

HIGHWAY AND TRANSIT NETWORKS

Developed for the Gen3 Travel Model

October 28, 2025



National Capital Region
Transportation Planning Board

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, 24 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 2050

Visualize 2050 is the federally required long-range transportation plan for the National Capital Region. It identifies and analyzes all regionally significant transportation investments planned through 2050 to help decisionmakers and the public "visualize" the region's future. Visualize 2050 was developed by the TPB in 2024 and 2025.

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Table of Contents

1	Introduction.....	5
1.1	Air Quality Conformity Determination Process	7
1.2	Network Development Program Overview	8
1.3	Report Structure	9
2	TPB Transportation Network Background	9
2.1	Modeled Area	10
2.2	Time-of-Day Considerations	10
2.3	Zone Area System	13
2.4	Highway Network Elements.....	19
2.5	Transit Network Elements	20
2.6	Overview of Network Travel Costs	22
2.7	Node Numbering System.....	24
3	Gen3 Model Network Inputs	28
3.1	Cost Deflation Inputs.....	28
3.2	Highway Network Files.....	31
3.2.1	Zonal Land Use.....	32
3.2.2	Highway Link and Node Coordinate Files	34
3.2.3	Roadway Functional Classification and the Facility-type Variable.....	37
3.2.4	Other Link Attributes	39
3.2.5	Toll Parameter File.....	42
3.2.6	Highway Network Screenlines	55
3.3	Transit Network Files.....	58
3.3.1	Transit and Non-Transit Mode Codes	59
3.3.2	Generate Non-transit Legs.....	66
3.3.3	Rail Station File	70
3.3.4	Transit Line/Route Files	71
3.4	Transit Path Building	73
3.5	Transit Fare Files	75
3.5.1	Gathering Fare Data from the Transit Providers.....	76
3.5.2	Calculating Zone-to-zone Fares Used by the Model	77
3.5.3	Fare Discounts	80
4	COG/TPB Multi-Year, Multi-Modal Unified Geodatabase	83
4.1	Unified Geodatabase Overview	83

4.2	Difference between TRNBUILD and PT Networks	85
4.3	Update and Changes to the Database and/or COGTools	87
4.4	Unified Geodatabase COGTools	90
4.5	Unified Geodatabase Tables: Overview and Highway Network Tables	93
4.6	Unified Geodatabase Tables: Transit Network Tables	100
4.7	General Transit Feed Specification (GTFS) Data	103

List of Tables

Table 2-1	Jurisdictional summary of 3,722 TPB TAZ ranges	15
Table 2-2	Differences between COG TAZ and TPB TAZ area systems.....	16
Table 2-3	PT Non-Transit Link Attributes.....	22
Table 2-4	TAZ/node numbering system overview	24
Table 2-5	Node numbering system for transit nodes	25
Table 2-6	Allocated highway node ranges by jurisdiction	26
Table 3-1	Listing of highway network input files	31
Table 3-2	Format description of the land use file (land_use.csv).....	33
Table 3-3	Round 10 Cooperative Forecasts regional totals by year	34
Table 3-4	Base highway link file description (link.dbf)	35
Table 3-5	: Highway node file description	36
Table 3-6	: Limit codes	36
Table 3-7	Area-type codes, from 1 to 7, based on population and employment density	40
Table 3-8	The six area-type codes and examples of each area type	41
Table 3-9	Toll parameter file (Toll_esc.dbf).....	49
Table 3-10	Dulles Toll Road (VA 267): Toll links.....	51
Table 3-11	Dulles Greenway Toll inks (Segments 1-4).....	53
Table 3-12	Dulles Greenway Toll inks (Segments 5-8).....	54
Table 3-13	Harry W. Nice Bridge toll links	54
Table 3-14	Listing of Gen3 Model transit network input files	58
Table 3-15	Listing of Gen3 model External and Visitor Transit Trip Files	59
Table 3-16	Transit mode codes	60
Table 3-17	Transit agencies in the Washington, D.C. area (TPB modeled area)	61
Table 3-18	Equivalency between transit modes and transit service	62
Table 3-19	Non-transit mode codes and link attributes in PT	64
Table 3-20	List of Non-Transit (NT) Mode IDs Generated in the" PT_NetProcess_PT.S" Process.....	69
Table 3-21	Variables in the transit station file (Station.dbf)	70
Table 3-22	Header section for each transit route in a PT transit line file	72
Table 3-23	2024 PT Fare Structure	76
Table 3-24	Metro-rail Fares in WMATA Tariff 45 (input to tariff.txt file for the MFARE1 process).....	77
Table 3-25	Metrobus Fares in WMATA Tariff 45	79
Table 3-26	Proposed Bus-to-Bus, Bus-to-Rail and Rail-to-Bus Transfer Discounts.....	81

Table 4-1 Comparison of Non-Transit Links Between TRNBUILD and PT Networks	86
Table 4-2 Updates made to the geodatabase and COGTools.....	88
Table 4-3 Network Links Feature Class table with "Link Type" codes (1-16) description.....	96
Table 4-4 Network Nodes Feature Class table with "Node Type" codes (1-13) description	97
Table 4-5 Base Links Table with "Mode" codes (1-16) description	98
Table 4-6 Transit Links Table	100
Table 4-7 Transit Route Stops Table	101
Table 4-8 Transit Lines Definition Table	102
Table 4-9 GTFS files.....	104
Table 4-10 Availability of GTFS data for transit providers in the Washington, D.C. area (TPB modeled area)	105

List of Figures

Figure 2-1 COG/TPB modeled area – 3,722-zone area system (TPB planning area shown in gray)	11
Figure 2-2 Location of external stations in the modeled area.....	17
Figure 2-3 Location of external stations in Baltimore Beltway area.....	18
Figure 3-1 Cost deflation parameter file (CPI_File.txt)	29
Figure 3-2 Projected CPI escalation at varying annual growth rates.....	30
Figure 3-3 Deflation process in the Gen3 Travel Model	31
Figure 3-4 Gen3 Highway network building process	32
Figure 3-5 Classification of roads and their emphasis on mobility and access.....	37
Figure 3-6 Example of different types of roads	38
Figure 3-7 Map of the six area types	42
Figure 3-8 Toll Setting Toggle Switch.....	44
Figure 3-9 Gen3 Model Flow with a “One-Run” Toll Setting Process.....	45
Figure 3-10 Gen3 Travel Model Toll Setting Process	46
Figure 3-11 Existing and the Visualize 2050 Managed-lane facilities in the regional highway networks.....	48
Figure 3-12 Dulles Toll Road: Toll facilities locations	50
Figure 3-13 Dulles Greenway: Toll facilities locations (Map 1 of 2).....	52
Figure 3-14 Dulles Greenway: Toll facilities locations (Map 2 of 2)	53
Figure 3-15 Highway Network screenlines: Inside the Beltway.....	56
Figure 3-16 Highway network screenlines: Outside the Beltway	57
Figure 3-17 PT Network Design for Transit Stops Off the Highway Network	65
Figure 3-18 PT Network Representation for the Bus Park-n-Ride Lots	66
Figure 3-19 Example to generate Access and Egress Non-transit legs	67
Figure 3-20 Non-transit Access and Egress legs creation process in the Gen3 Travel Model	68
Figure 3-21 Example of a transit line/route file in PT (LIN) format	71
Figure 3-22 Time period definition for calculation of average headway and run time	72
Figure 3-23 Process for conducting transit path building.....	75
Figure 3-24 Metrorail fares (peak and off-peak) and the rail-to-bus discounts (Tariff.txt)	78
Figure 3-25 Modified MFARE1 program	82
Figure 4-1 Relationship Between the network unified geodatabase and the Cube Voyager/PT Modeling Process ...	85
Figure 4-2 TPB Unified Geodatabase Structure	94

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 metropolitan Washington region. 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 Gen3/Version 1.0.5 Travel Model, is the first activity-based travel model (ABM), the culmination of a collaborative effort which has been developed by COG and the consultants on the Gen 3 model development project, RSG and Baseline Mobility Group (BMG). 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 travel demand modeling. The existing area 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 Gen3 family of travel demand models. The travel model currently requires network inputs that are used to develop highway and transit travel impedances between zones. The travel model requires modal travel impedances associated with four time periods; 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 Gen3 Travel Model is currently implemented with Bentley Systems Cube software, ActivitySim and a Python Package Manager (e.g., MiniForge3 or Anaconda).

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 a frequent 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 2050,” and the Transportation Improvement Program (TIP), which is a four-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 transportation networks produced for the Gen3 Travel Model. These networks were developed in parallel with those produced for the Gen2/Version 2.4 Travel Model for the Air Quality Conformity (AQC) analysis of Visualize 2050 and the FY 2026-2029 TIP, which is to be considered for approval by the TPB in December 2025. Staff developed networks based on the projection inputs from Visualize 2050 and ran the Gen3 Travel Model for the same forecast years included in the air quality conformity analysis. There is a separate network documentation report for the Gen2/Version 2.4 Travel Model.

Visualize 2050 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 2050, 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 2050 plan in this document refer to only that component.¹ Consistently, the forecast-year network inputs to the travel models are developed based on the financially constrained element only.

As stated earlier, transportation network files are developed in compliance with the travel demand model and its associated software. The currently adopted, production-use TPB travel demand model is known as the Generation 2/Version 2.4.6 Model. This travel model uses an area system with 3,722 TAZs and is currently applied using Bentley Systems Cube software (Version 6.5.1 CE). 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). The Gen3 Travel Model has transitioned to the newer Cube Voyager transit path builder (PT), which is designed as a multi-path path builder and provides a more realistic representation of an urbanized environment with multiple transit options. COG/TPB staff have developed a unified network database (containing both TRNBUILD and PT components) to support both the Gen2 and Gen3 travel demand models.

This report describes the process, technical conventions and specifications associated with the TPB’s network-related inputs to the Gen3 Travel Model. This report also includes other supporting documents that are directly related to the Visualize 2050 Plan and the FY 2026-2029 TIP network development

¹ See, for example, the previous analysis: “Air Quality Conformity Analysis of the 2022 Update to Visualize 2045, Full Report” (Washington, D.C.: National Capital Region Transportation Planning Board, Metropolitan Washington Council of Governments, June 15, 2022), [https://www.mwcog.org/documents/2022/06/15/air-quality-conformity-analysis-of-the-2022-update-to-visualize-2045-full-report/Project inputs in Appendix B](https://www.mwcog.org/documents/2022/06/15/air-quality-conformity-analysis-of-the-2022-update-to-visualize-2045-full-report/Project%20inputs%20in%20Appendix%20B).

process and specifications, including: 1) the air quality conformity analysis report,² which includes a complete listing of all transit and highway projects assumed in the Visualize 2050 plan and the FY 2026-2029 TIP; 2) the Gen3/Version 1.0.5 User's Guide,³ which documents the overall model application process; and 3) the Gen2/Version 2.4.6 network documentation. The Gen2 Model user's guide and other important model documentation can be found on the "Model Documentation" web page.⁴

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

1.1 Air Quality Conformity Determination 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 (AQC) Analysis of the region's Long-Range Transportation Plan (LRTP) and the Transportation Improvement Program (TIP). The AQC Analysis is done 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 mobile emissions budgets regarding prevailing air quality standards set by federal law. LRTPs must be updated every four years, but COG/TPB typically conducts the LRTP update and the air quality conformity analysis on a more frequent basis, such as every two years. The analysis entails 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 a biennial basis.⁵

The air quality conformity (AQC) analysis of the Visualize 2050 plan created networks for the following six analysis years: 2025, 2026, 2030, 2040, 2045 and 2050. A 2023 network was also developed for data requests, even though it was not an official analysis year. The AQC analysis looked into two options for

² Robert d'Abadie, "Air Quality Conformity Report, Visualize 2050 and the FY2026-2029 Transportation Improvement Program," Full Report (Washington, D.C.: National Capital Region Transportation Planning Board, Metropolitan Washington Council of Governments, Draft, October 22, 2025), <https://visualize2050.org/wp-content/uploads/2025/10/DRAFT-Visualize-2050-Air-Quality-Conformity-Report.pdf>

³ RSG, Baseline Mobility Group, and COG, "User's Guide for the COG/TPB Gen3/Version 1.0.5 Travel Demand Forecasting Model" (Washington, D.C.: Metropolitan Washington Council of Governments, National Capital Region Transportation Planning Board, October 23, 2025).

⁴ "Model Documentation," Metropolitan Washington Council of Governments, 2021, <http://www.mwcog.org/transportation/activities/models/documentation.asp>.

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.

the Southside Express Lane (SSEL) project for analysis years after 2030: Option A (no SSEL) and Option B (with SSEL).⁶

The usability testing of the Gen3 Model included four analysis years: 2025, 2030, 2045 and 2050. For simplicity, 2045 and 2050 scenarios assumed Option B with the SSEL project included.

