	60	35	30	51
VFR301	2019	Washington-Union Station	Spotsylvania	60	109	60	33
VMAS336	2019	Broad Run	Washington-Union Station	60	70	36	31
VMAS325	2019	UNION STATION	BROAD RUN	60	79	36	27
AMTK94I	2021	Fredericksburg	Washington-Union Station	60	97	60	37
AMTK95O	2021	UNION STATION VRE	Fredericksburg	60	72	60	50
AMTK176	2021	MANASSAS	UNION STATION	60	61	33	32
MBR871	2021	UNION STATION	BRUNSWICK STATION	60	94	50	32
MPEN1I	2021	BWI	UNION STATION	60	40	30	45
MPEN1O	2021	UNION STATION	BWI	60	35	30	51
VFR301	2021	Washington-Union Station	Spotsylvania	60	109	60	33
VMAS336	2021	Broad Run	Washington-Union Station	60	70	36	31
VMAS325	2021	UNION STATION	BROAD RUN	60	79	36	27
AMTK94I	2025	Fredericksburg	Washington-Union Station	60	97	60	37
AMTK95O	2025	UNION STATION VRE	Fredericksburg	60	72	60	50
AMTK176	2025	MANASSAS	UNION STATION	60	61	33	32
MBR871	2025	UNION STATION	BRUNSWICK STATION	60	94	50	32
MPEN1I	2025	BWI	UNION STATION	60	40	30	45
MPEN1O	2025	UNION STATION	BWI	60	35	30	51
VFR301	2025	Washington-Union Station	Spotsylvania	60	109	60	33
VMAS336	2025	Broad Run	Washington-Union Station	60	70	36	31
VMAS325	2025	UNION STATION	BROAD RUN	60	79	36	27
AMTK94I	2030	Fredericksburg	Washington-Union Station	60	97	60	37
AMTK95O	2030	UNION STATION VRE	Fredericksburg	60	72	60	50
AMTK176	2030	MANASSAS	UNION STATION	60	61	33	32
MBR871	2030	UNION STATION	BRUNSWICK STATION	60	94	50	32
MPEN1I	2030	BWI	UNION STATION	60	40	30	45
MPEN1O	2030	UNION STATION	BWI	60	35	30	51
VFR301	2030	Washington-Union Station	Spotsylvania	60	109	60	33
VMAS336	2030	Broad Run	Washington-Union Station	60	70	36	31
VMAS325	2030	UNION STATION	BROAD RUN	60	79	36	27

Note: Off-peak period is from 10:00 AM- 2:59 PM. Years 2040 and 2045 commuter rail data is the same as 2030.

Ref:" I:\ateam\docum\fy19\V2.3.75_Visualize2045NetworkReport\Report Tables\ V2375_Visualize2045_Met_Com_BRT_Files_ Updated_Chkdxlsx"

Source: Visualize 2045 plan and FY 2019-2024 TIP

Table 3-31 AM peak-period light rail, BRT, streetcar summary by year: 2019, 2021, 2025, 2030, 2040 and 2045

Transit Route Name	Transit Year	Origin	Destination	Hdwy	RT(mins.)	Dis.(mi)	Spd(mph)
DCSTHST1	2019	UNION STATION	OKLAHOMA AVE	15	12	1	5
MWAYN	2019	Braddock Rd Metro	Pentagon City Metro	12	26	4	9
MWAYS	2019	Pentagon City Metro	Braddock Rd Metro	12	24	4	10
MWAYS/	2019	Crystal City Metro	Potomac Ave & Reed Ave	12	8	4	30
MWAYN/	2019	Potomac Ave & Reed Ave	Crystal City Metro	12	11	1	5
DCSTHST1	2021	UNION STATION	OKLAHOMA AVE	15	12	1	5
MWAYN	2021	Braddock Rd Metro	Pentagon City Metro	12	31	5	10
MWAYS	2021	Pentagon City Metro	Braddock Rd Metro	12	29	5	10
MWAYN/	2021	Potomac Ave & Reed Ave	Crystal City Metro	12	11	2	11
MWAYS/	2021	Crystal City Metro	Potomac Ave & Reed Ave	12	8	1	8
29BRT1	2021	Burtonsville PNR	Silver Spring Transit Center	15	30	11	22
29BRT2	2021	Briggs Chaney PNR	Silver Spring Transit Center	15	30	11	22
PURLRT	2021	Bethesda	New Carrollton	6	59	16	16
29BRT2	2025	Briggs Chaney PNR	Silver Spring Transit Center	15	30	11	22
MWAYN	2025	Braddock Rd Metro	Army Navy Dr. Transit Station	12	31	5	10
MWAYS	2025	Army Navy Dr. Transit Station	Braddock Rd Metro	12	29	5	10
MWAYN/	2025	Potomac Ave & Reed Ave	Crystal City Metro	12	11	2	11
MWAYS/	2025	Crystal City Metro	Potomac Ave & Reed Ave	12	8	1	8
29BRT1	2025	Burtonsville PNR	Silver Spring Transit Center	15	30	11	22
DCSTHST2	2025	UNION STATION	BENNING RD METRO	10	24	4	10
CCTBRTU	2025	COMSAT	SHADY GROVE	15	46	10	13
DCSTGTWN	2025	Union Station/ H St.	Georgetown	10	25	3	7
CCTBRT	2025	COMSAT	SHADY GROVE	5	42	9	13
PURLRT	2025	Bethesda	New Carrollton	6	59	16	16
29BRT1	2030	Burtonsville PNR	Silver Spring Transit Center	15	30	11	22
29BRT2	2030	Briggs Chaney PNR	Silver Spring Transit Center	15	30	11	22
CCBRTU	2030	COMSAT	SHADY GROVE	15	46	10	13
CCTBRT	2030	COMSAT	SHADY GROVE	5	42	9	13
DCSTGTWN	2030	Union Station/ H St.	Georgetown	10	25	3	7
DCSTHST2	2030	UNION STATION	BENNING RD METRO	10	24	4	10
MWAYN	2030	Braddock Rd Metro	Army Navy Dr. Transit Station	12	31	5	10
MWAYN/	2030	Potomac Ave & Reed Ave	Crystal City Metro	12	11	2	11
MWAYS	2030	Army Navy Dr. Transit Station	Braddock Rd Metro	12	29	5	10
MWAYS/	2030	Crystal City Metro	Potomac Ave & Reed Ave	12	8	1	8
PURLRT	2030	Bethesda	New Carrollton	6	59	16	16
US1BRT	2030	HUNTINGTON METRO STATION	WOODBRIDGE VRE	6	38	15	24
VIERSBRT1	2030	Wheaton Metro Station	Rockville Metro Station	9	25	6	14
VIERSBRT2	2030	Wheaton Metro Station	Montgomery College	15	29	8	17
29BRT1	2040	Burtonsville PNR	Silver Spring Transit Center	15	30	11	22
29BRT2	2040	Briggs Chaney PNR	Silver Spring Transit Center	15	30	11	22
CCBRTU	2040	COMSAT	SHADY GROVE	15	46	10	13
CCTBRT	2040	COMSAT	SHADY GROVE	5	42	9	13
DCSTGTWN	2040	Union Station/ H St.	Georgetown	10	25	3	7
DCSTHST2	2040	UNION STATION	BENNING RD METRO	10	24	4	10
MWAYN	2040	Braddock Rd Metro	Army Navy Dr. Transit Station	12	31	5	10
MWAYN/	2040	Potomac Ave & Reed Ave	Crystal City Metro	12	11	2	11
MWAYS	2040	Army Navy Dr. Transit Station	Braddock Rd Metro	12	29	5	10
MWAYS/	2040	Crystal City Metro	Potomac Ave & Reed Ave	12	8	1	8
PURLRT	2040	Bethesda	New Carrollton	6	59	16	16
US1BRT	2040	HUNTINGTON METRO STATION	WOODBRIDGE VRE	6	38	15	24
VIERSBRT1	2040	Wheaton Metro Station	Rockville Metro Station	9	25	6	14
VIERSBRT2	2040	Wheaton Metro Station	Montgomery College	15	29	8	17
NBETHBRT	2040	Montgomery Mall Transit Center	White Flint Metro Station	7	17	3	11
RANDBRT	2040	White Flint Metro Station	US 29 & Tech Rd.	7	50	11	13
29BRT1	2045	Burtonsville PNR	Silver Spring Transit Center	15	30	11	22
29BRT2	2045	Briggs Chaney PNR	Silver Spring Transit Center	15	30	11	22
CCBRTU	2045	COMSAT	SHADY GROVE	15	46	10	13
CCTBRT	2045	COMSAT	SHADY GROVE	5	42	9	13
DCSTGTWN	2045	Union Station/ H St.	Georgetown	10	25	3	7
DCSTHST2	2045	UNION STATION	BENNING RD METRO	10	24	4	10
MWAYN	2045	Braddock Rd Metro	Army Navy Dr. Transit Station	12	31	5	10
MWAYN/	2045	Potomac Ave & Reed Ave	Crystal City Metro	12	11	2	11
MWAYS	2045	Army Navy Dr. Transit Station	Braddock Rd Metro	12	29	5	10
MWAYS/	2045	Crystal City Metro	Potomac Ave & Reed Ave	12	8	1	8
PURLRT	2045	Bethesda	New Carrollton	6	59	16	16
NBETHBRT	2045	Montgomery Mall Transit Center	White Flint Metro Station	7	17	3	11
RANDBRT	2045	White Flint Metro Station	US 29 & Tech Rd.	7	50	11	13
US1BRT	2045	HUNTINGTON METRO STATION	WOODBRIDGE VRE	6	38	15	24
VIERSBRT1	2045	Wheaton Metro Station	Rockville Metro Station	9	25	6	14
VIERSBRT2	2045	Wheaton Metro Station	Montgomery College	15	29	8	17
355BRT1	2045	Clarksburg Outlets	Rockville Metro Station	5	60	17	17
355BRT2	2045	Lakeforest Transit Center	Rockville Metro Station	12	24	7	18
355BRT3	2045	Montgomery College - Rockville	Bethesda Metro Station	10	32	9	17
NHBRT	2045	Colesville PNR	Takoma Park Metro Station	7	26	10	23

Note: AM peak period is represented by the service occurring from 7:00 -7:59 AM.