Two sets of network input files were created from the same Visualize 2050 network database: One set of network files were generated in Cube TRNBUILD format to support the official air quality conformity (AQC) analysis of Visualize 2050, which was conducted using the Gen2/Ver. 2.4.6 Travel Model, while the other set of network files were generated in Cube Public Transport (PT) format, which were subsequently used for usability testing of the Gen3 Travel Model.

The focus of this report is to document the network components in the developmental Gen3 Model, especially those different from the Gen2 Model (e.g., PT path building and fares). A separate Gen2/Ver. 2.4.6 Highway and Transit Network Report will document the network files and statistics for all the six analysis years used in the official AQC analysis of Visualize 2050.

1.2 Network Development Program Overview

Network development activities are carried out in a way that accommodates the air quality conformity (AQC) 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 2050 LRTP, developed in 2023, represents both the financial viability of projects and conformity with federal air quality standards. It included a complete financial analysis, a performance analysis, and an 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 to support the travel modeling work for the LRTP update and the AQC analysis. The following procedure has typically been followed in each LRTP update cycle:

- 1) Pre-existing network inputs developed for the previous air quality analysis, and the previous TIP and LRTP, are obtained as a starting point for highway network coding. For example, the inputs for the Visualize 2050 plan were built from the previously developed 2022 update to Visualize 2045 plan analysis inputs. The TPB's link and node network data are currently stored in a multi-year and multi-modal (highway and transit) Unified Geodatabase. TPB staff essentially develop a single multi-year database for each LRTP.⁷

⁶ At the time when this report is developed, the board decision on which option to be included in the final Visualize 2050 plan has not been made.

⁷ 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.

- 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 during each regular LRTP update with the latest schedule information provided by the local operators and provides the starting point for transit coding. Most of the transit schedule information is obtained from digital, machine-readable files, though for the few agencies who do not produce machine-readable schedule information, the schedule information is extracted manually from the transit route schedules published on their websites
- 4) The current-year TIP and LRTP 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,” as defined by the TPB.⁸

Other miscellaneous and policy-related network inputs that are not currently stored in the Unified 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 2050 and FY 2026-2029 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 Gen3 Travel Model and the attributes that are contained in each file. Chapter 4 describes the unified 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, containing both Cube TRNBUILD and Cube Public Transport (PT) components, in a geographically referenced framework. Although the unified geodatabase contains both TRNBUILD and PT components, this report focuses on PT network inputs of the Gen3Travel Model that are developed based on the Visualize 2050 LRTP project assumptions.

2 TPB Transportation Network Background

This chapter presents background on the transportation networks that are developed by TPB staff for regional travel demand models, 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 in the networks. The basic elements associated with highway and transit networks are described, along with a

⁸ Memorandum from Jane Posey to TPB Technical Committee, Subject: Defining Regional Significance for Conformity, October 6, 2011.

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.⁹ The modeled area extends well beyond the current TPB planning area, which is shown as the shaded area in Figure 2-1.

2.2 Time-of-Day Considerations

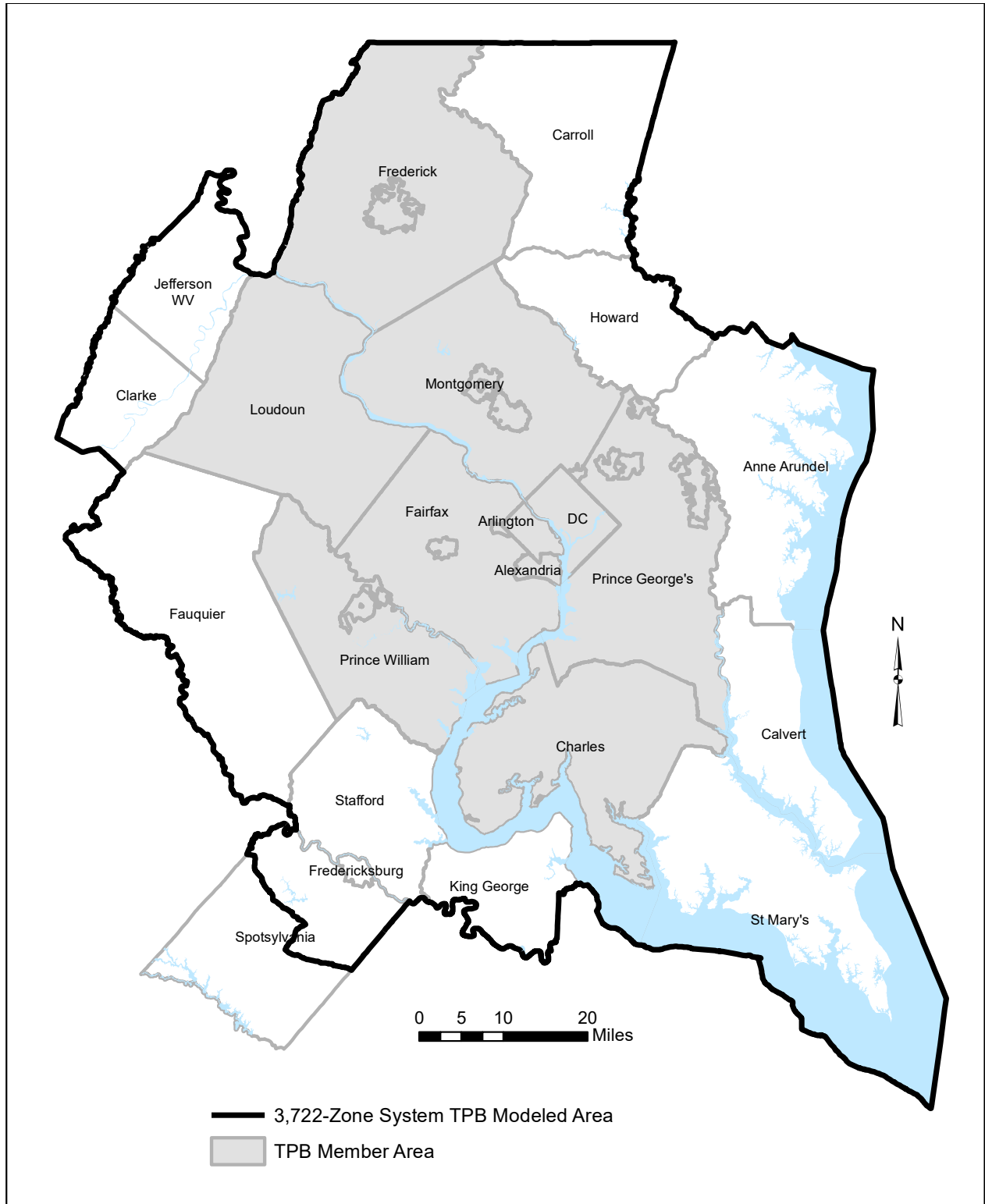
The travel model requires zonal travel times and costs for both peak and off-peak conditions because congestion levels experienced by different travel markets vary substantially over an average weekday. Thus, the travel model networks developed by TPB staff correspond to either peak or off-peak conditions.

Many of the primary highway facilities in the region operate with varying configurations during peak and off-peak hours of the day. Examples of highway facilities with time-of-day variability on operation include:

- High-Occupancy Vehicle (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.

⁹ 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 modeled area.

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



Ref: " I:\ateam\docum\fy25\Gen3_Network_Report_Vizualize2050 \Jur_Map2.emf"

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 (6 hours: 9:00 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)

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,** which are below the grain of the regional network. The highway network coding in the current network database reflects the time-of-day lane changes based on on-street parking restrictions in the District of Columbia (DC). There could be other areas around the region where the on-street parking restrictions are not reflected (e.g., Old Town Alexandria), but those are very limited.

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 Gen3 Travel Model require transit network inputs in Cube PT format for four TOD periods. The definition of the four TOD periods in the transit network is consistent with that in the highway network. Transit paths are developed based on the level of transit service in typical service hours for each time period, which are defined as follows:

1. AM Peak (AM): 7:00 AM – 7:59 AM for most transit services; 6:00 AM – 6:59 AM for transit services operating in the outer areas such as Howard County, Frederick County, and Loudoun County
2. Mid-Day (OP): 10: 00 AM – 2: 59 PM. Note that, to continue to support Gen2 Model which requires network inputs for the “AM” and “OP” periods, this Mid-Day period is labelled as “OP” instead of “MD” in the network database.
3. PM Peak (PM): 4:00 PM – 4 :59 PM
4. Night-Time (NT): 7:00 PM – 11:59 PM

Regional travel models require two variables for each transit route: Run Time and Headway, both in minutes. COG staff extract this information from the GTFS scheduling data for about 90% of the regional transit services. The information for the remaining 10% of transit services is derived based on their online or paper schedules. 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 each of the four time-of-day periods.¹⁰

2.3 Zone Area System

Transportation Analysis Zones (TAZs) represent the basic geographic unit by which regional travel flows by auto and by transit are estimated in 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 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. Each modeled jurisdiction incorporates cities within their boundaries. Fairfax County includes the City of Fairfax and the City of Falls Church (which are independent cities). Similarly, Prince William County includes the City of Manassas and City of Manassas Park. The TAZs within the cities’ boundaries are listed below 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 (3723 to 5000) 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 the current 3722-TAZ system, which had more zones as compared to the previous 2191-TAZ system, 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. Reviews of the initial 3,722-TAZ system uncovered some instances

¹⁰ Jim Yin to Feng Xie, “Development of Transit Networks for four Time of Day (TOD) Periods in the MWCOG Unified Network Database” Memorandum, April 6, 2022

where TAZ boundary refinements were needed to be used in the COG Cooperative Forecasting process. 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 meeting of the COG/TPB Travel Forecasting Subcommittee, held at the Metropolitan Washington Council of Governments, Washington, D.C., January 22, 2010), 23, <http://www.mwcog.org/uploads/committee-documents/Z15aV1dd20100122152445.pdf>.

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

Jurisdiction/City	Juris. Code	County FIP Code	Beginning TAZ No.	Ending TAZ No.	TAZ/Station Count
District of Columbia	0	1	1	393	393
Montgomery Co., Md.	1	31	394	769	376
Prince George's Co., Md.	2	33	770	1404	635
Arlington Co., Va.	3	13	1405	1545	141
City of Alexandria, Va.	4	510	1546	1610	65
Fairfax Co., Va.		59	1611	2159	549
City of Fairfax	5	600			
City of Falls Church		610			
Loudoun Co., Va.	6	107	2160	2441	282
Prince William Co., Va.		153	2442	2819	378
City of Manassas	7	683			
City of Manassas Park		685			
Frederick Co., Md.	9	21	2820	2949	130
Howard Co., Md.	10	27	2950	3017	68
Anne Arundel Co., Md.	11	3	3018	3116	99
Charles Co., Md.	12	17	3117	3229	113
Carroll Co., Md.	14	13	3230	3287	58
Calvert Co., Md.	15	9	3288	3334	47
St. Mary's Co., Md.	16	37	3335	3409	75
King George Co., Va.	17	99	3410	3434	25
City of Fredericksburg, Va.	18	630	3435	3448	14
Stafford Co., Va.	19	179	3449	3541	93
Spotsylvania Co., Va.	20	177	3542	3603	62
Fauquier Co., Va.	21	61	3604	3653	50
Clarke Co., Va.	22	43	3654	3662	9
Jefferson Co., WV	23	37	3663	3675	13
Total Internal TAZs					3,675
External Stations:			3676	3722	47
Reserved TAZ numbers			3723	5000	1,278
Note: 13 of the 3675 internal TAZs are unused: 61, 382, 770, 777, 2555, 2629, 3103, 3266, 3267, 3478, 3482, 3495, 3544					

Jurisdiction	City	TAZ No.
Fairfax Co., Va.	City of Fairfax	1630-1634, 1785,
		1791-1793, 1796-1801
	City of Falls Church	1920, 1927-1928,
		1933-1934, 1937-1940
Prince William Co., Va.	City of Manassas	2595, 2599, 2602, 2624,
		2627-2628, 2630-2632, 2637
	City of Manassas Park	263, 526, 442, 646

Ref: " I:\ateam\docum\fy22\Version2.4_2022Update_Visualize2045_Network_Report\Report_Tables\3722TAZ_Master_Node_Table_Jan_2015_V2.4.xlsx"