Ref: "I:\ateam\docum\fy19\V2.3.75_Visualize2045NetworkReport\Report Tables\V2375_Visualize2045_Met_Com_BRT_Files_ Updated_Chkd.xlsx"

Source: Visualize 2045 plan and FY 2019-2024 TIP

Table 3-32 Off-peak-period light rail, BRT, streetcar summary by year: 2019, 2021, 2025, 2030, 2040, and 2045

Transit Route Name	Transit Year	Origin	Destination	Hdwy	RT(mins.)	Dis.(mi)	Spd(mph)
DCSTHST1	2019	UNION STATION	OKLAHOMA AVE	30	12	1	5
MWAYN	2019	Braddock Rd Metro	Pentagon City Metro	12	22	4	11
MWAYS	2019	Pentagon City Metro	Braddock Rd Metro	12	24	4	10
DCSTHST1	2021	UNION STATION	OKLAHOMA AVE	30	12	1	5
MWAYN	2021	Braddock Rd Metro	Pentagon City Metro	12	27	5	11
MWAYS	2021	Pentagon City Metro	Braddock Rd Metro	12	29	5	10
PURLRT	2021	Bethesda	New Carrollton	12	59	16	16
29BRT2	2021	Briggs Chaney PNR	Silver Spring Transit Center	15	24	11	28
29BRT2	2025	Briggs Chaney PNR	Silver Spring Transit Center	15	24	1	3
MWAYN	2025	Braddock Rd Metro	Army Navy Dr. Transit Station	12	27	5	11
MWAYS	2025	Army Navy Dr. Transit Station	Braddock Rd Metro	12	29	5	10
DCSTHST2	2025	UNION STATION	BENNING ROAD METRO	10	24	4	10
CCTBRTU	2025	COMSAT	SHADY GROVE	30	46	10	13
DCSTGTWN	2025	Union Station/ H St.	Georgetown	10	25	3	7
PURLRT	2025	Bethesda	New Carrollton	12	59	16	16
CCTBRT	2025	METRO GROVE	SHADY GROVE	10	42	9	13
29BRT2	2030	Briggs Chaney PNR	Silver Spring Transit Center	15	24	11	28
CCBRTU	2030	COMSAT	SHADY GROVE	30	46	10	13
CCTBRT	2030	METRO GROVE	SHADY GROVE	10	42	9	13
DCSTGTWN	2030	Union Station/ H St.	Georgetown	10	25	3	7
DCSTHST2	2030	UNION STATION	BENNING ROAD METRO	10	24	4	10
MWAYN	2030	Braddock Rd Metro	Army Navy Dr. Transit Station	12	27	5	11
MWAYS	2030	Crystal City Metro	Braddock Rd Metro	12	29	5	10
PURLRT	2030	Bethesda	New Carrollton	12	59	16	16
US1BRT	2030	HUNTINGTON METRO STATION	WOODBRIDGE VRE	12	38	15	24
VIERSBRT1	2030	Wheaton Metro Station	Rockville Metro Station	18	20	6	18
VIERSBRT2	2030	Wheaton Metro Station	Montgomery College	30	24	8	20
29BRT2	2040	Briggs Chaney PNR	Silver Spring Transit Center	15	24	11	28
CCBRTU	2040	COMSAT	SHADY GROVE	30	46	10	13
CCTBRT	2040	METRO GROVE	SHADY GROVE	10	42	9	13
DCSTGTWN	2040	Union Station/ H St.	Georgetown	10	25	3	7
DCSTHST2	2040	UNION STATION	BENNING ROAD METRO	10	24	4	10
MWAYN	2040	Braddock Rd Metro	Army Navy Dr. Transit Station	12	27	5	11
MWAYS	2040	Crystal City Metro	Braddock Rd Metro	12	29	5	10
PURLRT	2040	Bethesda	New Carrollton	12	59	16	16
US1BRT	2040	HUNTINGTON METRO STATION	WOODBRIDGE VRE	12	38	15	24
VIERSBRT1	2040	Wheaton Metro Station	Rockville Metro Station	18	20	6	18
VIERSBRT2	2040	Wheaton Metro Station	Montgomery College	30	24	8	20
NBETHBRT	2040	Montgomery Mall Transit Center	White Flint Metro Station	15	17	3	11
RANDBRT	2040	White Flint Metro Station	US 29 & Tech Rd.	15	50	11	13
29BRT2	2045	Briggs Chaney PNR	Silver Spring Transit Center	15	24	11	28
CCBRTU	2045	COMSAT	SHADY GROVE	30	46	10	13
CCTBRT	2045	METRO GROVE	SHADY GROVE	10	42	9	13
DCSTGTWN	2045	Union Station/ H St.	Georgetown	10	25	3	7
DCSTHST2	2045	UNION STATION	BENNING ROAD METRO	10	24	4	10
MWAYN	2045	Braddock Rd Metro	Army Navy Dr. Transit Station	12	27	5	11
MWAYS	2045	Crystal City Metro	Braddock Rd Metro	12	29	5	10
NBETHBRT	2045	Montgomery Mall Transit Center	White Flint Metro Station	15	17	3	11
PURLRT	2045	Bethesda	New Carrollton	12	59	16	16
RANDBRT	2045	White Flint Metro Station	US 29 & Tech Rd.	15	50	11	13
US1BRT	2045	HUNTINGTON METRO STATION	WOODBRIDGE VRE	12	38	15	24
VIERSBRT1	2045	Wheaton Metro Station	Rockville Metro Station	18	20	6	18
VIERSBRT2	2045	Wheaton Metro Station	Montgomery College	30	24	8	20
355BRT1	2045	Clarksburg Outlets	Rockville Metro Station	15	60	17	17
355BRT2	2045	Lakeforest Transit Center	Rockville Metro Station	15	24	7	18
355BRT3	2045	Montgomery College - Rockville	Bethesda Meto Station	15	32	9	17
NHBRT	2045	Colesville PNR	Takoma Park Metro Station	15	26	10	23

Note: Off-peak period is from 10:00 AM- 2:59 PM.

Ref:" I:\ateam\docum\fy19\V2.3.75_Visualize2045NetworkReport\Report Tables\ V2375_Visualize2045_Met_Com_BRT_Files_ Updated_Chkd.xlsx"

Source: Visualize 2045 plan and FY 2019-2024 TIP

Table 3-33 shows the rail and road centerline miles for the years 2019, 2021, 2025, 2030, 2040, and 2045.

Table 3-33 Rail and road centerline miles

(modeled area)

	LOV LANE MILES	HOV/HOT LANE MILES	METRORAIL MILES	COMMUTER RAIL * MILES	BRT ** LANE MILES	STREETCAR, LIGHTRAIL *** MILES
	TOTAL	TOTAL	TOTAL	TOTAL	TOTAL	TOTAL
2019	22,967	304	119	220	5	2
2021	23,241	349	119	220	18	18
2025	23,996	387	131	231	27	23
2030	24,105	387	131	231	49	23
2040	24,363	414	131	231	62	23
2045	24,472	414	131	231	95	23

* Includes MARC & VRE
** Includes Metroway, US29, CCT, US1, Veirs Mill, Randolph Rd, Bethesda, MD 355, and New Hampshire Ave
*** Includes Purple Line & DC Streetcar (Benning Road, H St./Benning Rd., and Union Station/Georgetown)

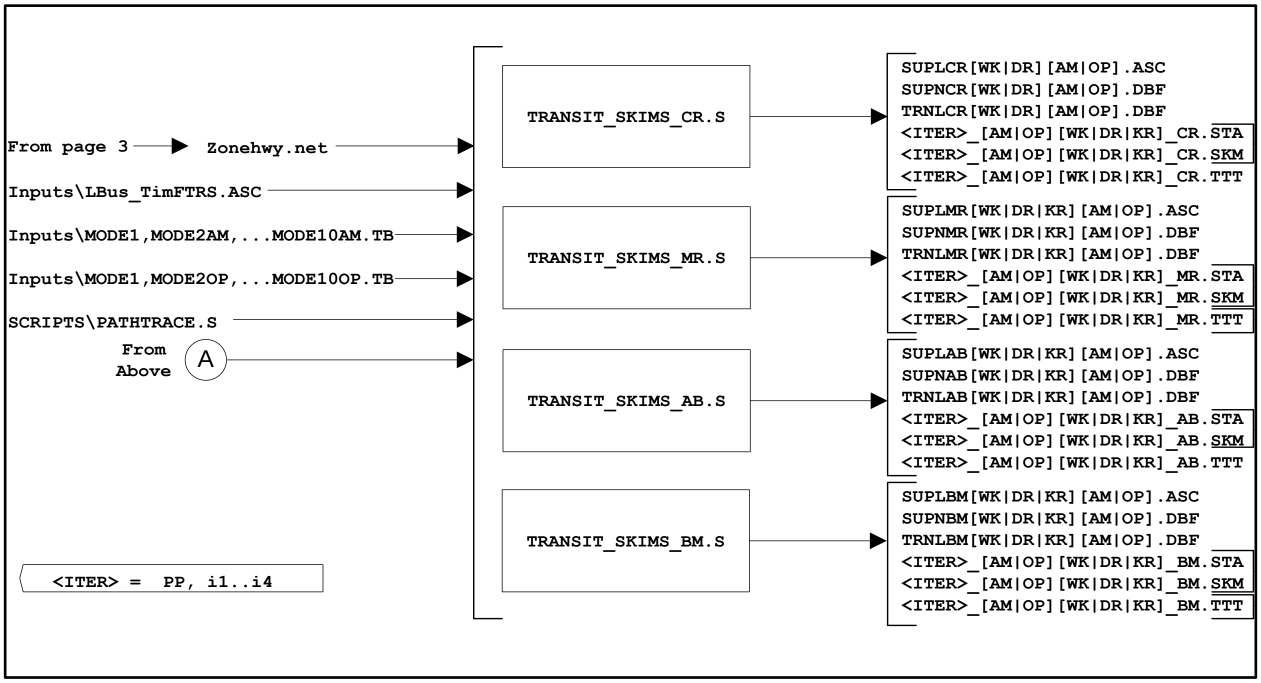
NOTE: If a lane operates as HOV/HOT during any part of the day, it is counted in the HOV/HOT column

Source: Air Quality Conformity Analysis, Visualize 2045, A Long-Range Transportation Plan for the National Capital Region. Washington, D.C.: National Capital Region Transportation Planning Board, Metropolitan Washington Council of Governments, October 17, 2018.

3.4 Transit path building

The transit path building and path skimming process involves the development of 22 sets of level-of-service (LOS) skims (matrices) corresponding to two time-of-day period (peak and off-peak), by four transit sub-modes (bus only, Metrorail only, bus-Metrorail combination, and commuter rail), by three access modes (walk, PNR, KNR). For the calculation of average headways and run times, the peak period is represented by the AM peak hour, and the off-peak period is represented by the five-hour midday period. Although one might expect 24 sets of skims (2 x 3 x 4), there are only 22 since KNR access to commuter rail mode is not considered by the mode choice model, and so the total number of required path sets equals 22. This process is shown schematically in Figure 3-24 and is covered in more detail in Chapter 21 Section 21.6 of the Version 2.3.75 User's Guide dated December 5, 2018.

Figure 3-24 Process for conducting transit path building



3.5 Transit Fare Files

3.5.1 Gathering fare data from the transit providers

WMATA is the dominant transit operator in the Washington, D.C. area, operating both the Metrorail and Metrobus systems. WMATA was created in 1967 as an interstate compact agency. The formal name for its area of coverage is the "Washington Metropolitan Area Transit Zone" (WMATZ), but it is more commonly referred to as the WMATA Compact area. As of 2009, the area includes the following jurisdictions:

- District of Columbia
- The following cities in Virginia
  - Alexandria
  - Falls Church
  - Fairfax
- The following counties in Virginia
  - Arlington
  - Fairfax
  - Loudoun
- The following counties in Maryland
  - Montgomery
  - Prince George's

The tariff used for this analysis was Tariff #37 that was effective June 25, 2017.

In addition to the WMATA tariff, transit fare data is collected for the other transit operators in the modeled area, such as Ride-On, ART, Fairfax Connector, MARC, VRE, and PRTC/Omni. Transit fare data for the Visualize 2045 LRTP is documented in a memo.[26]

3.5.2 Calculating zone-to-zone fares used by the model

The COG transit fare programs are known as MFARE1 and MFARE2. These were originally written as UMODEL programs, known as RPFARE1 and RPFARE2,[27] within the UTPS mainframe software system. In the early 1990s, they were then converted to FORTRAN programs called MFARE1 and MFARE2 for the Maryland Department of Transportation, and then, a year later, they were converted to Microsoft FORTRAN 5.0 for use with MINUTP.[28] The FORTRAN version was used in the Version 2.1D #50 Travel Model, in 2004. In 2007 or 2008, MFARE1 and MFARE2 were converted to TP+ scripts (which is now Cube Voyager), though the conversion was not documented, and the MFARE1 and MFARE2 scripts were first used in the Version 2.2 Travel Model in the spring of 2008.

MFARE1 estimates station-to-station Metrorail fares, which are distance based. Per WMATA policy, the distance component of the fare calculation is based on a "composite mile," which is calculated as the average of (a) the distance traveled along the rail system between the passenger's origin and destination stations and (b) the distance traveled in a straight line or "as the crow flies" between the two stations..[29] **MFARE2 first calculates non-Metrorail transit fares (commonly referred to as "bus" fares**, even though non-Metrorail transit also includes commuter rail, LRT, and BRT). **Next, MFARE2 outputs the following zone-to-zone matrices**:

1. Total transit fares. For paths that include Metrorail, this would include both the Metrorail fare and any other non-Metrorail transit fare that is involved.
2. Metrorail-only fares
3. "Bus"-only fares (i.e., non-Metrorail-transit-only fares)
4. "Bus" access to Metrorail fares (i.e., non-Metrorail-transit access to Metrorail fares)
5. "Bus" egress from Metrorail fares (i.e., non-Metrorail-transit egress from Metrorail fares)[30]

MFARE1 estimates station-to-station Metrorail fares using the composite distance, according to the following procedure, which is based on rules in the WMATA tariff:

- A fixed boarding fare charged for the first few miles.
- A secondary fare charged for the next few miles.
- A "tertiary" fare per mile charged for the remaining miles of the trips.
- The sum of above three fare elements should be less or equal to a maximum fare.
- Calculate discounted fare which applies to certain stations.

---

[26] William Bacon to Files, "Visualize 2045 Bus Fare Matrix Documentation" Memorandum, November 27, 2018.
[27] "RP" stands for the name of the original developer: Richard Pratt.
[28] William G. Allen Jr., "User's Guide for the MWCOG Fare Programs, Microcomputer Version," Final (Metropolitan Washington Council of Governments, June 1992), 2.
[29] Washington Metropolitan Area Transit Authority, "Tariff of The Washington Metropolitan Area Transit Authority Tariff on METRO FARES, Tariff Number 37, Effective June 25, 2017, page 5".
[30] Allen, "User's Guide for the MWCOG Fare Programs, Microcomputer Version," 2.

- Output final fares to a station-to-station matrix.[31]

One of the key inputs to the MFARE1 process is the section of the WMATA Tariff dealing with Metrorail fares (see, for example, Table 3-34). From this table, we can see that there is a peak and an off-peak fare and there is a maximum peak and off-peak fare ($6.00 and $3.85) exclusive of surcharge and differentials. The WMATA fare tariff data is input to the model using the file tariff.txt (see Figure 3-25)

Table 3-34 Metrorail fare structure, WMATA Tariff #37

Metrorail Fare Structure	Regular Fares		All Senior & Disabled
(Effective July 1, 2017)	Peak	Off-Peak	Fares are 1/2 Peak Fare
First 3 composite miles	$2.25	$2.00	
Each additional composite mile more than 3 and less than or equal to 6	$ 0.332	$0.244	$1.10 - $3.00
Each additional composite mile greater than 6	$0.288	$0.216	
Maximum peak fare (Exclusive of Surcharge and Differentials)	$6.00	$3.85	$3.00

Source: WMATA. "Tariff of The Washington Metropolitan Area Transit Authority Tariff on METRO FARES, Tariff Number 37, Effective June 25, 2017, page 6"

Ref: I:\ateam\docum\fy19\V2.3.75_Visualize2045NetworkReport\Report Tables\ Metro_Fare_Tariff#37.xls

[31] Allen, 3.

Figure 3-25 Metrorail fares (peak and off-peak) and the rail-to-bus discounts (Tariff.txt)

```
;;---------------------------------------------------------------------------
;;  WMATA Tariff 37 effective June 25, 2017 fare structure input to MFARE2.S
;;
;;     (Prepared March 26, 2018/jp)
;;
;;  file tariff.txt
;;---------------------------------------------------------------------------
;;  Peak and OffPeak Metrorail Policy
;
; Fare Increment      Fare Rate in Cents     Trip Distance Increment(in Composite Miles)
; in Cents           per Composite mile:    Associated with Fare Increment/Rate
;-------------------  -------------------    --------------------------

Pk_Fare_Incr1 = 225.0  Pk_Fare_Rate1 = 0.0   Pk_Fare_Dist1 =   3.0   ;
Op_Fare_Incr1 = 200.0  Op_Fare_Rate1 = 0.0   Op_Fare_Dist1 =   3.0   ;

Pk_Fare_Incr2 =   0.0  Pk_Fare_Rate2 = 33.0  Pk_Fare_Dist2 =   3.0   ;
Op_Fare_Incr2 =   0.0  Op_Fare_Rate2 = 24.0  Op_Fare_Dist2 =   3.0   ;

Pk_Fare_Incr3 =   0.0  Pk_Fare_Rate3 = 29.0                          ;
Op_Fare_Incr3 =   0.0  Op_Fare_Rate3 = 22.0                          ;

Pk_Fare_Max   =  600.0                                               ;
OP_Fare_Max   =  385.0                                               ;



;;---------------------------------------------------------------------------
;;  Rail-to-Bus discounts in current year cents based on selected tariff   ;;
;;                                                  ;;
DC_RailBus_Disc =  150.0 ;  Area defined by Jur='0' in the zone file input ;; Discount available to SmartTrip card holders only
MD_RailBus_Disc =  150.0 ;  Area defined by Jur='1' in the zone file input ;;
VA1_RailBusDisc =  150.0 ;  Area defined by Jur='2' in the zone file input ;;
VA2_RailBusDisc =  150.0 ;  Area defined by Jur='3' in the zone file input ;;
```

MFARE2 calculates “bus” (non-Metrorail transit) fares using a set of “bus” fare zones. The current program allows for up to 21 bus fare zones in the modeled area. Each TAZ must be associated with either one or two bus fare zones. This is done in the TAZ fare zone file (TAZFRZN.ASC), which is discussed later. The geography of the bus fare zones can be changed from year to year, to reflect areas that have similar transit fares, such as the area around a commuter rail line. Maps of the current bus fare zones can be seen in Figure 3-26 and Figure 3-28. The first figure shows the primary bus fare zones. The second shows the secondary bus fare zones. And the third figure shows the combined effect of overlaying the two bus fare zone systems. Bus fare zone 1 (Figure 3-26) corresponds roughly to the original WMATA Compact area, before Loudoun County was added. In some cases, the bus fare zones are in two discontiguous pieces, such as bus fare zone 2 (Figure 3-26). In some cases, the bus fare zone may be made up of three discontiguous pieces, such as bus fare zone 9, which has two sections in Figure 3-26 and one section in Figure 3-27. In Figure 3-28, we can see the combined effect: there are some parts of Frederick Co. where the TAZs are associated with only one bus fare zone (such as 8, 9 or, 10), but there are some parts of Frederick Co. where the TAZs are associated with two bus fare zones (such as 8 and 9, or 9 and 10). At any rate, no TAZ can be associated with more than two bus fare zones. Names for the 21 bus fare zones can be found in Table 3-36.