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

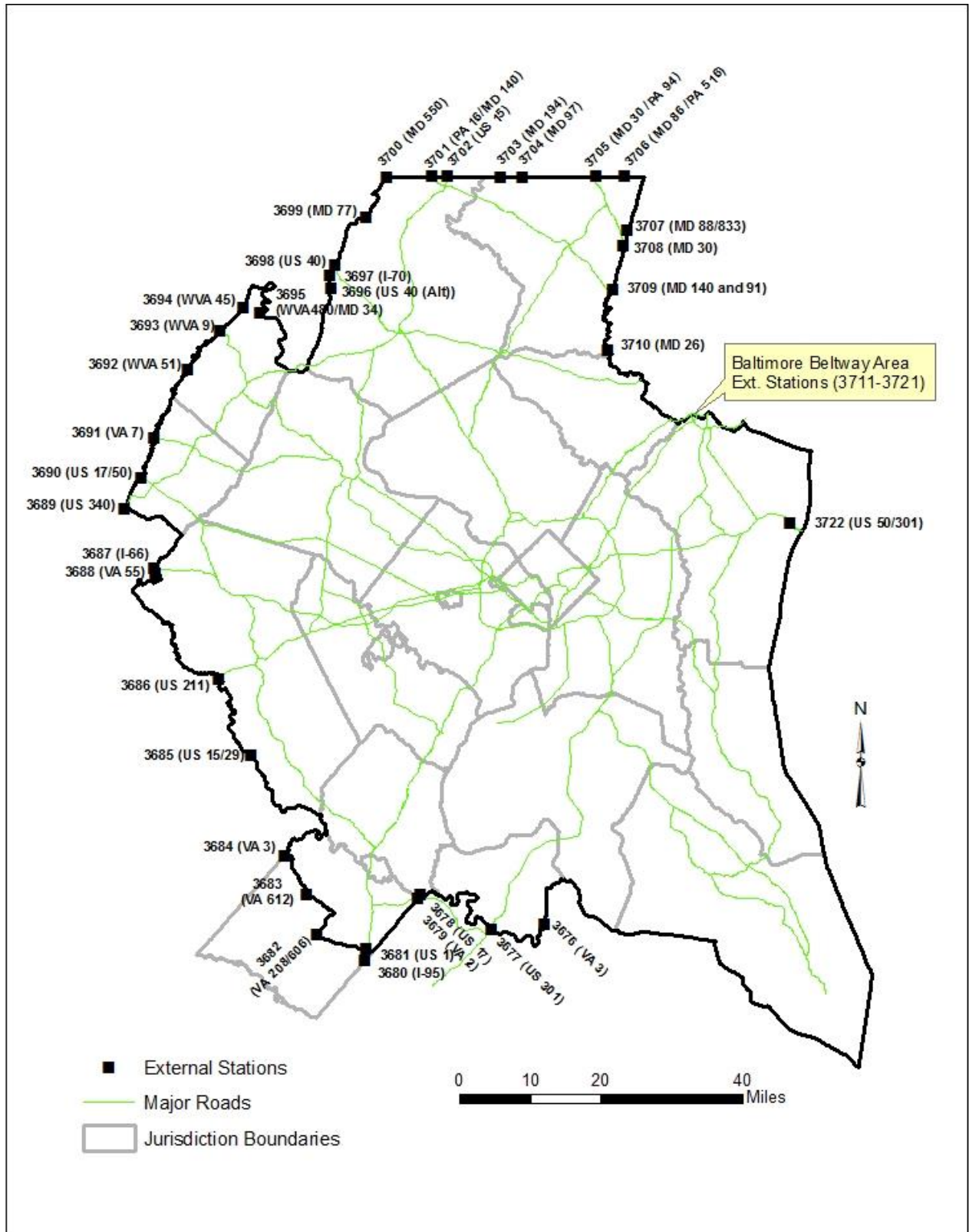
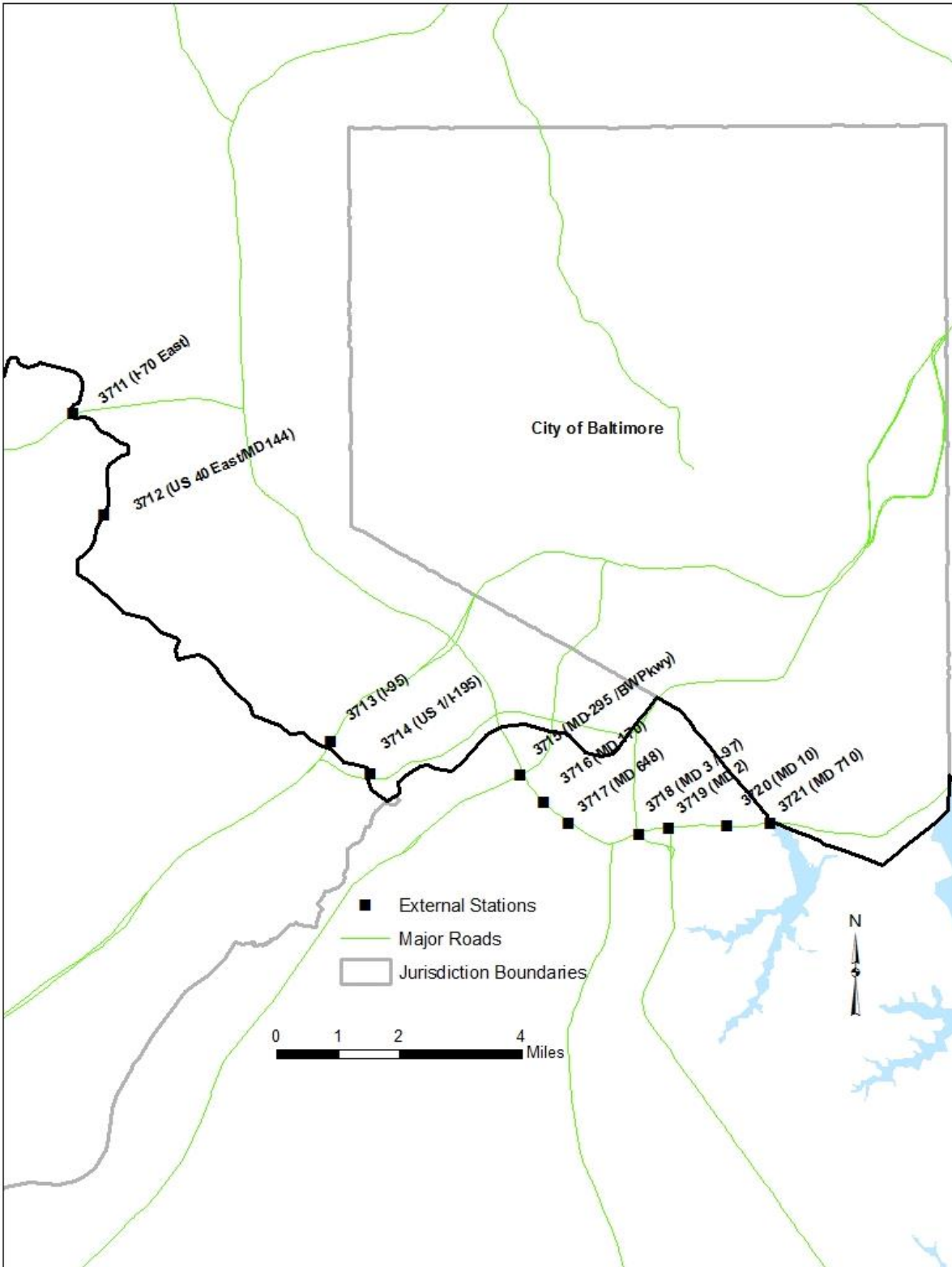


Figure 2-3 Location of external stations in Baltimore Beltway area



Ref: "I:\ateam\docum\fy14\2013LRTP_Network_Report\Ext_Sta_Balt_Feb12.jpg"

2.4 Highway Network Elements

The transportation networks used by the Gen3 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 and transit connectivity and capacity that exists between zones. The model evaluates travel 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 are assumed to travel from one zone centroid to another zone centroid.
- **PNR Nodes:** Point locations which represent park-and-ride (PNR) parking lots at Metrorail, commuter rail, light rail stations, and streetcar/BRT 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 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 Driveway Links:** Segments that represent access links between Metrorail/commuter rail/light rail PNR lots and the highway network. These are two-way links, traffic is not "loaded" on these types of links; they are used for the sole purpose of developing congested TAZ-to-PNR travel times identified with 'Mode' value (Mode=11).
- **KNR Drive/walk access links:** Drive-access and walk-access two-way links connecting highway nodes and rail stations identified with 'Mode' value (Mode=14).
- **Pedestrian tunnel links:** Walk links that provide connections between Metrorail and commuter rail stations identified with 'Mode' value (Mode=13).
- **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 but not in the highway 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 (for example in PT highway network Bus PNR Driveway links (Mode=17) are coded as transit only links). 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 as well as additional transit -related “point” and “segment” elements that are necessary for PT transit path building. 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, streetcar, 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 Links:** KNR access links do not connect to PNR lots; they connect directly to rail stations.
- **Rail Links:** These represent fixed guideway (Metrorail, commuter rail, light rail, streetcar and BRT) segments that connect rail stations and are part of the background highway network. With the transition from the TRNBUILD transit path builder to the Public Transport (PT) transit path builder, there is no longer as much of a distinction between a highway network and a transit network in the multimodal transportation network database, which contains both highway and transit links in one network system.
- **PNR lot-to-station/Bus Stop Node Transfer Links:** Unique two-way links between highway nodes and bus PNR access stops and bus PNR lots.
- **Bus PNR Driveway Link:** Transit only two-way links between highway nodes and bus PNR access stops.
- **Special Walk Access Links:** Walk connections between zone centroids and transit stops accessible from the TAZ.
- **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 key words/general characteristics (LINE NAME, LONGNAME, OPERATOR, 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 the route delineation, node numbers without a “-” sign represent stops while those with a “-” sign in the front are non-stops. In PT, transit line files are text files, with the file name or file extension LIN (e.g., MODE1AM.LIN).

A summary of PT transit support links (non-transit links) and their key link attributes developed for the Gen3 Model are shown in

Table 2-3 PT Non-Transit Link Attributes

Link Type	Mode Code	From Node	ToNode	Mode Type	Direction	Ftype	Limit Code	Speed (mph)
PNR Driveway Links	11			Drive	1	4	0	30
Metrorail		20000-54999	11001-11999					
Commuter Rail		20000-54999	12001-12999					
Bus		20000-54999	13001-13999					
Special walk-access links	12			Walk	2	0	0	3
Metrorail		1 - 3675	8001-8999					
		8001-8999	1 - 3675					
Commuter Rail		1 - 3675	9001-9999					
		9001-9999	1 - 3675					
Pedestrian Tunnel Links	13			Walk	2	0	0	3
Metrorail / Commuter Rail		8001-8999	9001-9999					
		9001-9999	8001-8999					
KNR Drive/walk access links	14			Drive&Walk	2	4	0	25
Metrorail		8001-8999	20000-54999					
		20000-54999	8001-8999					
Commuter Rail		9001-9999	20000-54999					
		20000-54999	9001-9999					
PNR lot-to-station/Bus Stop Node	15			Walk	1	0	0	3
Metrorail PNR Lot		11001-11999	8001-8999					
Commuter PNR Lot		12001-12999	9001-9999					
Bus PNR Lot		13001-13999	15001-15999					
Bus Stop								
Unused	16							
Bus PNR Driveway Link	17	15001-15999	20000-54999	Drive	2	4	9	15
		20000-54999	15001-15999					

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Most of the highway and transit network inputs are files that contain attributes of elements listed above. These 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 Gen3 Travel Model, like all the models in the Gen2 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-2018) prices (dollars or cents) or are converted to constant-year prices as part of the model application process. The year 2018 is the model “base-year” because that was the year when model calibration data was collected (primarily, the 2017/2018 Regional Travel Survey data). The travel model currently considers five travel cost components each affecting different 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 in PT 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 and coded into the network. For forecast years, variably priced tolls are estimated in a heuristic toll setting process, which is detailed in the next chapter. The Gen3 Model integrates the toll setting process in the model flow and provides the model user the option to turn it on or off. When toll setting is turned off, the model will use pre-specified toll input files.¹² Both PNR parking costs and tolls are coded as input variables in current-year prices.

As suggested by the list above, parking costs associated with auto trips are handled separately from parking costs for transit trips. Specifically, parking costs associated with auto trips are calculated using a parking cost model inherited from the Gen2 Model, which is applied with the Cube Voyager script *prefarv23.s*. These parking costs are a function of job density in the destination TAZ. This script also calculates “terminal time,” i.e., the time to park and un-park a car at either end of an auto trip (see section 21.7 of the Gen2/Version 2.4.6 Travel model user’s guide¹³). Since these parking costs are calculated with a parking cost model, the network coder does not have to collect this information. Lastly, auto operating costs are computed directly in year-2018 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 better reflect observed behavior. Shadow prices are available in both Gen2 and Gen3 models, but they have not been used in the current travel models (all set to zero values). For more information, see chapter 21 of the current Gen2/Version 2.4.6 Travel Model User’s Guide. Also, unlike the other cost components, the PNR lot cost is not considered in the mode choice modeling process.

¹² Feng Xie and Bahar Shahverdi to Mark Moran, “Integrating Toll Setting in Gen3 Model Flow: Testing and Recommendations” Memorandum, March 15, 2024.

¹³ User’s Guide for the COG/TPB Gen2/Version 2.4.6 Travel Demand Forecasting Model. Metropolitan Washington Council of Governments, National Capital Region Transportation Planning Board, July 13, 2023. https://www.mwcog.org/assets/1/6/mwcog_tpb_travel_model_Ver2.4.6_User_Guide.pdf

Highway tolls are coded on a highway network on a link-by-link basis and are specified either as 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 toll costs as well as an extra penalty for trips crossing the Potomac River. The monetary toll cost between a pair of origin/destination zones therefore comprises of tolls charged on any toll segments along the minimum generalized cost path.

Zone-to-zone transit fares are computed in the Gen3 Model as part of transit path skimming in PT based on a specification of fare structures for each transit operator.¹⁴ This is different from the fare-zone matrices used in the Gen2 Model.

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 for transit modeling in Public Transport (PT) on the 3,722-TAZ system is shown in Table 2-4. The numbering system allocates nodes from lowest to highest to TAZs, station nodes, PNR lot nodes, and finally highway nodes.

Table 2-4 TAZ/node numbering system overview

Node Type	Jurisdiction	Beginning TAZ / Node	Ending TAZ / Node	TAZ / Node Count
TAZ Centroids	Internal TAZs	1	3675	3,675
	External Stations:	3676	3722	47
	Reserved TAZ numbers	3723	5000	1,278
Highway Network Nodes	Highway Nodes:	20000	54999	35,000
Transit Nodes	Transit Station Nodes	8000	10999	3,000
	Transit PNR Lot Nodes	11000	13999	3,000
	Transit Reserved Nodes	14000	14999	1,000
		16000	19999	4,000

Note: 13 Internal TAZs are unused

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The sub-allocation of transit nodes above is further detailed in Table 2-5 and Table 2-6.

¹⁴ Jane Posey and Nazneen Ferdous to Files, "2024 Transit Fares for Public Transport (PT)", MWCOG/TPB Memorandum. September 19, 2024.

Table 2-5 Node numbering system for transit nodes

Node Type	Beginning TAZ / Node	Ending TAZ / Node	TAZ / Node Count
Metrorail Station Node:	8000	8999	1000
Commuter Rail Station Node:	9000	9999	1000
MARC Stations	9000	9050	51
VRE Stations	9051	9199	149
External dummy stations	9200	9999	800
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
LRT/Bus PNR Lot Node:	13000	13999	1000
Bus/PNR drive way Node:	15001	15999	1000
Reserved Transit Nodes	14000	14999	1000
	16000	19999	4000
Note: - Union Station 9001 is both a VRE and a MARC station			
- 9200, 9201,9202 External dummy MARC stations are assigned for Penn Line, Cameden Line, and Brunswick Line, respectively.			

Ref: "1:\ateam\docum\fy25\Gen3_Network_Report_Vizualize2050\Report_Tables\3722TAZ_Master_Node_Table_Dec_2024.xlsx "

Highway node numbers are allocated in discrete ranges by jurisdiction, as shown in Table 2-6.

Table 2-6 Allocated highway node ranges by jurisdiction

Jurisdiction	Current			Additional (Current + 100000)		
	Beginning Node	Ending Node	Allocated Nodes	Beginning Node	Ending Node	Allocated Nodes
District of Columbia	20000	21999	2000	120000	121999	2000
Montgomery Co., MD	22000	25999	4000	122000	125999	4000
Prince George's Co., MD	26000	29999	4000	126000	129999	4000
Arlington Co., VA	30000	31999	2000	130000	131999	2000
City of Alexandria, VA	32000	33999	2000	132000	133999	2000
Fairfax Co., VA	34000	37999	4000	134000	137999	4000
Loudoun Co., VA	38000	39999	2000	138000	139999	2000
Prince William Co., VA	40000	41999	2000	140000	141999	2000
Frederick Co., MD	42000	43999	2000	142000	143999	2000
Howard Co., MD	44000	45499	1500	144000	145499	1500
Anne Arundel Co., MD	45500	46999	1500	145500	146999	1500
Charles Co., MD	47000	47999	1000	147000	147999	1000
Carroll Co., MD	48000	48999	1000	148000	148999	1000
Calvert Co., MD	49000	49499	500	149000	149499	500
St. Mary's Co., MD	49500	49999	500	149500	149999	500
King George Co., VA	50000	50499	500	150000	150499	500
City of Fredericksburg, VA	50500	50999	500	150500	150999	500
Stafford Co., VA	51000	51999	1000	151000	151999	1000
Spotsylvania Co., VA	52000	52999	1000	152000	152999	1000
Fauquier Co., VA	53000	53999	1000	153000	153999	1000
Clarke Co., VA	54000	54499	500	154000	154499	500
Jefferson Co., WVA	54500	54999	500	154500	154999	500
Reserved Nodes	90000	90999	1000			

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In November 2017, Montgomery County staff 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 90000-90999 was reserved for that purpose, to be used by Montgomery County staff and consultants.

In April 2020, as the allocated node numbers (“Current” node numbers in the table above) were running out, especially in Washington, D.C. and Montgomery County, staff created additional node number ranges (“Additional” in the table above) for each jurisdiction in the modeled area.¹⁵

¹⁵ Sanghyeon Ko and Feng Xie to Mark Moran, “Node range extension for TPB Travel Demand Model and test results with Version 2.3.86 Model”, MWCOG/TPB Memorandum, April 16, 2020.

3 Gen3 Model Network Inputs

Chapter 2 provided a broad overview of the TPB transportation networks in terms of the TAZ system, network elements, and node numbering conventions. This chapter presents more detail on the specific network 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”. Like the Gen2 family of travel models, the Gen3 Model identifies modeled scenarios using scenario-specific *subdirectories*, each containing generic input *filenames*. More details on the Gen 3 model application may be found in the Gen3 travel model user’s guide.

3.1 Cost Deflation Inputs

The Gen3 Model application includes a procedure that creates an inflation/deflation factor for converting current-year monetary costs into constant-year (year-2018) 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/regions/mid-atlantic/data/consumerpriceindexannualandsemiannual_table.htm

The CPI parameter file (Figure 3-1) is usually updated at the beginning of an LRTP update cycle.¹⁶ The file contains a table showing the annual CPI starting from 2018 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 (2023) is 0.8241. 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.

¹⁶ Meseret Seifu to Mark S. Moran et al., “Update of the CPI Schedule to be used in the Gen3/Version 1.0.0 Travel Model,” Memorandum, April 15, 2024.

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

```

;; - MWCOG Gen3 Travel Model - Cost deflation Table
;; - 4/15/2024 - MS
;; Data from BLS / All Urban Consumers (CPI-U) US City Avg.1982-84=100.0
;; https://www.bls.gov/regions/mid-atlantic/data/consumerpriceindexannualandsemiannual_table.htm

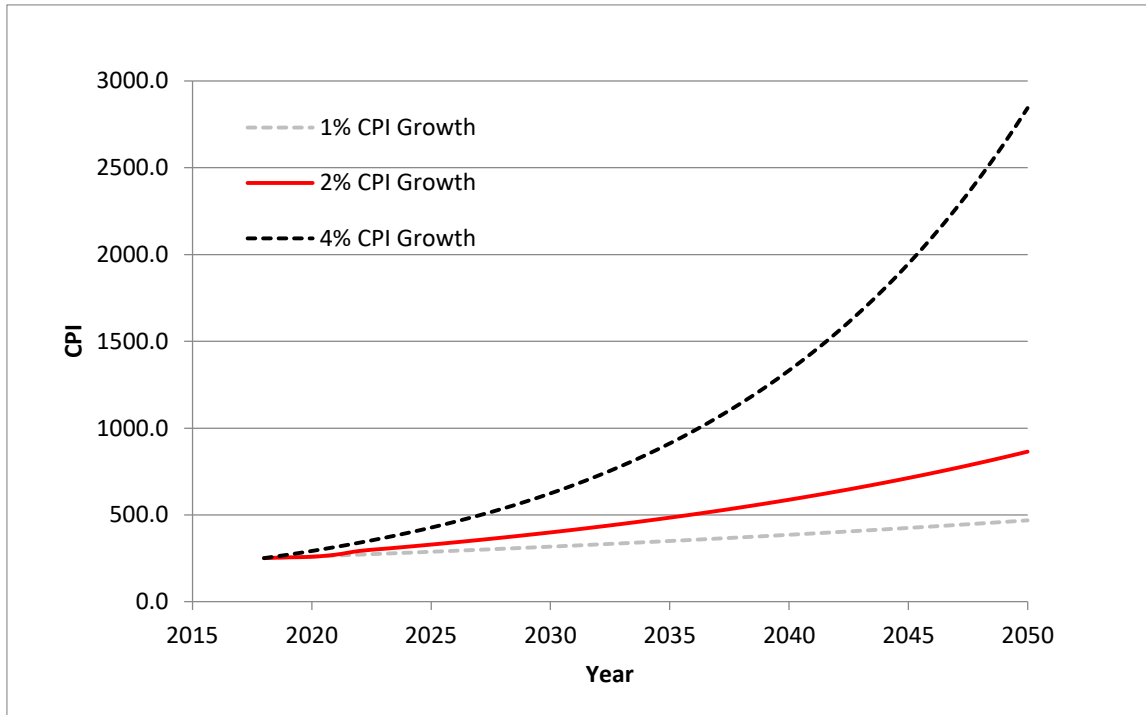
InflationFTR      = 1.0      ; Inflation Assumption (DEFAULT IS 1.0)
Defl_OverRide     = 0.0      ; Deflation Override (DEFAULT IS 0.0)  If Non-zero it is used as
deflator
                                ; Used as deflator IF NON-ZERO
BaseCPIYear       = 2018     ; Base year of the CPI Table
CurrCPIYear       = 2023     ; Current year on CPI Table
;
;=====
; 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=' 2018, 251.107,      0.00,                1.0000 ', ; <--- BaseCPIYear
' 2019, 255.657,      1.81,                0.9822 ', ;
' 2020, 258.811,      1.52,                0.9702 ', ;
' 2021, 270.970,      2.57,                0.9267 ', ;
' 2022, 292.655,      3.90,                0.8580 ', ;
' 2023, 304.702,      3.94,                0.8241 ' ; <--- CurrentCPIYear

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

```

Ref: "I:\ateam\mod_inputs\CPI\2023\CPI_GEN3_Ver.1.0.0\CPI_File.txt"

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

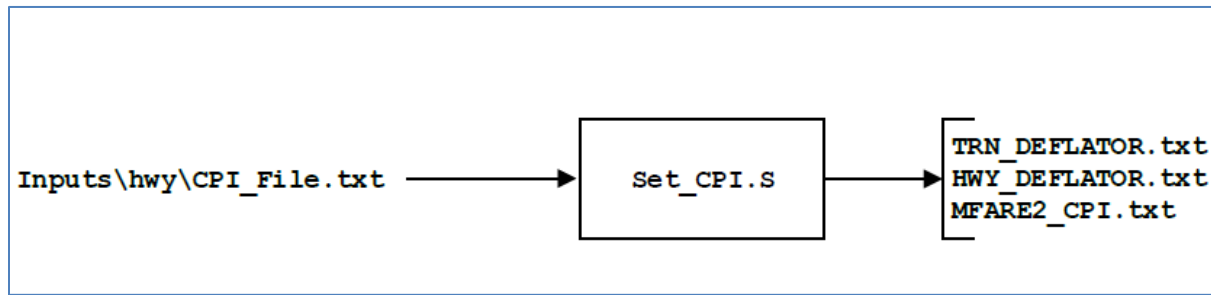


Ref: "I:\ateam\docum\fy25\Gen3_Network_Report_Vizualize2050\Report_Tables\CPI_Gen3_Ver.1.0.3.xlsx"

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, respectively, in subsequent modeling steps. The MFARE2_CPI.txt file contains summary CPI information.

Figure 3-3 Deflation process in the Gen3 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 unified geodatabase that is discussed in Chapter 4. Other inputs relating to zonal land activity and policy parameters are generated either manually or by offline procedures.