Figure 3-26 Regional Primary Bus Fare Zone Map

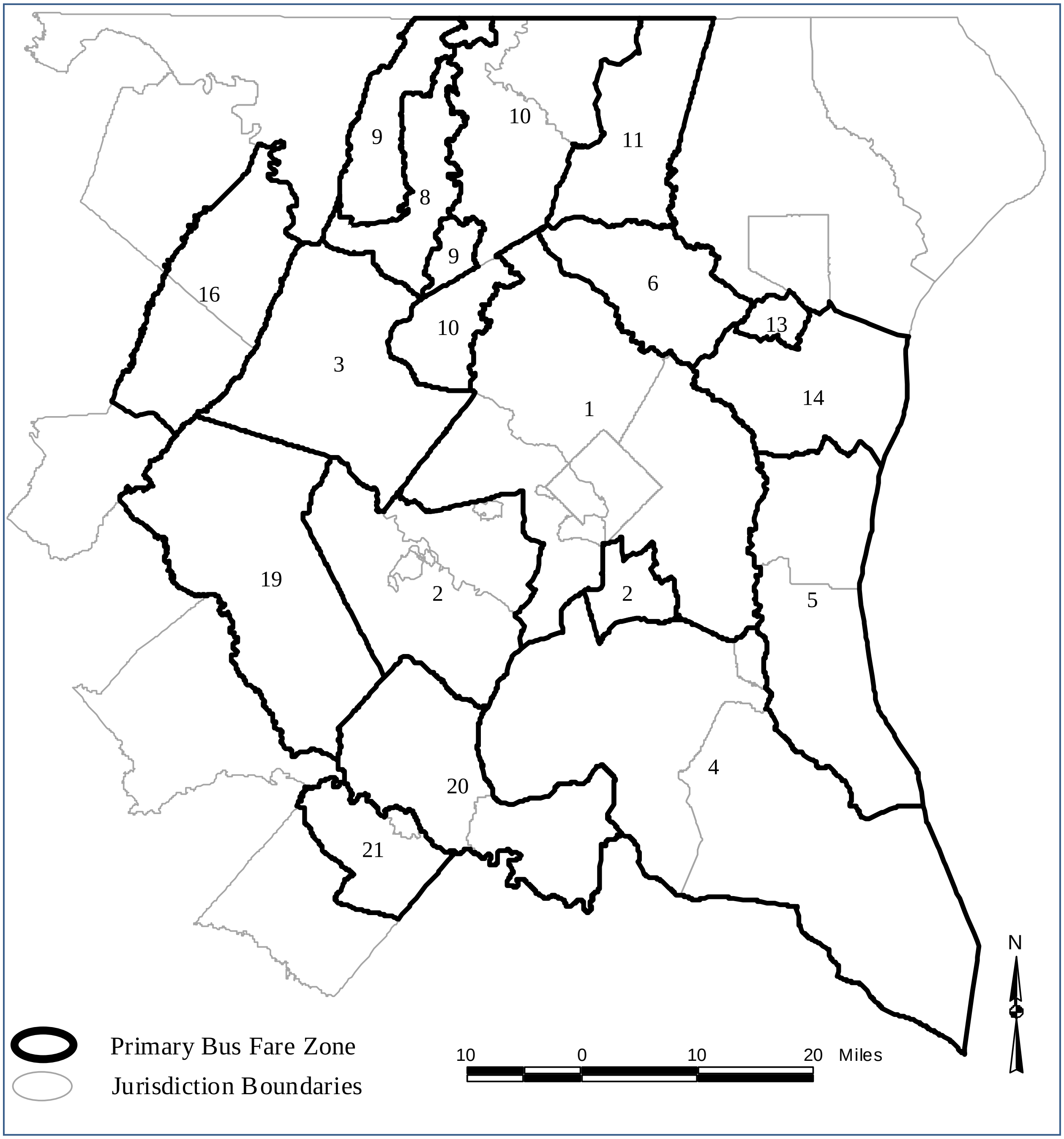


Figure 3-27 Regional Secondary Bus Fare Zone Map

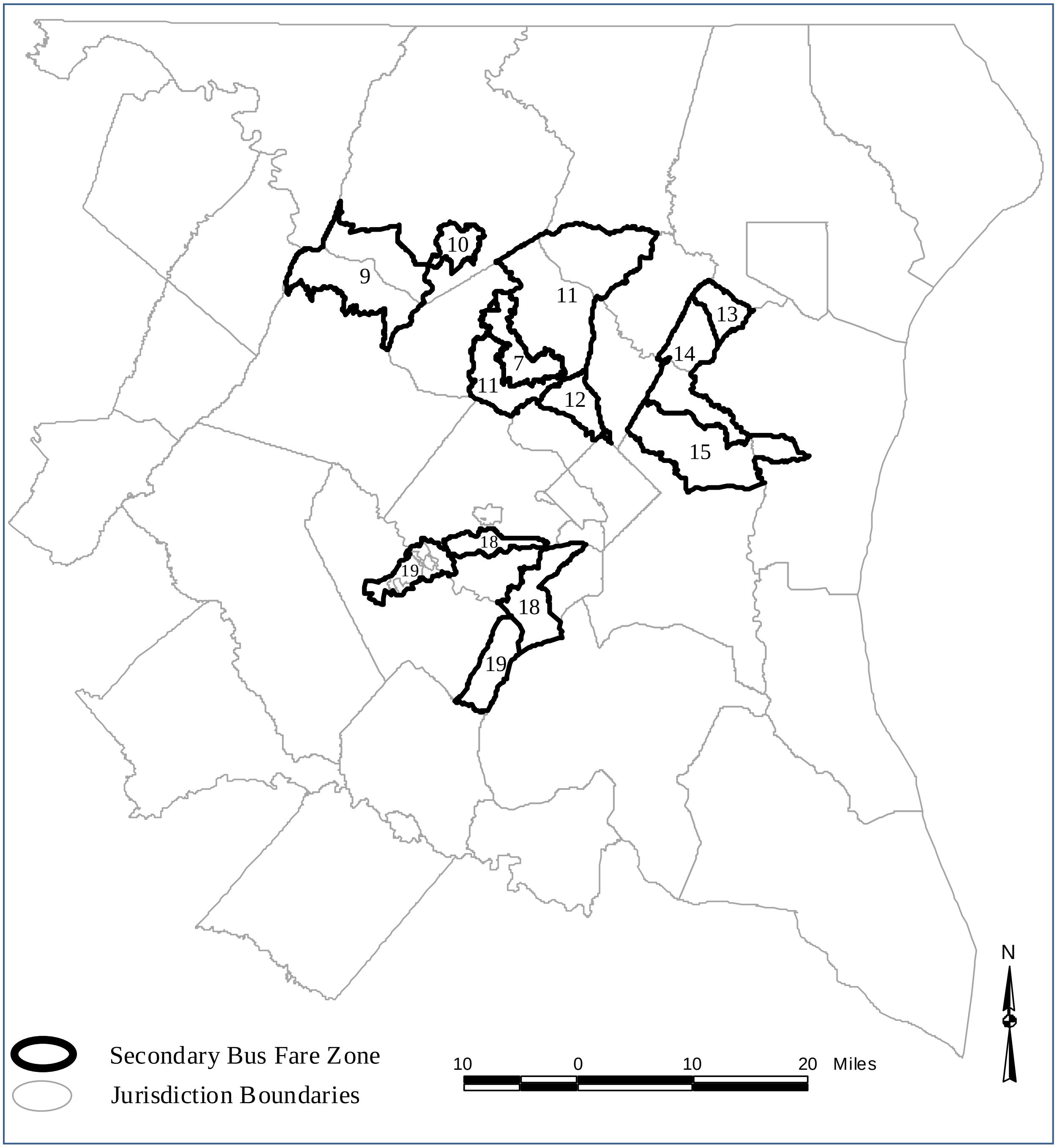
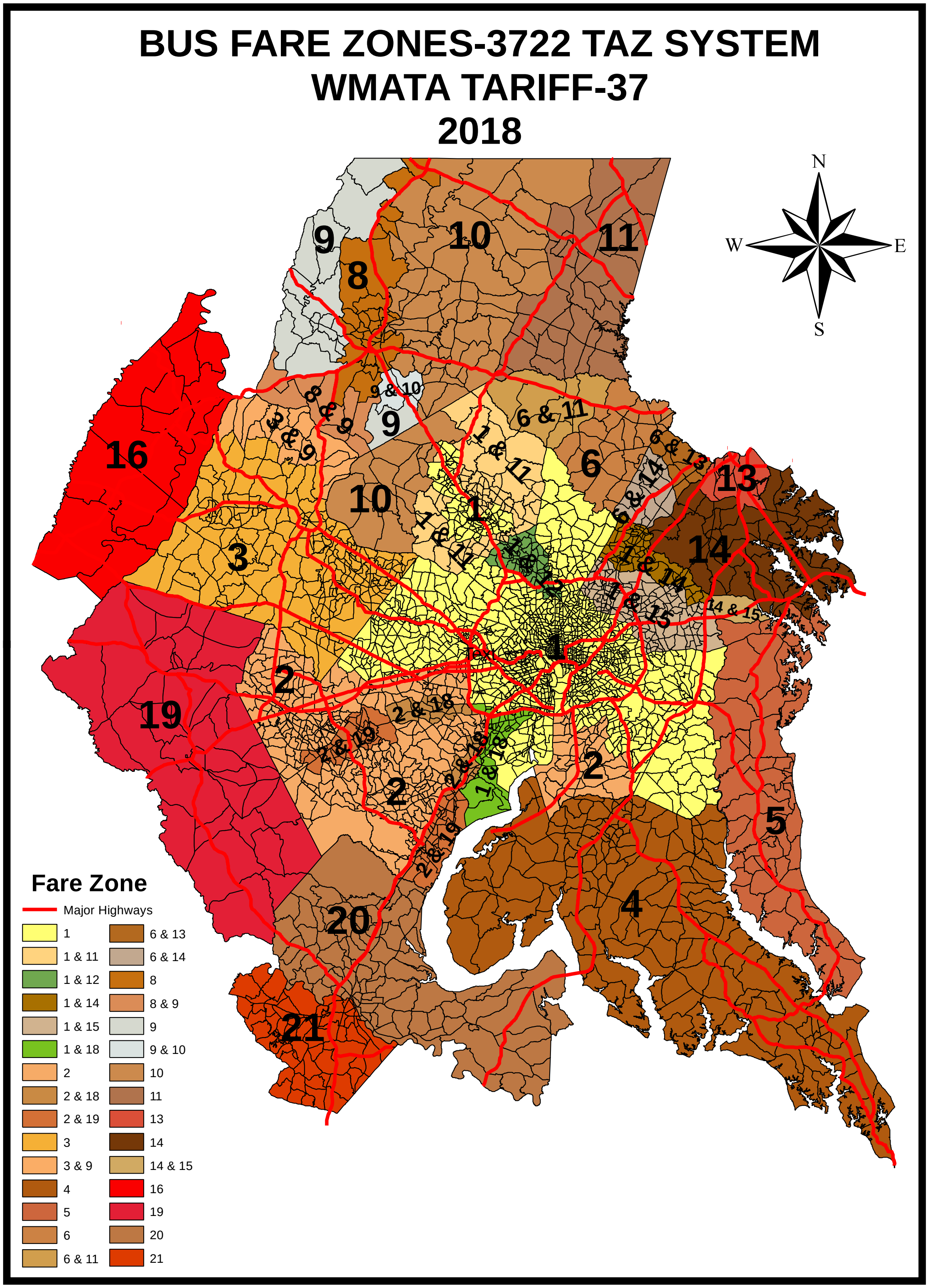


Figure 3-28 Combine bus fare zones (primary overlaid with secondary)



When a TAZ is identified as being in more than one bus fare zone, the fare is calculated using the average fare for both zones. Additionally, each Metrorail station must be associated with a bus fare zone. These associations between bus fare zones and TAZs, and between bus fare zones and Metrorail stations, are stored in the TAZ bus fare zone file (TAZFRZN.ASC), whose file format can be seen in Table 3-35.

Table 3-35 File format: File relating bus fare zones to TAZs and Metrorail stations (TAZFRZN.ASC)

Columns	Format	Field Description
Zonal data (All lines in the file)		
1-8	I4	TAZ Number (1-3,675) and Metrorail Station No. (1-150)
9-16	I4	1st Bus fare zone 1 (currently numbered 1 to 21)
17-24	I4	2nd Bus fare zone 2 (currently numbered 1 to 21)
Metrorail station data (first 150 lines of the file only)		
41-48	I4	1st Bus Fare Zone (currently numbered 1 to 21)
49-56	I4	2nd Bus Fare Zone (currently numbered 1 to 21)
57-64	I8	Jurisdiction code
65-72	I8	P discount
73-80	I8	A discount

The "bus" fare matrix is a 21-by-21 matrix that represents the average non-Metrorail-transit fares from one "bus" fare zone to another. In theory, there can be a separate bus fare zone for peak and off-peak travel. In practice, COG/TPB staff has adopted the practice of using only one bus fare matrix, since there is typically little time-of-day variation in the non-Metrorail transit fares. The current bus fare matrix is shown in Table 3-36. This table also provides names for the bus fare zones and changes since the 2016 CLRP are shaded.

Table 3-36 AM Peak and Off-Peak Bus Fare Matrix between MWCOG Fare Zones (Expressed in 2017 cents)

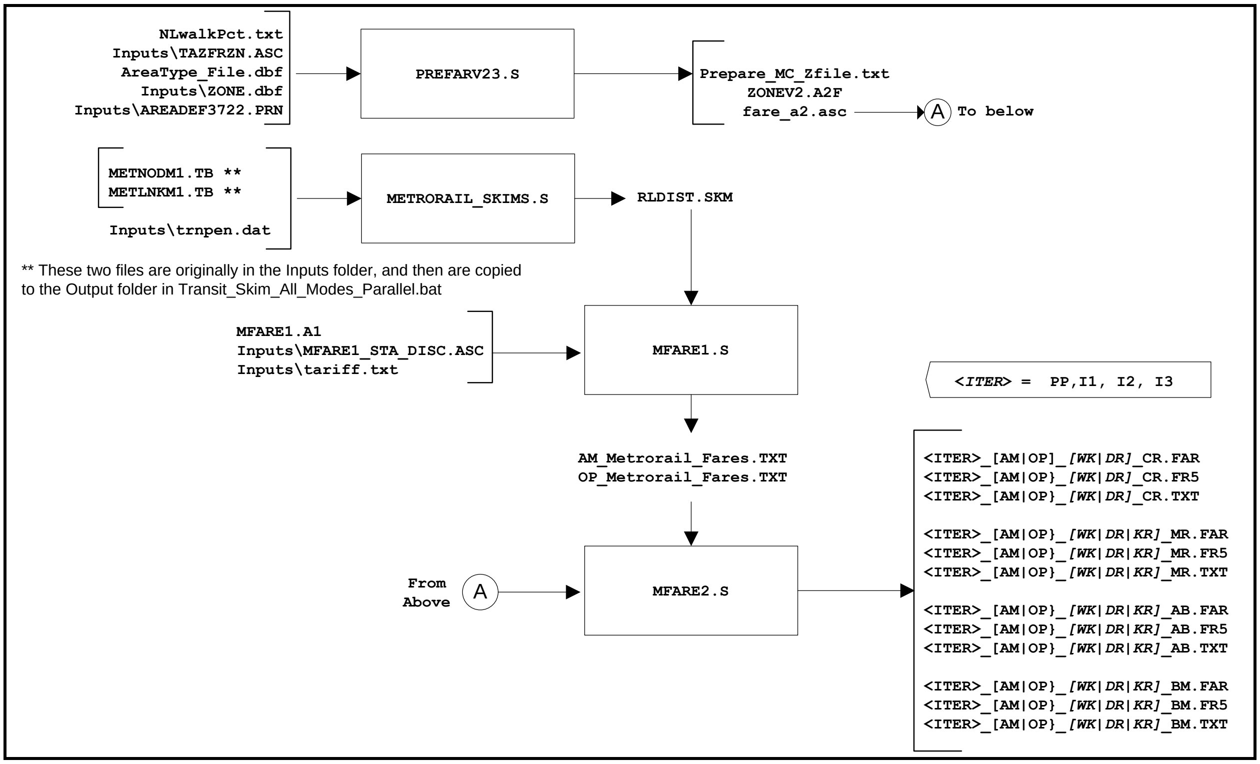
	WMATA Regular Service	WMATA Express Ser. & Internal Metrobus Special Fare Service	Loudoun Comm. Bus	Charles & St. Mary's Comm. Bus (MTA)	Calvert and Southern AA Comm Bus (MTA)	Howard Comm. Bus (MTA)	Not Used Corridor Cities Transitway (Mont. Co)	Frederick Internal Bus	MARC Rail Brunswick (Frederick)	MARC Rail Brunswick (Mont. R8)	MARC Rail Brunswick (Mid. Mont)	MARC Rail Brunswick (Inner)	MARC Rail Penn/ Camden (Outer)	MARC Rail Penn/ Camden (Mid)	MARC Rail Penn/ Camden (Inner)	MARC Rail Brunswick (W.VA and Clark auto Connect)	VRE Zones 1 & 2 (Inside Beltway)	VRE Zones 3 & 4 (FFX and PW)	VRE Zones 5 & 6 (PW & FAUQ Auto Connect)	VRE Zones 7 & 8 (Staff. & KG Auto Connect)	VRE Zone 9 (Spots. & Fred'brg)
Fare Zone	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**
1	200	558	900	412	386	348	498	482	522	430	368	307	430	368	307	795	410	499	588	678	745
2	558	178	1458	970	944	906	1056	1040	1080	988	926	865	988	926	865	1353	721	250	155	452	519
3	900	1458	100	1312	1286	1248	1398	1382	1422	1330	1268	1207	1330	1268	1207	1695	1310	1399	1488	1578	1645
4	412	970	1312	100	798	760	910	894	934	842	780	719	842	780	719	1207	822	911	1000	1090	1157
5	386	944	1286	798	425	734	884	868	908	816	754	693	816	754	693	1181	796	885	974	1064	1131
6	348	906	1248	760	734	348	846	830	870	778	716	655	778	716	655	1143	758	847	936	1026	1093
7	498	1056	1398	910	884	846	130	747	633	516	130	439	928	866	805	1293	908	997	1086	1176	1243
8	482	1040	1382	894	868	830	747	114	114	617	617	617	912	850	789	696	892	981	1070	1160	1227
9	522	1080	1422	934	908	870	633	114	500	503	503	503	952	890	829	582	932	1021	1110	1200	1267
10	430	988	1330	842	816	778	516	617	503	386	386	386	860	798	737	386	840	929	1018	1108	1175
11	368	926	1268	780	754	716	130	617	503	386	309	309	798	736	675	795	778	867	956	1046	1113
12	307	865	1207	719	693	655	439	617	503	386	309	307	737	675	614	795	717	806	895	985	1052
13	430	988	1330	842	816	778	928	912	952	860	798	737	386	386	386	1225	840	929	1018	1108	1175
14	368	926	1268	780	754	716	866	850	890	798	736	675	386	309	309	1163	778	867	956	1046	1113
15	307	865	1207	719	693	655	805	789	829	737	675	614	386	309	232	1102	717	806	895	985	1052
16	795	1353	1695	1207	1181	1143	1293	696	582	386	795	795	1225	1163	1102	700	1205	1294	1383	1473	1540
17	410	721	1310	822	796	758	908	892	932	840	778	717	840	778	717	1205	409	476	566	655	722
18	499	250	1399	911	885	847	997	981	1021	929	867	806	929	867	806	1294	476	237	297	387	454
19	588	155	1488	1000	974	936	1086	1070	1110	1018	956	895	1018	956	895	1383	566	297	230	297	364
20	678	452	1578	1090	1064	1026	1176	1160	1200	1108	1046	985	1108	1046	985	1473	655	387	297	237	275
21	745	519	1645	1157	1131	1093	1243	1227	1267	1175	1113	1052	1175	1113	1052	1540	722	454	364	275	230