Table 3-1 Listing of highway network input files

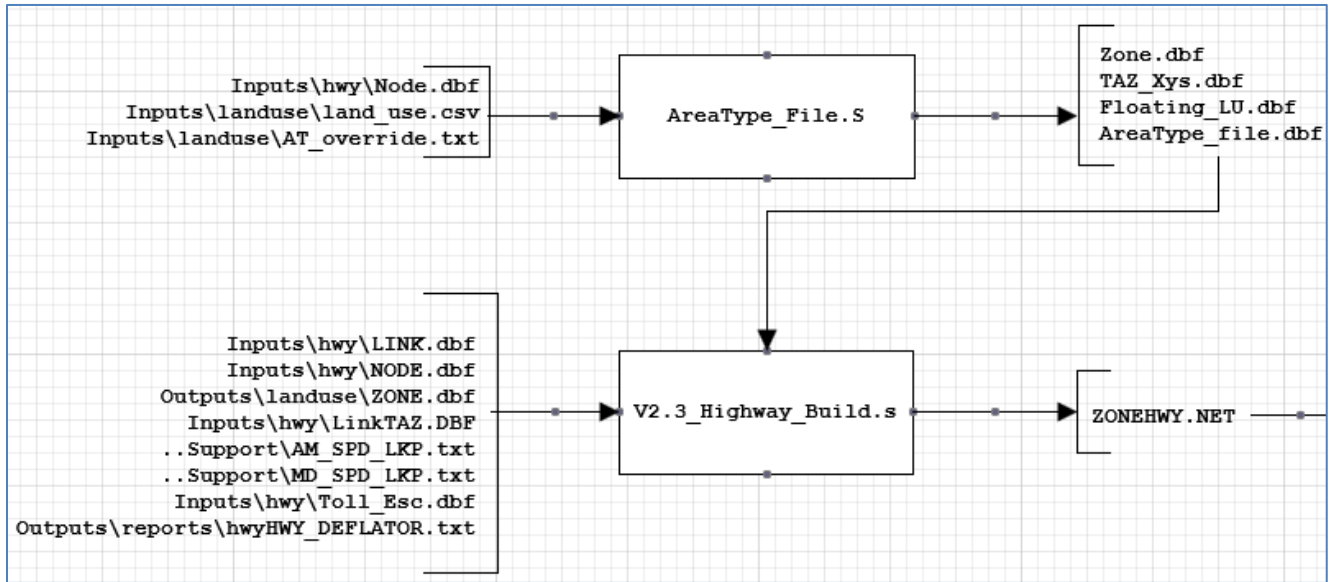
Filename	Description	Type	Source
Node.dbf	XY coordinates of nodes in highway network	DBF	Geodatabase
Link.dbf	Highway network links	DBF	Geodatabase
land_use.csv/Zone.dbf*	Land use/land activity data at zonal level, 3722 TAZ	Text	Analyst-generated
AreaType_File.dbf	Zonal Area Type file	DBF	Analyst-generated
Toll_Esc.dbf	Toll policy parameters by link "Tollgrp" code	DBF	Analyst-generated
LinkTAZ.DBF	Nearest Taz to each link file	DBF	Analyst-generated
AM_SPD_LKP.txt	AM speed lookup (Area type by Facility type)	Text	Analyst-generated
MD_SPD_LKP.txt	MD Speed lookup (Area type by Facility type)	Text	Analyst-generated

Note: * Zone.dbf file is generated based on land_use.csv

Ref: "I:\ateam\docum\fy25\Gen3_Network_Report_Vizualize2050\Report_Tables\Gen3_inputs.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 more detail in the next sections of the report.

Figure 3-4 Gen3 Highway network building process



3.2.1 Zonal Land Use

The land_use.csv file contains zonal land activity and other items that are shown in Table 3-2. While the zone.dbf file that is used in the Gen2 Model is kept in the Gen3 Model, the land_use.csv file contains additional zonal attribute information that is not available in zone.dbf. This file is created from a Python process that reads a single, standardized, multi-year file from COG’s Cooperative Forecasts of land activity, creates individual (year-by-year) files for the travel model, and includes additional zonal information that are required by the Gen3 Model. The most recent COG Cooperative Forecasts, Round 10 land activity was employed in the air quality conformity analysis of Visualize 2050 and the FY 2026-2029 TIP. The Round 10 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 2026 in the Visualize 2050 plan analysis, the land activity values are linearly interpolated.

Table 3-2 Format description of the land use file (land_use.csv)

File Name	Variable Name	Description
land_use.csv	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	Land Area of TAZ in square miles
	TAZXCRD	TAZ X-Coordinates (NAD83-based in whole feet)
	TAZYCRD	TAZ Y-Coordinates (NAD83-based in whole feet)
	K_8	Kindergarten - 8th grade enrollment
	G9_12	High school enrollment
	COLLEGE	College enrollment
	Park_Acres	Park area of TAZ in acres
	GC_Acres	Golf course area of TAZ in acres
	PRKCST	Parking cost in TAZ
	OPRKCST	Off-peak parking cost in TAZ
	TERMINAL	Terminal time for trip-ends in TAZ, in minutes
	AREATYPE	Area type of TAZ

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 employment definition adjustment, which ensures that all counties and jurisdictions in the modeled area use a consistent employment definition. 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 10 Cooperative Forecasts regional totals by year

Year	HH	HHPOP	GQPOP	TOTPOP	TEMP
2020	2,762,121	7,369,058	134,060	7,503,118	3,945,666
2025	2,924,239	7,682,520	136,093	7,818,613	4,187,436
2030	3,092,815	8,054,341	141,003	8,195,344	4,416,890
2035	3,249,319	8,396,507	142,828	8,539,335	4,645,724
2040	3,396,571	8,722,165	143,912	8,866,077	4,835,661
2045	3,533,770	9,040,591	145,117	9,185,708	5,021,895
2050	3,669,571	9,333,799	146,663	9,480,462	5,205,714

Note: These values include the employment definition adjustment factor that ensures that a consistent definition of employment is used across the modeled area.

Ref I:\ateam\mod_inputs\l\u\rnd_10_0_taz3722\memo\Tables\ tables_in_memo_v01.xlsx (Tab: Table7_Figure2)

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) <i>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</i>
	SCREEN	Screenline Code
	FTYPE	Link Facility Type Code (0-6) <i>0/centroids, 1/Freeways, 2/Major Art., 3/Minor Art, 4/ Collector, 5/Expressway, 6/ Ramp</i>
	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	Geometric network link identifier
	LINKID	Logical network link identifier
	NETYEAR	Planning year of network link
	SHAPE_LENGT	Geometric length of network link (in feet)
	PROJECTID	Project identifier
	TRANTIME	Place markers: have a value of Zero for all links
	WKTIME	
	MODE	<i>0/Highway Links, 3/ Metrorail, 4/Commuter Rail, 5/Light Rail, 10/BRT/Streetcar, 11/PNR Driveway Links, 12/ Special Walk-Access Links, 13/ Pedestrian Tunnel Links, 14/ KNR Drive/Walk Access Links, 15/ PNR Lot-to-Station/Bus Stop Node, 17/ Bus PNR Driveway Link</i>
	SPEED (mph)	<i>Highway Links = 0</i>
		<i>Metrorail, Commuter Rail, BRT/Streetcar = Various</i>
		<i>Light Rail= 16, PNR Driveway Links = 30, KNR Drive/Walk Access Links= 25, Bus PNR Driveway Link =15</i>
		<i>Special Walk-Access Links, Pedestrian Tunnel Links, PNR Lot-to-Station/Bus Stop Node = 3</i>
	Street Name	Street/Road name

The highway network node file, node.dbf (Table 3-5), contains the XY coordinates for both TAZs and highway nodes, as well as fare zone information for Metrorail and commuter rail.

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)
	MRFZONE	Metrorail Station Fare Zone
	CRMZONE	MARC Station Fare Zone
	CRVZONE	VRE Station Fare Zone

Road attributes that may vary by time of day are represented by three 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 were discussed in section 2.4 (“Highway Network Elements”). 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.

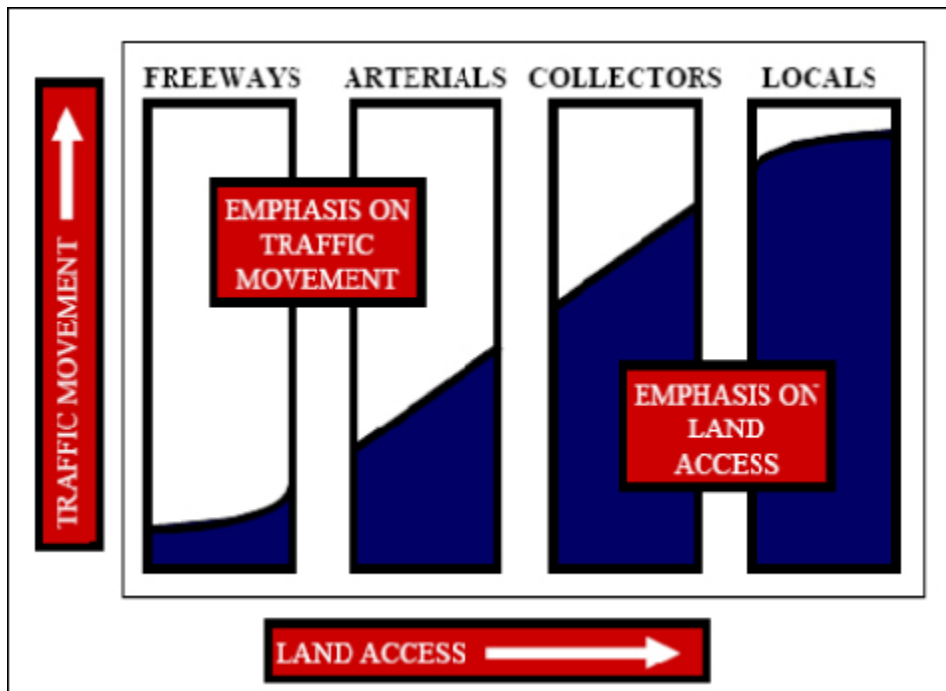
3.2.3 Roadway Functional Classification and the Facility-type Variable

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: ¹⁷

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:

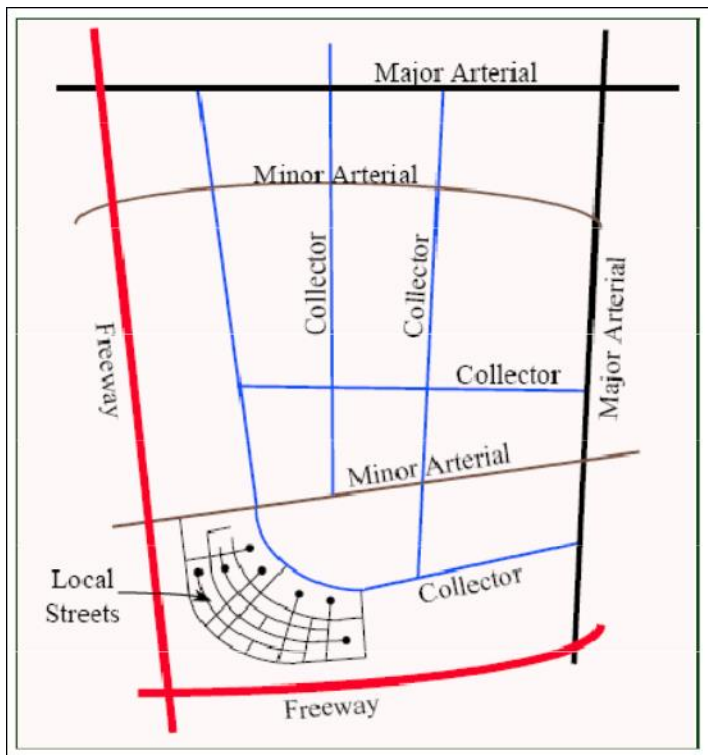
- 0: centroid connectors
- 1: interstates and freeways
- 2: major arterials

¹⁷ 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
- 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: ¹⁸

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

The federal government has its own classification scheme, called the federal functional classification system.¹⁹ 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

¹⁸ BLF Marketing, Wilbur Smith Associates, Inc., and RKG Associates, Inc., chap. 3.

¹⁹ "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.

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 ensure that the facility usage and operation are 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.