[shaded] Fare has increased from the 2016 CLRP

Source: WMATA Tariff #37, effective June 25, 2017.

In addition to MFARE1 and MFARE2, there are two other Cube Voyager scripts that are used in fare development: Prefarv23.s, Metrorail_Skims.s. The entire automated fare development process, consisting of all four programs is shown in Figure 3-29.

Figure 3-29 Process for developing zone-to-zone transit fares



Source: Page A-12 of the User's Guide for the MWCOG/TPB Travel Forecasting Model, Version 2.3.75. Dec. 5, 2018
Ref: "I:\ateam\docum\fy19\tpb_tdfm_gen2\ver2.3\travel_model_user_guide\Ver2.3.75_flowchart_v3.vsd"

Ultimately, 22 fare matrices are developed by sub-mode, time-of-day period, and access type:

- Four sub-modes (Bus Only Metrorail only, Metrorail/ Bus, and Commuter Rail) by;
- Two time-of-day periods (peak and off-peak), by;
- Three access types (Walk, PNR, and KNR).

Since commuter rail access is distinguished by walk and auto access only (i.e., no differentiation between KNR and PNR), 22 matrices are developed (instead of the 24 implied above).

Table 3-37 lists the main transit fare input files. Chapter 17 of the Version 2.3.75 Travel Model User's Guide, dated Dec. 5, 2018, also discusses the fare development process.

Table 3-37 Listing of Transit Fare Input Files

Filename	Description	Type	Source
tazfrzn.asc	Fare Zone File	Text	Analyst-generated
areadef3722.prn	Input TAZ-Mode choice district equivalence	Text	Analyst-generated
trnpen.dat	Metrorail network turn penalty file	Text	Analyst-generated
metlnkm1.tb	Metrorail links	Text	Geodatabase
metnodm1.tb	Metrorail nodes	Text	Geodatabase
mfare1_Sta_Disc.ASC	Metrorail Station fare discount array in cents	Text	Analyst-generated
tariff.txt	WMATA Transit fare (tariff) policy	Text	Analyst-generated
mfare1.a1	Metrorail station XYs scaled to 1/100ths of miles	Text	Geodatabase
BUSFARAM.ASC	AM bus fare matrix	Text	Analyst-generated
BUSFAROP.ASC	Off-peak bus fare matrix (same as AM)	Text	Analyst-generated

Ref: "i:\ateam\docum\fy14\2013LRTP_Network_Report\v23_inputs_v10.xlsx"

4 COG/TPB Multi-Year, Multi-Modal Geodatabase

The network link and node inputs to the TPB travel model are maintained and managed in a multi-year, multi-modal spatial database, implemented as an ArcGIS geodatabase. The geodatabase interacts with a customized editing program, known as COGTools,[32] that runs within ArcGIS (Version 10.4). The program enables highway and network elements in the database to be viewed and edited interactively. This chapter provides some background on the geodatabase (GDB) design, structure and operation. The chapter also addresses how TPB staff utilizes digital, machine-readable transit information that is now publicly available to update and refresh the regional transit networks each year.

4.1 Geodatabase Overview and Editor

The TPB's transportation network geodatabase (GDB) serves as a central repository for highway and transit node and link data. It is currently prepared in Microsoft Access format as a personal geodatabase and stores network data in a multi-modal (highway and transit) and a multi-year framework. The geodatabase includes spatial/geographic information that allows network elements to viewed and edited in the ArcGIS environment. The GDB also includes link attribute data that is required by the travel model. The use of a structured, time-series network database offers several key advantages that did not exist previously:

- Consistency in node and link geometry is enforced over time-series networks. Consistency in link attribute coding over time is also enforced.
- Transit network elements are integrated with highway elements in a relational database. Before the GDB existed, transit features were developed as independent text files that referenced the highway node system. The GDB combines transit and highway features so that they may be viewed (or mapped) as a complete system. The use of related tables means that edits to the highway network result in updates to the associated transit network. This linkage is also available in Cube Base.[33]
- Consistency and accuracy of link screenline and jurisdiction codes are enforced over time. Before the GBD existed, screenline codes and jurisdiction codes were manually coded on highway links and subject to error and inconsistent coding from year to year. Using the GDB, screenlines and jurisdictional boundaries are represented as physical entities. The GDB then uses these physical entities and spatial operations to dynamically assign the appropriate jurisdiction and screenline code to each relevant link, thus reducing the likelihood of manual coding errors.
- The use of a geo-referenced database has greatly facilitated the incorporation of external data from partner agencies into the network development process. Most of the traffic counts,

[32] Qiang Li and Jim Yin, "COGTOOLS User Guide, Revision 3.0" (Washington, D.C.: Metropolitan Washington Council of Governments, National Capital Region Transportation Planning Board, October 17, 2013).
[33] See, for example, p. 590, "Consistency between highway and transit networks", Citilabs, Inc., "Cube Base Reference Guide, Version 6.4.1" (Citilabs, Inc., September 30, 2015).

highway inventory data, observed speed data and transit routing information exists in some type of geo-referenced format.

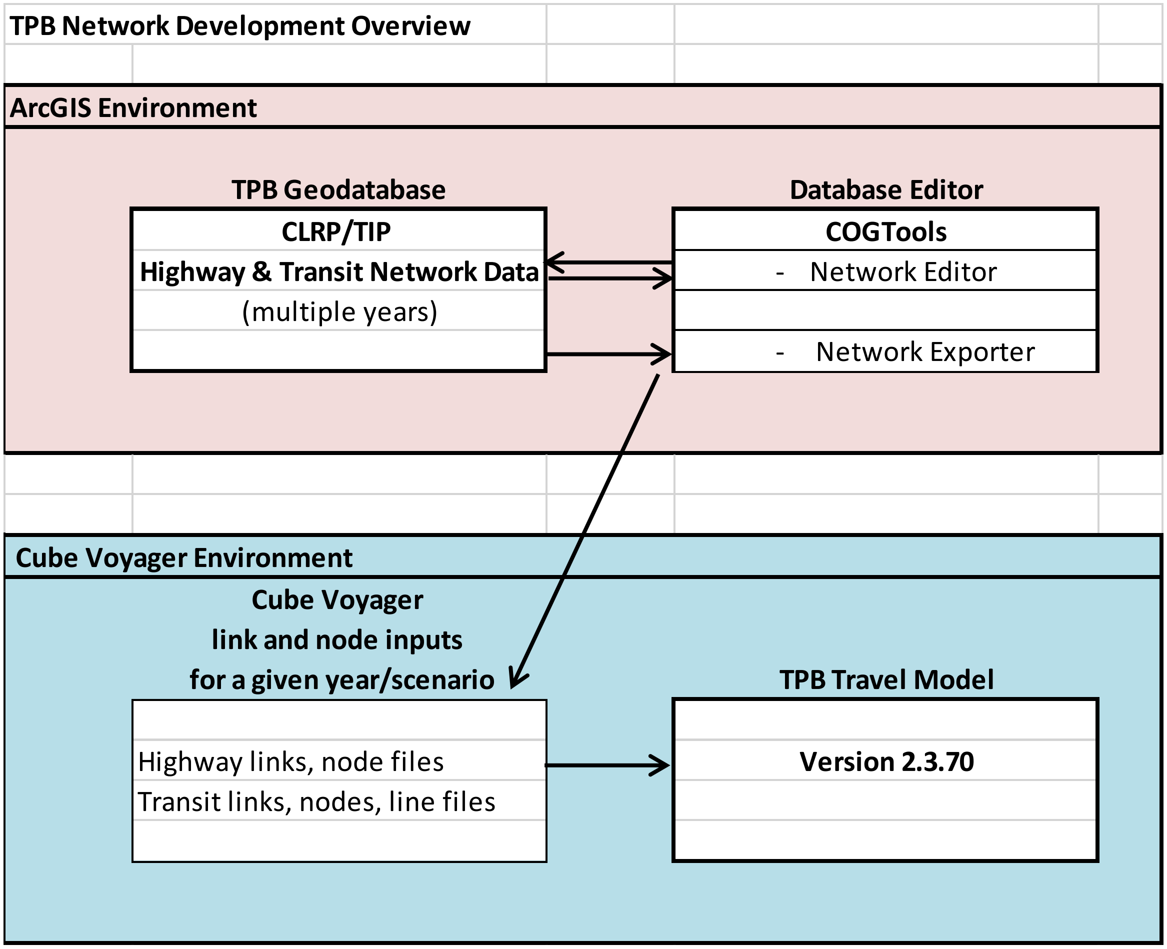
Some of the shortcomings of the current GDB approach include the following:

- Each network scenario is represented by a network year. This is generally not a problem, since the network year and network scenario are the same thing, but it means that one cannot easily represent two network scenarios that would occur in the same year.
- Edits to the highway network are reflected in the transit network, but only in a limited capacity.
- Although highway networks can be generated for any year between the base and horizon year, transit networks can be generated for only the designated milestone years.