3.2.4 Other Link Attributes

Modeled link free-flow speeds and capacities are based on the facility type (FTYPE) and area type (ATYPE) variables. 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 midpoint 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

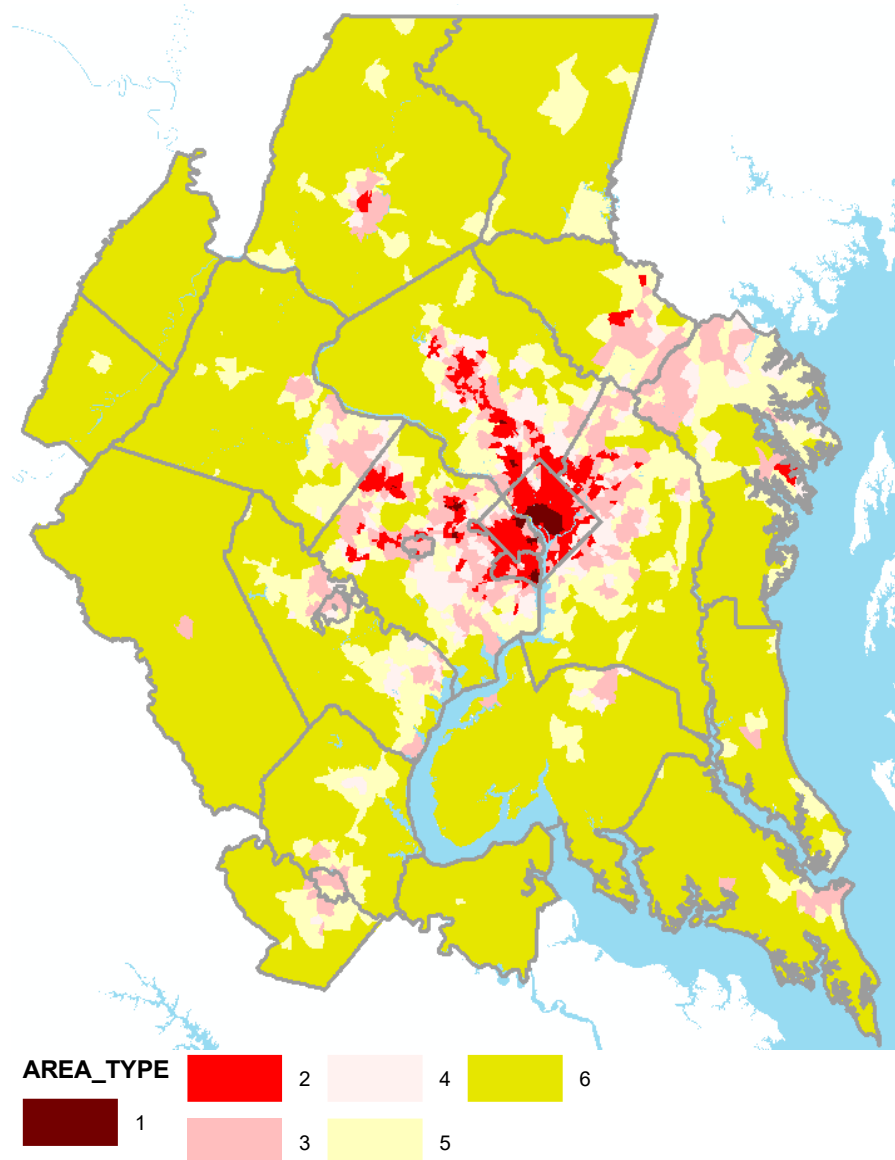
One-Mile "Floating" Population Density (Pop/Sq mi)	One- mile "Floating" Employment Density (Emp/Sq mi)						
	0-100	101-350	351-1,500	1,501- 3,550	3,551- 13,750	13,751- 15,000	15,001+
0-750	6	6	5	3	3	3	2
751-1,500	6	5	5	3	3	3	2
1,501-3,500	6	5	5	3	3	2	2
3,501-6,000	6	4	4	3	2	2	1
6,001-10,000	4	4	4	2	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	<ol style="list-style-type: none"> 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	<ol style="list-style-type: none"> 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	<ol style="list-style-type: none"> 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	<ol style="list-style-type: none"> 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	<ol style="list-style-type: none"> 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	<ol style="list-style-type: none"> 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 choose, override the calculated area-type values by using an override feature in the model. An example 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: In Virginia, HOT/express toll lane operations on I-95/I-395 between the 14th Street Bridge and VA 17 (Warrenton Rd- exit 133) in Stafford County are included in all networks representing 2022 and beyond. In the Visualize 2050 Plan the I-95 express lanes from the Springfield interchange to Opitz will convert from having reversible operation to having bi-directional operation in 2030. The I-395 HOV lanes from Turkeycock Run to just south of the 14th Street Bridge converted to HOT/express toll in 2019. On I-495 (Capital Beltway) in Virginia HOT/express toll lane operations are included as follows:

- Beginning in 2013: From Hemming Avenue to south of Old Dominion Drive;
- Beginning in 2026: From south of Old Dominion Drive to the American Legion Bridge;

The HOV lanes on I-66 inside the Beltway converted to HOT/express toll lanes in 2017. HOT/express toll lanes on I-66 outside the Beltway to 1.2 miles west of US 15 are included in all networks starting in 2022.

In Maryland, the Intercounty Connector (ICC) is included in all networks representing 2012 and beyond. The toll rates used in the Visualize 2050 plan for ICC are effective as of Summer 2024.

On I-270, HOV lanes will be converted to HOT/express toll lane operations as follows:

- Beginning in 2030: I-270 western spur;
- Beginning in 2040: From I-270 on the eastern spur from MD 187 (Old Georgetown Road) north to the main I-270;
- Beginning in 2045: I-270 spur to I-370.

Maryland Beltway I-495 HOT/express toll lanes from the Virginia state line (including the American Legion Bridge) to the I-270 western spur are included in all networks in 2035 and beyond as shown in Figure 3-11.

As mentioned earlier, the transportation networks used for the Gen3 Model usability testing included the Southside Express Lane (SSEL) project for the analysis years after 2030.

The Metropolitan Washington region includes several tolled highway facilities that vary substantially in tolling policy. On some facilities, such as the Dulles Toll Road 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 Intercounty Connector (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 also 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

Toll setting process is used to provide “planning-grade” toll estimates that serve as an indicator of travel demand patterns on the regional highway system of variably priced tolling facilities. In the Gen2 Model, the toll setting process is executed separately from the final model run. In the Gen3 Travel Model, TPB staff integrates the toll setting process into the model chain, which reduces model runtime and provides users the option to turn toll setting on and off.²¹ Specifically, staff stitched the previous two model runs (“pump-prime” run and “final” run) into one model run and provided a toggle switch in the main batch file to turn toll setting on or off depending on the user preference as shown in Figure 3-8 (highlighted in yellow). Figure 3-9 illustrates the “one-run” process. The toll modeling components are displayed in

²⁰ See, for example, Jane Posey to Files, “Visualize 2050 Toll Rates,” Memorandum, June 18, 2025.

²¹ Feng Xie and Bahar Shahverdi to Mark Moran, “Integrating Toll Setting in Gen3 Model Flow: Testing and Recommendations,” Memorandum, March 15, 2024

orange. When the toggle switch for toll setting is set to be “False”, the model flow on the righthand side of the chart (shown in green color) skips toll setting and uses pre-specified toll input files to generate travel demand forecasts in five SFB loop iterations. When the toggle switch is set to be “True”, on the other hand, the model will start with toll inputs with minimum toll rates. After the model goes through one Pump Prime Iteration (“pp”) and four regular iterations (“i1”, “i2”, “i3” and “i4”), the resulting O-D trip tables are fed into the toll setting process, which performs the toll search algorithm and generates estimated tolls on the variably priced toll lanes. Using the updated toll input files that contain the estimated toll rates, the model then executes five more iterations to generate the final travel demand forecasts. The model flow with toll setting is shown on the lefthand side of the chart (shown in blue color). The flowchart in Figure 3-10 illustrates the toll setting process in the Gen3 Travel Model.

Figure 3-8 Toll Setting Toggle Switch

```

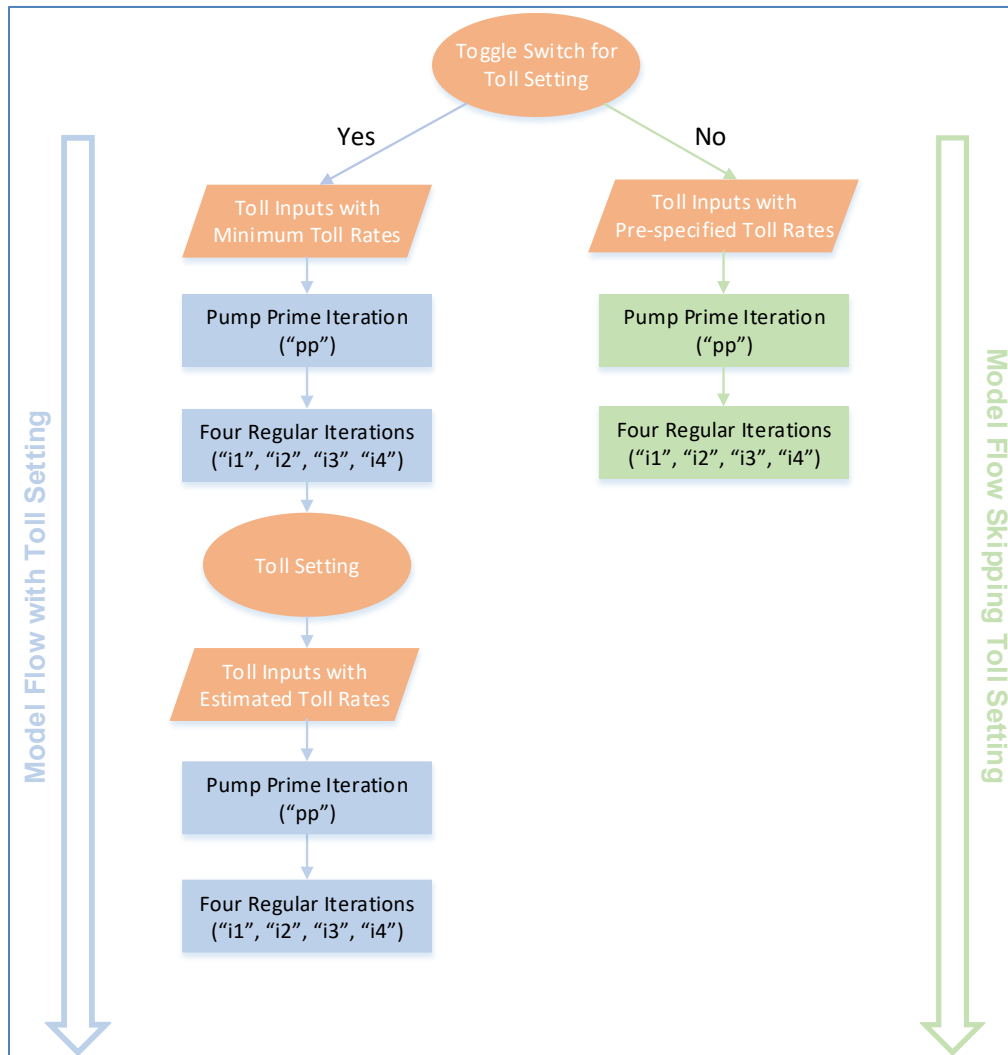
1  :::#####
2  ::
3  :: MWCOG Gen 3 Model
4  ::
5  :::#####
6  ::@ECHO OFF
7
8  :: ===== USER SPECIFICATIONS=====
9
10 :: STEP ZERO: Set model year/alternative variables
11 set _year =2018
12 set _alt =Ver3.0_Base
13
14 :: STEP ONE: Set USE_MAMBA_OR_ANACONDA to either ANACONDA or MAMBA
15 SET USE_MAMBA_OR_ANACONDA=ANACONDA
16
17 :: STEP TWO:Set Python environment name
18 :: Make sure this environment is installed following the instructions in README.md
19 SET PYENVNAME=gen3_model121
20
21 :: STEP THREE: Set Anaconda/Mamba and Python paths
22 If /I %USE_MAMBA_OR_ANACONDA% EQU MAMBA (
23 SET MAMBA_OR_ANACONDA_DIR=C:\ProgramData\mambaforge
24 :: SET MAMBA_OR_ANACONDA_DIR=C:\Users\%USERNAME%\AppData\Local\mambaforge
25 :: SET PYTHON=C:\Users\%USERNAME%\AppData\Local\mambaforge\envs\%PYENVNAME%\python.exe
26 SET PYTHON=C:\Users\%USERNAME%\conda\envs\%PYENVNAME%\python.exe)
27
28 If /I %USE_MAMBA_OR_ANACONDA% EQU ANACONDA (
29 SET MAMBA_OR_ANACONDA_DIR=C:\ProgramData\Anaconda3
30 :: SET MAMBA_OR_ANACONDA_DIR=C:\Users\%USERNAME%\Anaconda3
31 :: SET MAMBA_OR_ANACONDA_DIR=C:\Users\%USERNAME%\AppData\Local\Anaconda3
32 :: SET PYTHON=C:\Users\%USERNAME%\Anaconda3\envs\%PYENVNAME%\python.exe
33 :: SET PYTHON=C:\Users\%USERNAME%\AppData\Local\conda\conda\envs\%PYENVNAME%\python.exe
34 :: SET PYTHON=C:\Users\%USERNAME%\AppData\Local\Anaconda3\envs\%PYENVNAME%\python.exe
35 SET PYTHON=C:\Users\%USERNAME%\conda\envs\%PYENVNAME%\python.exe
36 )
37
38 :: STEP FOUR: Set RUN_MINI to True to skip Iterations 2 to 4 of the model
39 :: This "mini" version reduces the model's footprint in terms of runtime and storage space
40 :: and is sufficient for tasks like functionality testing and benchmarking.
41 :: It is recommended to include "mini" in the scenario folder name to indicate a mini run.
42 SET RUN_MINI=False
43
44 :: STEP FIVE: Set AUTO_SHUTDOWN to True to automatically shut down a server at the end of a model run
45 :: This is useful when the model is run on an on-demand cloud server that is charged by hours used.
46 SET AUTO_SHUTDOWN=False
47
48 :: STEP SIX: Set TOLL_SETTING to True to turn on the toll setting processing
49 :: When TOLL_SETTING is turned off, the model runs use the toll inputs in the "Toll_Esc.dbf" file.
50 set TOLL_SETTING=True
51
52
53 :: ===== DEFAULT MODEL SPECIFICATIONS =====
54 :: setup folders
55 SET SCEN_DRIVE=%d0
56 ECHO SCEN_DRIVE: %SCEN_DRIVE%

```

Source: ²²

²² Ibid, Page 4

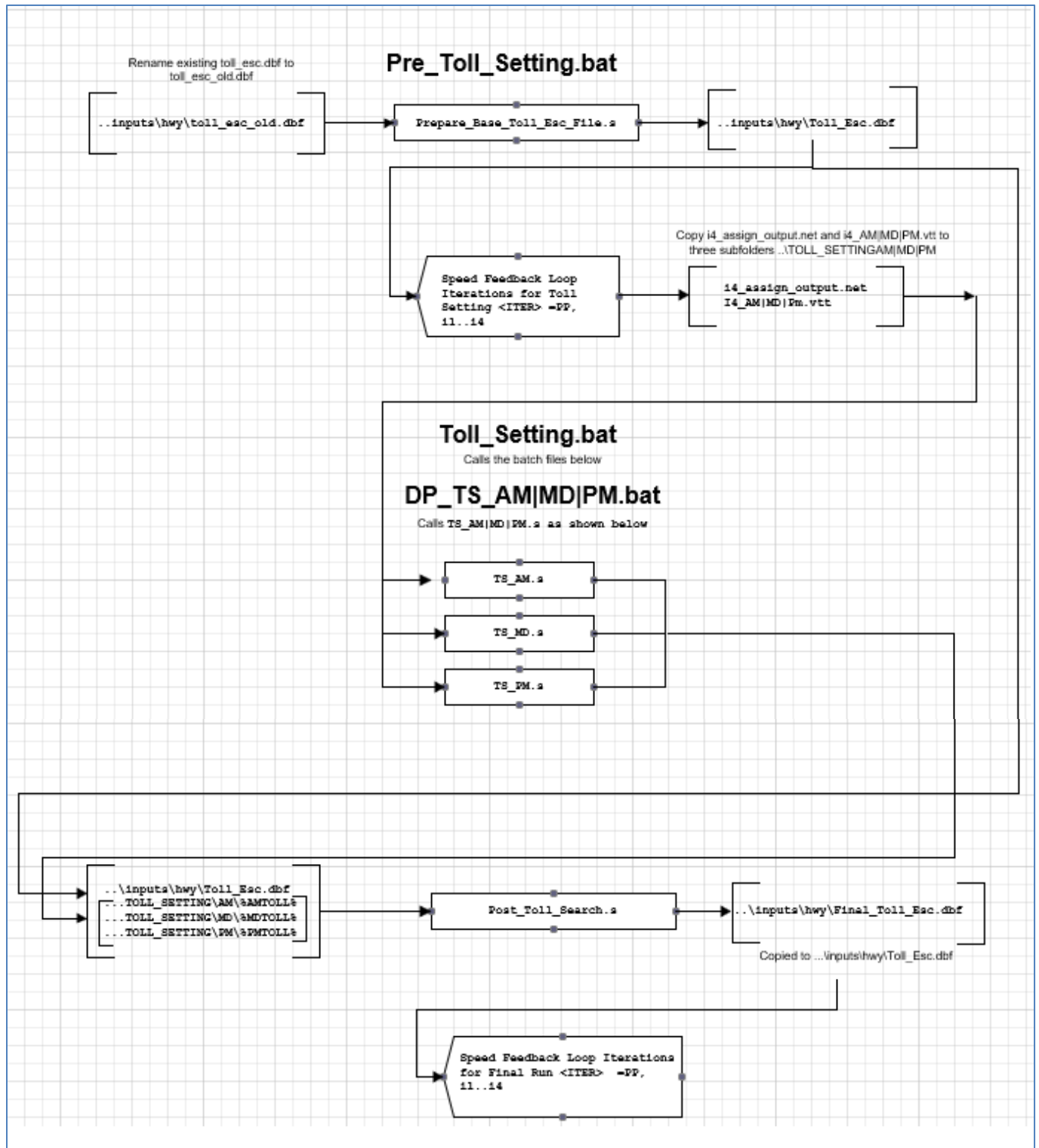
Figure 3-9 Gen3 Model Flow with a "One-Run" Toll Setting Process



Source: ²³

²³ Ibid, page 3

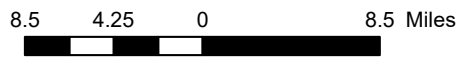
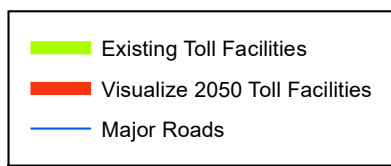
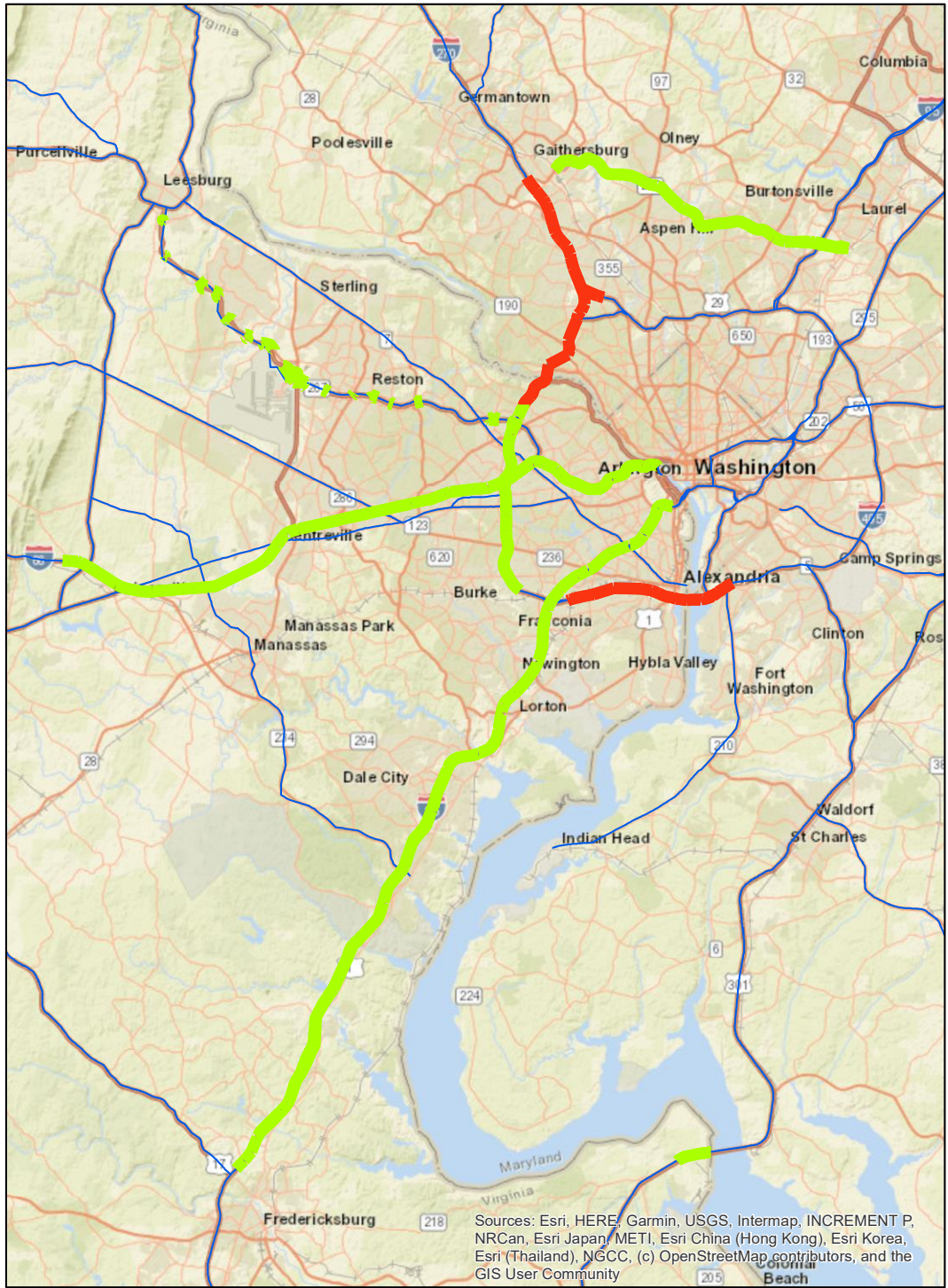
Figure 3-10 Gen3 Travel Model Toll Setting Process



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-2024 network, for instance, that would contain the tolls as they were in 2024. 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 Toll Lanes. The TOLLGRP rates are estimated in the toll setting process and written into the toll parameter/escalation file (TOLL_ESC.dbf), which is subsequently used as the input to the final model run. Table 3-9 lists the specific variables in the file.

Figure 3-11 Existing and the Visualize 2050 Managed-lane facilities in the regional highway networks



Ref:\ateam\docum\fy25\Gen3_Network_Report_Vizualize2050\Report_Tables\Toll_Facilities_Viz2050_Gen3.emf

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	<i>Toll Type (1 = operating in calibration year, 2 = operating after calibration year)</i>

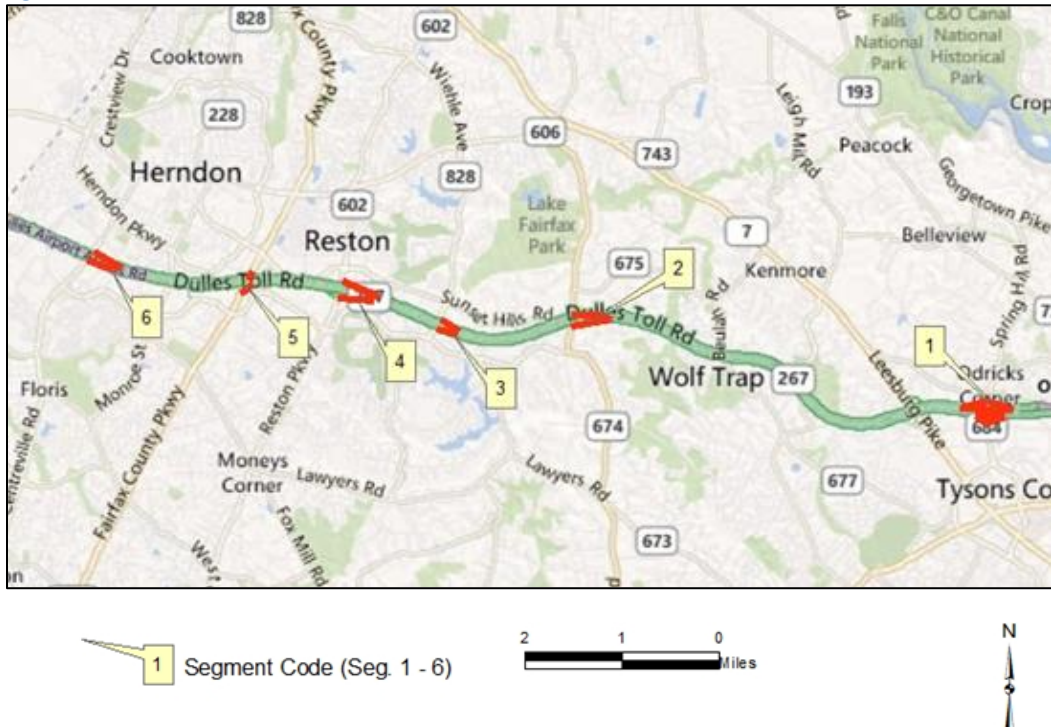
I:\ateam\docum\fy22\Version2.4_2022Update_Visualize2045_Network_Report\Report_Tables\Lst_of NW_Fare_Files.xlsx"

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 3-12 shows tolling locations on the Dulles Toll Road.

Figure 3-12 Dulles Toll Road: Toll facilities locations



The Visualize 2050 plan forecast-year networks reflects year-2024 toll values, as shown in Table 3-10. Note that in this table, the nominal toll rate is fixed at the year-2024 value through 2050, which implies that real tolls (prices) are dropping from 2024 to 2050. In the model, all prices are converted to a common year (2018, the calibration year) and then grown to the modeled year being analyzed. Thus, a year-2024 toll would first be brought to year-2018 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. 29, the deflation year goes only to 2023. That is because, when the CPI file was being developed, data for the entirety of 2024 was not yet available. Thus, when year-2024 tolls are deflated, they are deflated using the year-2023 deflation value (0.8241).