The last two of these shortcomings are discussed in more detail later in the chapter.

TPB staff produces a new version of the multi-year GDB with each update of the LRTP, such that it reflects latest version of the LRTP and TIP. The GDB is not developed from "scratch," but rather, is typically developed using the GDB produced from the prior fiscal year (and the prior LRTP) as a starting point. A macro-scale view of the relationship between the GDB and the TPB travel model is shown in Figure 4-1. The figure indicates that the GDB development occurs in the ArcGIS environment.

Figure 4-1 Relationship Between the network geodatabase and the Cube Voyager Modeling Process



Ref: " I:\ateam\docum\fy18\2016LRTP_OffCycle_Network_Report\Rpt_Tables\chapter4_overview_process.xlsx"

As shown in Figure 4-1, the GDB is maintained in ArcGIS and is not an integrated component of the travel modeling environment, which makes use of Citilabs Cube software and is normally launched from a Windows command prompt. The GDB interacts with a customized and interactive program editor named COGTools. The editor is applied as an added "tool bar" within the standard ArcGIS graphical user interface. The COGTools application includes two primary functions: 1) the ability to edit (add, delete or modify) network elements within the GDB and 2) the ability to export year-specific files from the GDB into to Cube Voyager-format files that are read directly into the travel model. The COGTools application also enables customized viewing and mapping of the highway and transit features in the GDB. Note that there are currently two versions of COGTools in operation. One supports the current Gen2/Ver. 2.3 Travel Model, thus, it exports transit network components in Cube TRNBUILD format. The other supports the developmental Gen2/Ver. 2.5 Travel Model, thus, it exports transit network components in Cube Public Transport (PT) format. The version of COGTools supporting TRNBUILD works with ArcGIS 10.4. The version of COGTools supporting PT works only with an older version of ArcGIS (9.3). If the Ver. 2.5 model becomes the production-use model for TPB work, there could be clear benefits to update COGTools so that it would work with ArcGIS 10.4 (or newer).

Before the current Esri geodatabase/COGTools approach, TPB staff used a "master" network stored in ArcInfo to manage the highway networks. In 2004, TPB staff invented a way to perform batch updates on link attributes such as facility type and number of lanes. This process was known as "TIPUP," i.e., TIP update process. In 2009, this process was revised and re-named "PrepTIP," i.e., prepare TIP batch update program.[34]

Following the batch update, manual edits are typically implemented to fine-tune network updates using the COGTools toolbar. Highway editing functions include the ability to:

- Add new facilities: Two approaches
  - Copy the link from a HERE street centerline file and add it to the geodatabase[35]
  - Manually draw the link on the screen via a mouse or other similar pointing device
- Split highway links (insert a node within an existing highway link)
- Delete highway links
- Edit highway link attributes

The toolbar also includes the following transit editing capabilities:

- Add a transit route
- Copy a transit route
- Delete a transit route
- Modify an existing transit route alignment (represented as a series of nodes)
- Edit transit route attributes

The COGTools design dynamically implements transit network changes in response to highway edits, albeit in a limited capacity. For example, when a highway network link is split, the affected transit route(s) are dynamically modified to include the added node within the existing route string.[36] However, if a highway network link is deleted, the affected transit route(s) are not modified, but the user is prompted to manually reconfigure the transit route. Also, only existing transit years in the geodatabase at the time of the highway edit are affected by transit edits. The transit editing tool is designed to identify transit routing errors, including discontinuities in the node string and cases where the transit route is coded in a manner that is inconsistent with the highway link directionality.

The current COGTools application treats highway network editing in a multi-year context. Highway and transit network edits are implemented with attention to a specific "year" attribute that exists on each link. The 2016 LRTP Off-cycle highway networks were prepared, for milestone years: 2017, 2020, 2025 Option A, 2030 Option A, and 2040 Option A. The COGTools editor allows for the generation of highway networks for *any year* between the base year and horizon year, respecting the edits implemented for

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[34] Robert Snead, Charlene Howard, and Jane Posey, "Highway Network Database Batch Updates: PrepTIP Program," Memorandum, March 11, 2009.

[35] To use this functionality, a HERE data layer must be present in the editing window. In the future, we hope to enhance this function to improve the user experience.

[36] This capability is also available in the Citilabs Cube Base graphical network editor, provided the user has both the highway and transit networks open at the same time.

each milestone year. Highway edits implemented for a given year, say 2020, will carry forth among networks for all years hence, including both milestone years and intermediate years. Transit networks, unlike highway networks, are developed individually for specific milestone years, so the database lacks the ability to propagate changes from one transit network to the next. However, all the transit years that are developed are stored together in the GDB.

The COGTools toolbar also allows for exporting year-specific files from the GDB to input files that are directly used by the travel model. The exporting process is performed separately for highway files and transit files. The highway export may be performed for any year and two formats may be selected:

1) *Cube Voyager input file* (link.dbf and node.dbf), or
2) *Personal geodatabase* (link and node feature classes).

The first format is designed to export network link and node files, in DBF file format, for any year specified by the user (i.e., any milestone or non-milestone year). The files exported comply with the input file format required by the Version 2.3.75 Travel Model. The second format may be used to export highway network line and point feature classes from the geodatabase and build a highway network *(*.net)* in Cube Base, using the GIS tools module in Cube Base ("Build highway network from a feature class / shapefile").

The highway exporting function includes the following features:

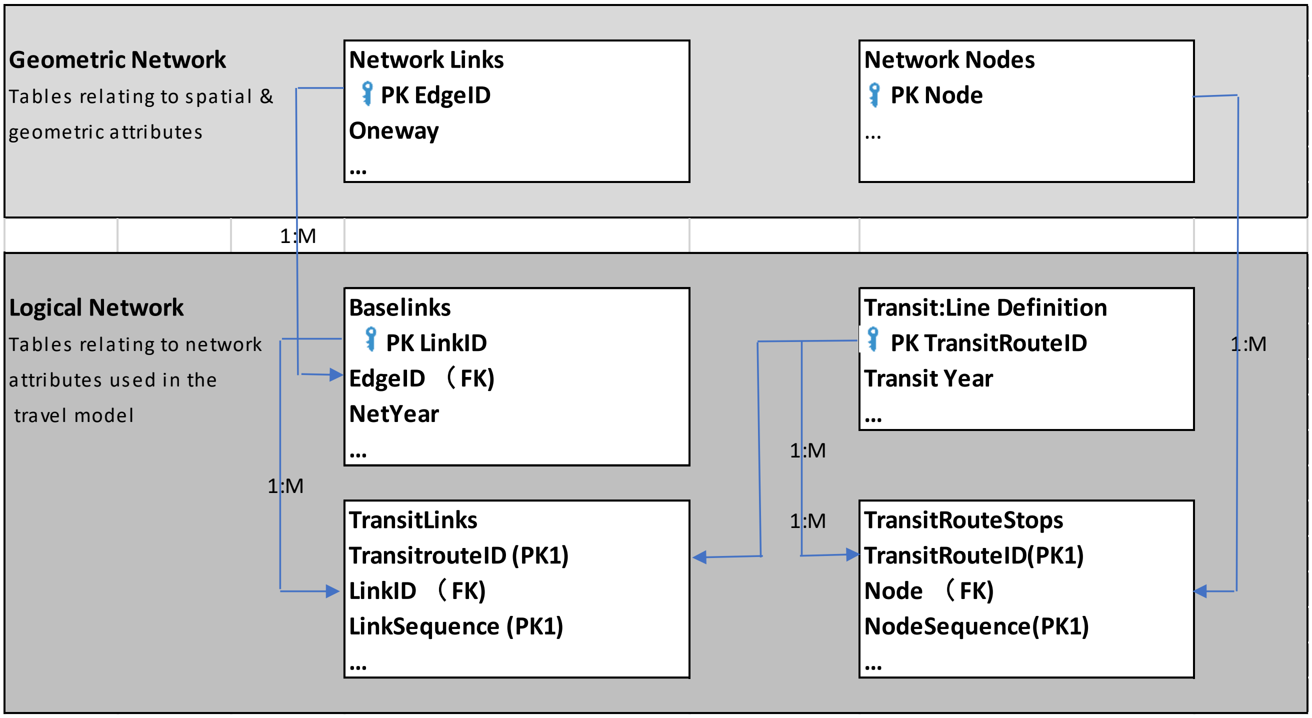
- It assigns link distances that reflect HERE/NAVTEQ centerline "true shape" lengths. Link distances are converted from feet to whole miles with an explicit decimal.
- It assigns jurisdiction codes to the highway network links based on the jurisdictional boundary shapes. Jurisdictional boundaries are included as a feature class in the network geodatabase. Highway links are associated with jurisdictions based on the midpoint of the link relative to jurisdictional boundaries.
- It assigns screenline codes to all highway network links that intersect the screenline feature class/layer that is contained in the network geodatabase.

The transit exporting function generates the full complement of year-specific transit link, node and route/line files for each transit year specifically included in the database. These are compliant with TPB's Version 2.3.75 Travel Model specifications.

4.2 Geodatabase Tables Overview

A more detailed view of the tables that exist within the GDB structure is shown in Figure 4-2. The GDB is a collection of related MS Access tables that are of two general types: geometric network tables and logical network tables. The geometric network consists of two "feature class" tables: a network links table and a network nodes table. The two tables contain basic attributes of links and nodes in the transportation network, and geographic information that is necessary for displaying network features on a map.

Figure 4-2 TPB Geodatabase Structure



Ref: " I:\ateam\docum\fy19\V2.3.75_Visualize2045NetworkReport\Report Tables\GDB_Structure.xlsx"

In Figure 4-2, "PK" means "primary key" and "FK" means "foreign key," as described below. The geodatabase is a relational database, which means it is a database composed of tables ("relations"). Tables can be related to each other, in which case, there is a minimum and maximum number of elements allowed on each side of the relationship, known as the minimum and maximum cardinality. In general, the maximum cardinality values can be 1:1 (one-to-one), 1:M (one-to-many), M:1 (many-to-one), and N:M (many-to-many). Minimum cardinalities (not shown in Figure 4-2) are typically zero (optional) or one (mandatory). Additionally, tables are normally set up to contain only unique records (no duplicates). A key value is a variable that uniquely defines a record in a table. Since there can be more than one variable that can serve as a key, each of these variables is called a candidate key. Normally, one of the candidate keys is chosen as the primary key (PK). If a database is stored in a database management system (DBMS), normally the DBMS enforces "entity integrity" (e.g., no duplicate rows allowed) and "referential integrity" (ensure that minimum and maximum cardinalities are obeyed). Although COGTools is essentially a spatial DBMS, it enforces neither entity integrity or referential integrity. Nonetheless, it can still be useful to show which variables are the primary and foreign keys. For example, when two tables have a 1:M relationship, the first table is called the parent and the other table is called the child. In the case of a 1:M relationship, the primary key of the parent table is placed inside the child table as a foreign key. In some cases, a key is composed of two or more variables, in which case the key is called a composite key.

In Figure 4-2, there is a 1:M relationship between the "Network Links" table and the "BaseLinks" table, so the primary key of the "Network Links" table (EdgeID) is placed as a foreign key in the "Baselinks" table. Note that both the "TransitLinks" table and the "TransitRouteStops" table each have a composite key (labeled as PK1), which is composed of two variables: TransitRouteID and LinkSequence.

The network links attributes are shown in Table 4-1. Two notes about Table 4-1: First, the attribute RouteName is a placeholder and is currently blank. In the future, it is hoped to populate this attribute with actual link (road segment) names. Second, the information in the table about the oneway flag attribute is correct, even though it seems counter-intuitive: Namely, "1" indicates a two-way link and "2" indicates a one-way link. The network node table attributes are shown in Table 4-2.

In contrast, the logical network is a group of tables that contain travel model-related attributes associated with the links and nodes. The logical network consists of four tables:

1. Base Links: Highway and transit network link attributes (see Table 4-3).
2. Transit Links: Transit network-related links (see Table 4-4).
3. Transit Route Stops: Transit route alignments, expressed as a network node sequence (see Table 4-5).
4. Transit Line Definition: The transit line attributes (see Table 4-6).

The highway network is composed of geometric elements from the network links and network node tables and logical network elements from the Baselinks table. The EdgeID variable in the network links table is a unique number that uniquely identifies each physical (geometric) link. It does not vary by direction or network year. As noted earlier, as shown in Figure 4-2, the EdgeID variable is the primary key field that relates the geometric and logical highway networks. The relationship between the geometric network and the logical network is one to many (1:M). That is, each record/link in the geometric network (Network Link feature class table) may correspond to one, or many records/links in the logical network (Base Links table). Records/links in the logical network represent different network years.

In the logical network, LinkID is a unique number assigned to identify links by direction and transit year. It is a primary key variable that relates the logical network base links table and transit links table. The relationship between logical links and transit links is also one to many (1:M). That is, each logical network link may correspond to zero, one, or many transit links.

In the transit network, TransitRouteID is unique number assigned to identify transit route for different transit years in the TransitLineDefinition table. It is the primary key variable that relates the TransitLinks and TransitRouteStops tables. The relationship between TransitLineDefinition and transitLinks/TransitRouteStops is one to many (1:M).

In the geometric network, the Network Nodes feature class mainly provides the geographic location of transportation facilities, such as transit stations, bus stops, park-and-ride lots, intersections, and zone centroids. Node is the unique numerical ID and functions as the primary key that relates the geometric network and the logical network, i.e., the nodes feature class table and the base links table.

Table 4-1 Network Links Feature Class table with "Link Type" codes (1-16) description

Field Name	Data Type	Description
OBJECTID	Long Integer	Geodatabase record identifier
Shape	N/A	Geodatabase geometry field
EdgeID	Long Integer	Geometry network link identifier
LinkType	Long Integer	Link type code: 1. Highway Link 2. Bus Link 3. TAZ Connector 4. Metrorail Link 5. Commuter Rail Link 6. Light Rail Link 7. Light Rail to Bus 8. Metro Station to Bus Stop 9. Commuter Station to Bus Stop 10. Metro PNR to Station 11. Commuter PNR to Station 12. Bus PNR to Bus Stop 13. Light PNR to Station 14. BRT/Street Link 15. BRT/Street PNR to Station 16. BRT/Street to Bus
ANode	Long Integer	A Node
BNode	Long Integer	B Node
FunctionClass	Long Integer	Link facility type code (0 - 6) *0/centroids, 1/Freeways, 2/Major Art., 3/Minor Art, 4/ Collector, 5/ Expressway, 6/ Ramp*
Oneway	Integer	One-way or two-way link code: *1= two-way and 2= one-way*
RampFlag	Text	RampFlag is sometimes populated with "P", and represents updates to perpendicular links of the facility being updated for some projects. This is used in the PrepTIP process—the links with RampFlag=P have the year updated, but not the number of lanes or facility type of the project with which they are associated.
RouteID	Long Integer	(Not Used)
RouteName	Text	Facility name (place holder field, not currently populated)
UpdateBy	Text	Person's name updating the geodatabase
Screen	Long Integer	Screenline Code (1-38)
JUR	Integer	Jurisdiction code (0 -23): *0/dc, 1/mtg, 2/pg, 3/alr/, 4/alx,5, ffx, 6/ldn, 7/ pw, 8/(unused), 9/ frd, 10/how, 11/aa, 12/chs, 13/(unused), 14/car, 15/cal, 16/stm, 17/ kg, 18/fbg, 19/stf, 20/spts, 21/fau, 22/clk, 23/jef*
Length	Double	Link Length in feet
Shape_Length	Double	ArcGIS auto-generated geometry length "true shape" in feet

Ref: "I:\ateam\docum\FY18\2016LRTP_OFFCYCLE_NETWORK REPORT\Rpt_Tables\gdb_tables.xlsx"

Table 4-2 Network Nodes Feature Class table with "Node Type" codes (1-13) description

Field Name	Data Type	Description
OBJECTID	Long Integer	Geodatabase record identifier
Shape	N/A	Geodatabase geometry field
Node	Long Integer	Node numbers
NodeType	Long Integer	Node type code: 1= Highway Node 2= Bus Node 3= TAZ Centroid 4= Metrorail Node 5= Commuter Rail Node 6= Light Rail Node 7= Light Rail Parking Lot Node 8= Metro Parking Lot Node 9= Commuter Parking Lot Node 10= Bus PNR Node 11=BRT Street Node 12= BRT Street PNR 13= Station Dummy Centroid Node
Jur	Text	Jurisdiction code (0 - 23) *0/dc, 1/mtg, 2/pg, 3/alr/, 4/alx,5, ffx, 6/ldn, 7/ pw, 8/(unused), 9/ frd, 10/how, 11/aa, 12/chs, 13/(unused), 14/car, 15/cal, 16/stm, 17/ kg, 18/fbg, 19/stf, 20/spts, 21/fau, 22/clk, 23/jef*
UpdatedBy	Text	(Not Used)
X_COORD	Double	X coordinate of a node (MD State Plane, NAD83, feet)
Y_COORD	Double	Y coordinate of a node (MD State Plane, NAD83, feet)
Name	Text	TransitStop/Station Name
NetYear	Long Integer	The year the network node becomes active in the database

Ref: "I:\ateam\docum\FY16\2015LRTP_Network_Report\NW_Report_Tables\gdb_tables.xlsx"

Table 4-3 Base Links Table with "Mode" codes (1-16) description

Field Name	Data Type	Description
OBJECTID	Long Integer	Geodatabase record identifier
LinkID	Long Integer	Logical network link Identifier
EdgeID	Long Integer	Geometry network link identifier
ANode	Long Integer	A Node
BNode	Long Integer	B Node
NDPR2	Text	Combination of Anode and Bnode (Not Used)
BaseYear*	Long Integer	Year 2000 or Year 2001
TravelDirection	Text	(Not Used)
Distance	Double	Link distance in miles (X.XX)
LinkType	Long Integer	Link type code (1-16)
Mode	Long Integer	Mode Code (1-16):
		1= Local Metrobus
		2= Express Metrobus
		3= Metrorail
		4= Commuter Rail
		5= Light Rail
		6= Other primary - Local bus
		7= Other primary - Express bus
		8= Other secondary - Local bus
		9= Other secondary – Express bus
		10= Bus Rapid Transit or Streetcar
		11= Drive Access link
		12= Bus-to-rail Transfer link
		13= Walking link
		14= (Not Used)
		15= PNR-to-Rail station/Bus stop
		16= Zonal Access or Egress
TOLL	Integer	Toll value in current year dollars
TollGrp	Long Integer	Toll Group code (1- 9999)
FType	Long Integer	Link facility type code (0 - 6)
		0/centroids, 1/Freeways, 2/Major Art., 3/Minor Art, 4/ Collector, 5/ Expressway, 6/ Ramp
LType	Text	Link type: *H=Highway links, T=Transit only links, and Z=TAZ*
AType	Long Integer	Area type code (1 -6)
<Period> Lane	Long Integer	<Period> number of lanes
<Period> Limit	Long Integer	<Period> limit code (0 - 9)
Screen	Long Integer	Screenline code
NetYear	Long Integer	The year the network link becomes active in the database
ProjectID	Text	Project identifier
ZoneID	Long Integer	TAZ centroid identifier (1-3,722)
Status	Long Integer	Link status code: *1= Active and 2= Retired*
COGStatus	Text	(Not Used)
UpdateDate	Text	The date and time of link attributes update
Jur	Long Integer	Jurisdiction code (0 - 23) *0/dc, 1/mtg, 2/pg, 3/alr/, 4/alx,5, ffx, 6/ldn, 7/ pw, 8/(unused), 9/ frd, 10/how, 11/aa, 12/chs, 13/(unused), 14/car, 15/cal, 16/stm, 17/ kg, 18/fbg, 19/stf, 20/spts, 21/fau, 22/clk, 23/jef*
Count	Long Integer	(Not Used)
Speed	Double	(Not Used)
Key		
<Period> =	AM	AM peak period (6:00 9:59 AM)
	PM	PM peak period (3:00 - 7:00 PM)
	OP	Off-peak period (10:00 Am - 2:59 PM)
BaseYear*	2000	Links entered into the databasae by DCI when first developed
	2001	Links subsequently entered into the databasae by DTP staff

4.3 Transit Network Tables

In the logical network, the transit network is represented by the following three tables:

1. Transit Links: Maintains the attributes of the transit network links.
2. Transit Route Stops: Consists of all transit connection points including bus stops, transit stations, and park-and-ride lots.
3. Transit Lines Definition: Contains year-specific transit data for each transit route.

The TransitRouteID variable is a primary key in the "Transit Line Definition" table and a foreign key in the "Transit Links" table and "Transit Route Stops" table. Thus, as shown in Figure 4-2, it links these three tables together. Attributes maintained in the Transit Links, Transit Route Stops, and Transit Lines Definition tables are shown in Table 4-4, Table 4-6, and Table 4-5, respectively.

Table 4-4 Transit Links Table

Field Name	Data Type	Description
ObjectID	Long Integer	Geodatabase record identifier
LinkID	Double	Logical network link identifier
TransitRouteID	Long Integer	Transit Route identifier
ANode	Double	A Node
BNode	Double	B Node
LinkSequence	Double	Sequence number of links that form a transit route
Scenario	Text	Project identifier
TransitYear	Double	Specific year of the transit route
SYear	Double	Year project is open for use
Operation	Double	Operation time code: *1= AM peak and 2= off-peak*

Ref: "I:\ateam\docum\FY16\2015LRTP_Network_Report\NW_Report_Tables\gdb_tables.xlsx"

Table 4-5 Transit Route Stops Table

Field Name	Data Type	Description
ObjectID	Long Integer	Geodatabase record identifier
TransitRouteID	Long Integer	Transit Route identifier
Node	Long Integer	List of nodes used by a transit route
NodeSequence	Long Integer	Sequence number of nodes on a specific transit route
Operation	Long Integer	Transit operation preriod code: *1= AM peak (7:00AM -7:59 AM) and 2= off-peak (10:00AM-2:59PM)*
StopFlag	Integer	Transit stop or non-stop code: *0= Stop and 1= Non-Stop*
SourceYear	Long Integer	Base year from which transit route is derived
SYear	Long Integer	Year project is open for use
Scenario	Text	Project identifier
TransitYear	Long Integer	Specific year of the transit route

Table 4-6 Transit Lines Definition Table

Field Name	Data Type	Description
ObjectID	Long Integer	Geodatabase record identifier
TransitRouteID	Long Integer	Transit Route identifier
TransitRouteName	Text	Transit Route name
OriginNode	Long Integer	Origin-of-transit-route stop node identifier
DestinationNode	Long Integer	End-of-transit-route stop node identifier
OriginNodeName	Text	Origin transit line station name e.g. Shady Grove Station
DestiNodeName	Text	End-of-the line station name e.g. Glenmont Station
Oneway	Long Integer	One-way or two-way route code: *1= two-way and 2= one-way*
Mode	Long Integer	Mode Code: 1= Local Metrobus 2= Express Metrobus 3= Metro Rail 4= Commuter Rail 5= Light Rail 6= Other primary - Local bus 7= Other primary - Express bus 8= Other secondary - Local bus 9= Other secondary – Express bus 10= Bus Rapid Transit or Streetcar 11= Drive Access link 12= Bus-to-rail Transfer link 13= Walking link 14= (Not Used) 15= PNR-to-Rail station/Bus stop 16= Zonal Access or Egress
Headway	Double	Transit vehicle headway (in mins.)
Runtime	Long Integer	Transit route running time (in mins.)
Operation	Long Integer	Transit operation preriod code: *1= AM peak (7:00 AM -7:59 AM) and 2= off-peak (10 AM-2:59 PM)*
SourceYear	Long Integer	Base year from which transit route is derived
Scenario	Text	Project identifier
TransitYear	Long Integer	Specific year of the transit route
SYear	Long Integer	Year project is open for use
RunSpeed	Long Integer	(Not Used)
LineDistance	Long Integer	(Not Used)
Operator	Text	Transit operator / owner name, e.g. WMATA

Ref: "I:\ateam\docum\FY16\2015LRTP_Network_Report\NW_Report_Tables\gdb_tables.xlsx"

4.4 General Transit Feed Specification (GTFS) Data

One of the standard procedures in the network development process for a regular update of the long-range transportation range plan is an update of the base-year transit network line files. The base-year transit network is the starting point for developing all the future-year transit networks. The update generally involves:

1) Ensuring that the transit lines reflect the most up-to-date run times and service frequencies.
2) Checking on whether individual transit lines have been added or removed.

In the past, the update was done using the paper route schedules published by the transit operators. In the late 1990s, the larger transit operators, such as WMATA and Ride-On, provided some digital, machine-readable schedule data that could be used to calculate average run times and frequencies (headways) for each of the two time-of-day periods (peak and off peak).[37] [38] In 2005, Google and Portland's TriMet transit agency developed an electronic data format for incorporating transit data into online maps. The format was initially known as "Google Transit Feed Specification" (GTFS). Over the next few years, this standard became the default format for sharing public transit scheduling information, and later, the name was changed to "General Transit Feed Specification" (also GTFS). A GTFS feed is a collection of comma-separated (CSV) files that represents a public transit system's schedules and transit route itineraries. Each file contains an aspect of transit service, including stops, routes, trips, and other schedule data. The GTFS specification is defined by the series of files shown in Table 4-7.

Currently, COG staff makes use of both the machine-readable, digital data from GTFS and paper schedules (or PDF files from transit operator websites), when the GTFS data is not available. Given the manual effort involved, the transit line updating process has generally been one of the more onerous tasks in the network development area.

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[37] Mark S. Moran, "Using Electronic Files from WMATA to Calculate Average Headways and Run Times for 1998 WMATA Bus Service," Internal Report (Washington, D.C.: Metropolitan Washington Council of Governments, February 18, 1999).

[38] Mark S. Moran, "Fall 1999 Ride On Bus Schedule Data: Using SAS to 1) Calculate Average Headways and Run Times and 2) Determine Which Routes Are Eligible for Coding as Two-Way Routes," Internal Report (Washington, D.C.: Metropolitan Washington Council of Governments, October 20, 1999).

Table 4-7 GTFS files

Filename		
agency.txt	Required	One or more transit agencies that provide the data in this feed.
stops.txt	Required	Individual locations where vehicles pick up or drop off passengers.
routes.txt	Required	Transit routes. A route is a group of trips that are displayed to riders as a single service.
trips.txt	Required	Trips for each route. A trip is a sequence of two or more stops that occurs at specific time.
stop_times.txt	Required	Times that a vehicle arrives at and departs from individual stops for each trip.
calendar.txt	Required	Dates for service IDs using a weekly schedule. Specify when service starts and ends, as well as days of the week where service is available.
calendar_dates.txt	Optional	Exceptions for the service IDs defined in the calendar.txt file. If calendar_dates.txt includes ALL dates of service, this file may be specified instead of calendar.txt.
fare_attributes.txt	Optional	Fare information for a transit organization's routes.
fare_rules.txt	Optional	Rules for applying fare information for a transit organization's routes.
shapes.txt	Optional	Rules for drawing lines on a map to represent a transit organization's routes.
frequencies.txt	Optional	Headway (time between trips) for routes with variable frequency of service.
transfers.txt	Optional	Rules for making connections at transfer points between routes.
feed_info.txt	Optional	Additional information about the feed itself, including publisher, version, and expiration information.

GTFS information in the Washington, D.C. region is available for about 87% of the existing transit routes. As shown in Table 4-8, 17 of the 36 transit service providers included in the regional transit network currently post GTFS information. Although fewer than half of the transit services are provided in GTFS format, the 87% figure arises from the fact that the larger transit agencies (like WMATA and Ride-On) tend to offer GTFS data, whereas the smaller agencies tend to not offer GTFS data.

Table 4-8 Availability of GTFS data for transit providers in the Washington, D.C. area (TPB modeled area)

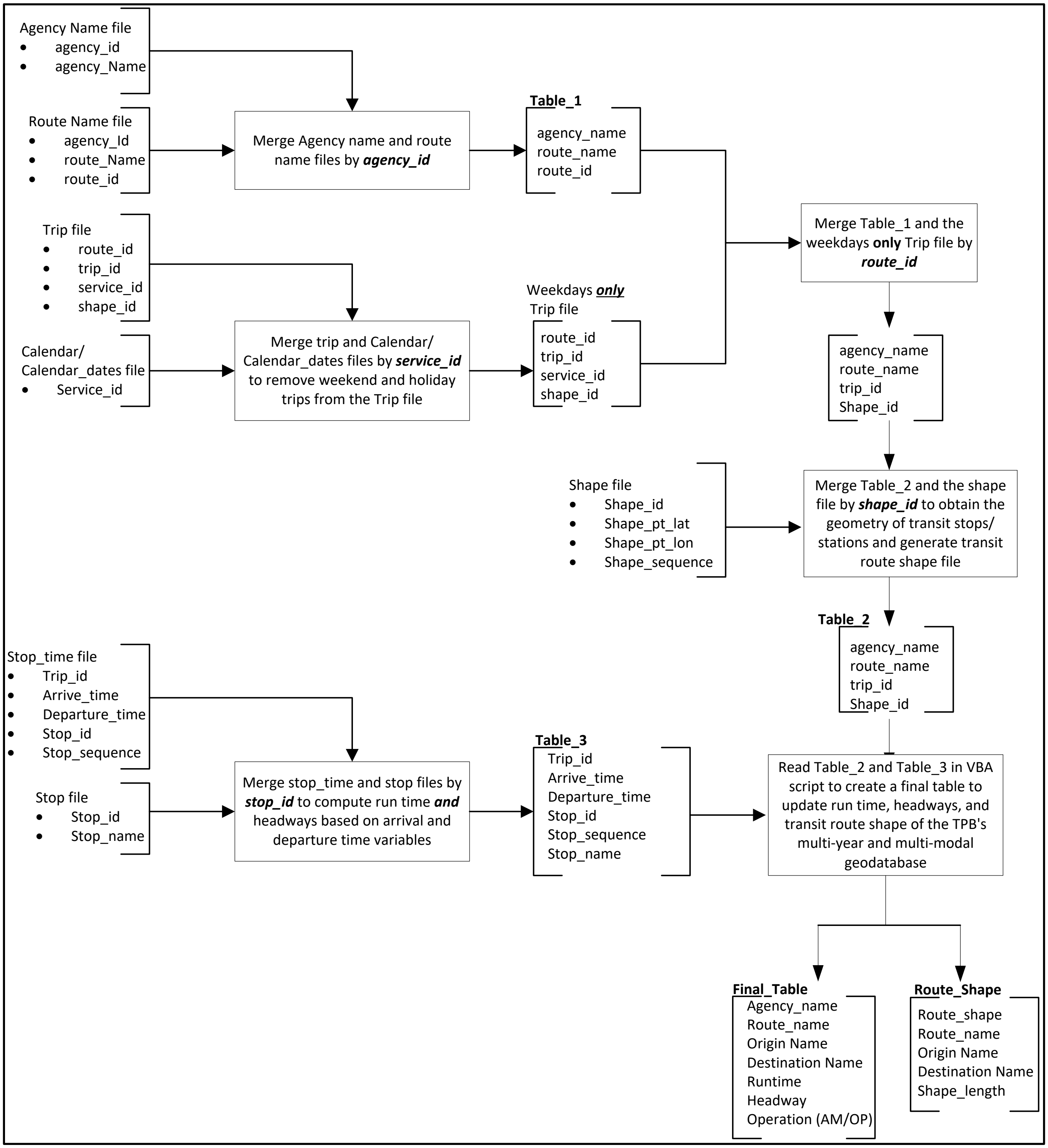
Seq. No.	Transit Service	Transit Provider	GTFS Data	Paper Schedule
1	WMATA Metrorail & Metrobus	Washington Metropolitan Area Transit Authority (WMATA)	x	
2	ART Bus	Arlington County	x	
3	City of Laurel Bus	The Regional Transportation Agency of Central Maryland (RTA)	x	
4	CUE Bus	Fairfax City	x	
5	DASH Bus	City of Alexandria	x	
6	Fairfax Connector	Fairfax County	x	
7	Howard Transit	Howard County	x	
8	Lee Coaches Commuter Bus	Maryland Transit Administration (MTA)	x	
9	MTA	Maryland Transit Administration (MTA)	x	
10	Omni Link	PRTC (Prince William County)	x	
11	Omni Ride	PRTC (Prince William County)	x	
12	Ride-On Bus	Montgomery County	x	
13	St. Mary's Transit System	Maryland Transit Administration (MTA)	x	
14	The Bus	Prince George's County	x	
15	TransIT	Frederick County	x	
16	Amtrak	Amtrak		x
17	Bethesda Circulator	City of Bethesda		x
18	Calvert County Bus	Calvert County		x
19	Carroll Transit System	Carroll County		x
20	City of Annapolis Bus	Annapolis Department of Transportation		x
21	Corridor Cities Transitway	Montgomery County		x
22	DC Circulator	District Department of Transportation (DDOT)	x	
23	DC Streetcar	District Department of Transportation (DDOT)	x	
24	Fredericksburg Feeder Bus to VRE	City of Fredericksburg		x
25	Fredericksburg Regional Transit	City of Fredericksburg		x
26	LC Transit	Loudoun County		x
27	MARC	Maryland Transit Administration (MTA)		x
28	Metroway	Arlington County, City of Alexandria, WMATA		x
29	National Coach Commuter Bus	Martz Group		x
30	REX Bus	WMATA		x
31	TAGS	Transportation Association of Greater Springfield		x
32	US 1 BRT	Fairfax County		x
33	Tyson's Circulator	Fairfax County		x
34	Virginia Railway Express (VRE)	PRTC & NVTC		x
35	Washington Flyer	Metropolitan Washington Airports Authority (MWAA)		x
36	Vango	Charles County		x
		Total	17	19

Ref: "I:\ateam\docum\fy19\V2.3.75_Visualize2045NetworkReport\Report tables\transit_service_v2.3.75.xlsx"

Note: Although Metrorail schedule information is *available* from GTFS, TPB staff generally uses non-GTFS information for Metrorail, which it obtains directly from the transit agency. TPB staff also develops commuter rail schedule information (VRE and MARC, for both base year and future year) from non-GTFS sources.

TPB staff downloads GTFS data directly from the primary transit providers or from the GTFS Data Exchange website (**http://transit.land/** or **http://transitfeeds.com/**) each fall. Once GTFS data are ready, TPB staff has developed an automated database procedure to convert these text files into Microsoft Access database tables and compute average transit route run times and average route headways by time-of-day period. The automated database procedure also extracts geometric (route itinerary) information. The procedure for processing GTFS data is shown in Figure 4-3.

Figure 4-3 Process for combining GTFS data into the COG Geodatabase



Ref: "I:\ateam\docum\fy19\V2.3.75_Visualize2045NetworkReport\GTFS_Data_Process_Flowchart.docx"

After the GTFS data are added to the GDB, transit service from providers which do not use GTFS is coded into the GDB using schedule information from each provider's website. This completes the base-year transit network files upon which all forecast-year transit network files are built.