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

Segment	A	B	Location	Direction	Toll Values (in 2024 cents)
					2024
1	35130	35133	Main Toll Plaza-Rt 684 Interchange (LOV)	Inbound	400
	35136	35129	Main Toll Plaza-Rt 684 Interchange (LOV)	Outbound	400
	35430	36657	Greensboro Dr at Tyco Rd	Inbound	200
	36657	35129	Greensboro Dr at Tyco Rd	Outbound	200
	35130	35132	Spring Hill Road- Off Ramp	Inbound	200
	35132	35133	Spring Hill Road- On Ramp	Inbound	200
	35136	35131	Spring Hill Road- Off Ramp	Outbound	200
	35131	35129	Spring Hill Road- On Ramp	Outbound	200
	2	35097	35096	Rt 674 (Hunter Mill Road) - On Ramp	Inbound
35194		35095	Rt 674 (Hunter Mill Road) - Off Ramp	Outbound	200
3	35101	35100	Rt 828 (Wiehle Avenue)- On Ramp	Inbound	200
	35196	35099	Rt 828 (Wiehle Avenue)- Off Ramp	Outbound	200
4	35105	35104	Rt 602 (Reston Pkwy)-On Ramp	Inbound	200
	35198	35103	Rt 602 (Reston Pkwy)-Off Ramp	Outbound	200
5	35287	35291	Rt 7100 (Fairfax Co. Pkwy)- On Ramp	Inbound	200
	35289	35286	Rt 7100 (Fairfax Co. Pkwy)- Off Ramp	Outbound	200
6	35109	35108	Rt 228 (Centreville Road) -On Ramp	Inbound	200
	35200	35107	Rt 228 (Centreville Road) -Off Ramp	Outbound	200

Note: Toll rates current to summer, 2024. Year 2024 toll values are used for all forecast years.

Ref: " I:\ateam\docum\fy25\Gen3_Network_Report_Vizualize2050\Report_Tables\Grnway_Dulles_Viz2050_Gen3.xlsx Tab-Dulles_Toll_Rd"

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 3-13 and Figure 3-14. 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 represents the west of Route 28 (Sully Road) interchange with a weighted toll of \$7.53 in 2024 and beyond. A weighted toll of \$5.53 in 2024 and beyond is used for all westbound and eastbound on-ramps at Routes 28, 606, and 607. A weighted toll of \$4.83 in 2024 and beyond is coded for all westbound and eastbound on-ramps at Routes 772, Claiborne Parkway, and Belmont Ridge Road. A weighted toll of \$4.10 in 2024 and beyond is coded for all on-ramps at Route 653/Shreve Mill Road. No toll is charged at the future Battlefield Parkway interchange.

Figure 3-13 Dulles Greenway: Toll facilities locations (Map 1 of 2)

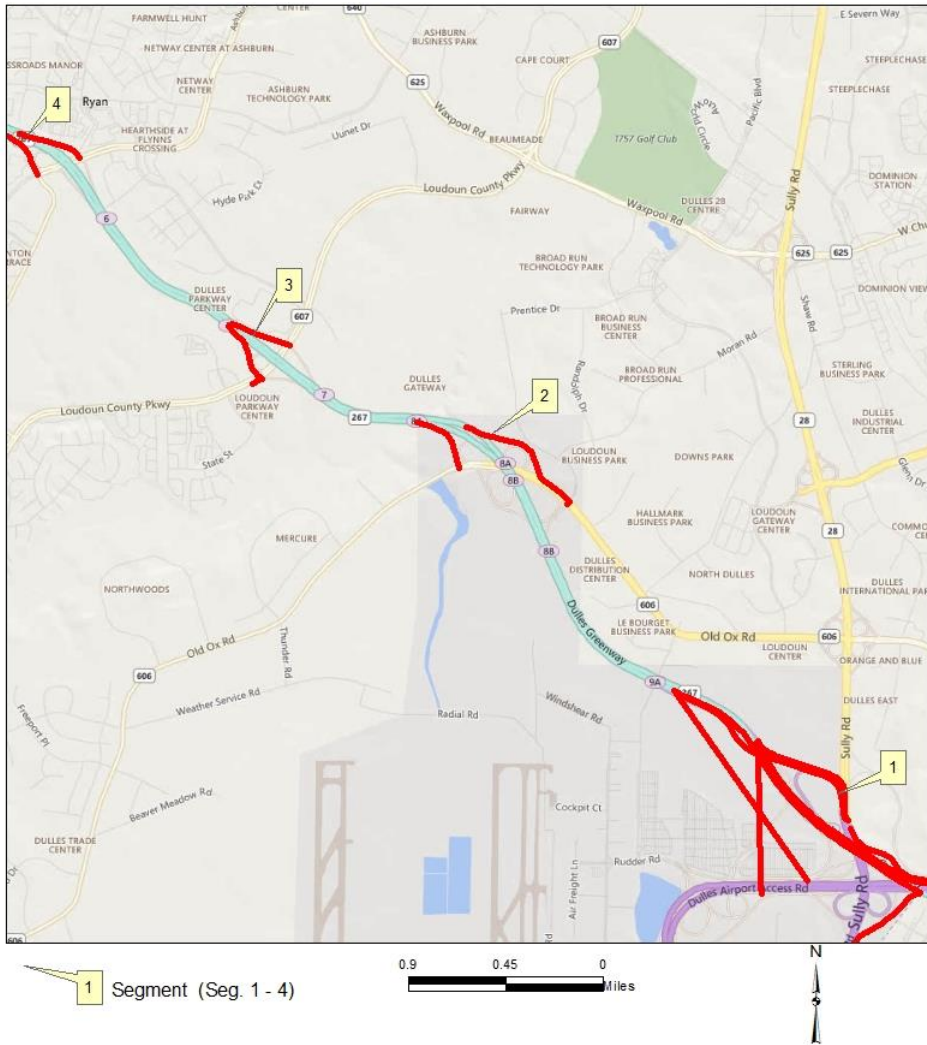


Table 3-11 Dulles Greenway Toll Inks (Segments 1-4)

Seg	Anode	Bnode	Location	Direction	Toll Values (in 2024 cents)	
					2024	
1	38046	38098	Rt. 28	Outbound		753
	38266	34810	Rt. 28	Inbound		753
	38025	34810	Rt. 28 Toll Plaza on- Ramp	Inbound		200
	38046	38018	Rt. 28 Toll Plaza off- Ramp	Outbound		200
	38064	38098	Rt. 28 to Dulles Greenway on-Ramp	Outbound		553
	38266	38064	Dulles Greenway to Rt. 28 off-Ramp	Inbound		553
	38043	38098	Airport Access road to Dulles Greenway on- Ramp	Outbound		553
	38266	38047	Dulles Greenway to Airport Access road off Ramp	Inbound		553
2	38029	38271	Rt 606 (Old Ox Road) on-Ramp	Outbound		553
	38272	38273	Rt 606 (Old Ox Road) off-Ramp	Inbound		553
3	38100	38276	Rt 607 (Loudoun Co. Pkwy) on-Ramp	Outbound		553
	38277	38278	Rt 607 (Loudoun Co. Pkwy) off-Ramp	Inbound		553
4	38065	38281	Rt 772 (Old Ryan Rd) on-Ramp	Outbound		483
	38282	38283	Rt 772 (Old Ryan Rd) off-Ramp	Inbound		483

Ref: "I:\ateam\docum\fy25\Gen3_Network_Report_Vizualize2050\Report_Tables\Grnway_Dulles_Viz2050_Gen3.xlsx Tab-Grnway"

Figure 3-14 Dulles Greenway: Toll facilities locations (Map 2 of 2)

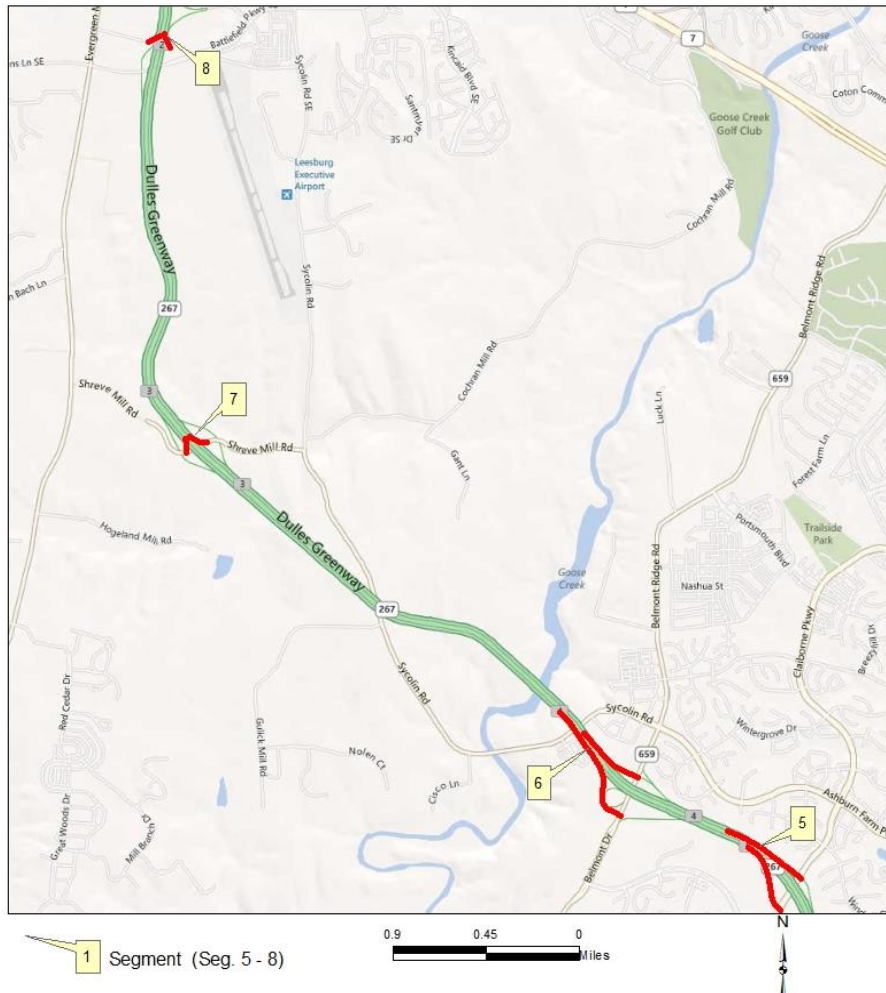


Table 3-12 Dulles Greenway Toll links (Segments 5-8)

Seg	Anode	Bnode	Location	Direction	Toll Values (in 2024 cents)
					2024
5	38069	38289	Claiborn Pkwy on-Ramp	Outbound	483
	38290	38291	Claiborn Pkwy off-Ramp	Inbound	483
6	38070	38294	Belmont Ridge Road on-Ramp	Outbound	483
	38295	38296	Belmont Ridge Road off-Ramp	Inbound	483
7	38071	38299	VA 653 Shreve Mill Road on-Ramp	Outbound	410
	38300	38301	VA 653 Shreve Mill Road on-Ramp	Inbound	410
8	38072	38304	Battlefield Pkwy on-Ramp	Outbound	na
	38305	38306	Battlefield Pkwy off-Ramp	Inbound	na

Note: Toll rates current to summer, 2024. Year 2024 toll values are used for all forecast years.

Ref: " I:\ateam\docum\fy25\Gen3_Network_Report_Vizualize2050\Report_Tables\Grnway_Dulles_Viz2050_Gen3.xlsx Tab-Grnway"

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

A	B	Location	Direction	Toll Values (in 2024 cents)
				2024
50002	50001	Virginia - Maryland	Inbound	241
50001	50002	Maryland - Virginia	Outbound	241

Note: Toll rates current to summer, 2024. Year 2024 toll values are used for all forecast years.

Ref: " I:\ateam\docum\fy25\Gen3_Network_Report_Vizualize2050\Report_Tables\Grnway_Dulles_Viz2050_Gen3.xlsx Tab-Dulles_Toll_Rd"

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 2024 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 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.

It should be noted that the toll setting process in the TPB regional travel demand models is primarily designed to provide “planning-grade” estimates of variably priced tolls as an indicator of travel patterns in the freeway system. The outputs from the toll setting process have never been calibrated or validated to observed data, and thus, this process should not be viewed as a realistic representation of the tolling system on the ground. In fact, a recent analysis suggested that the estimated end-to-end tolls on

express toll lanes from the Gen3 Model were substantially lower than the observed data.²⁴ As such, TPB staff recommend against the practice of directly using the outputs from the COG/TPB toll setting process in any type of operation-level studies.

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 a facility such as I-395 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.²⁵ The screenline locations are shown in Figure 3-15 and Figure 3-16.

²⁴ Feng Xie and Bahar Shahverdi to Mark Moran, “Improving the Toll Setting Process in the Gen3 Travel Model: Testing and Recommendations”, COG/TPB Memorandum, May 15, 2025.

²⁵ The “screen” variable includes codes from 1 to 38, but the numbers 21 and 30 are unused.

Figure 3-15 Highway Network screenlines: Inside the Beltway

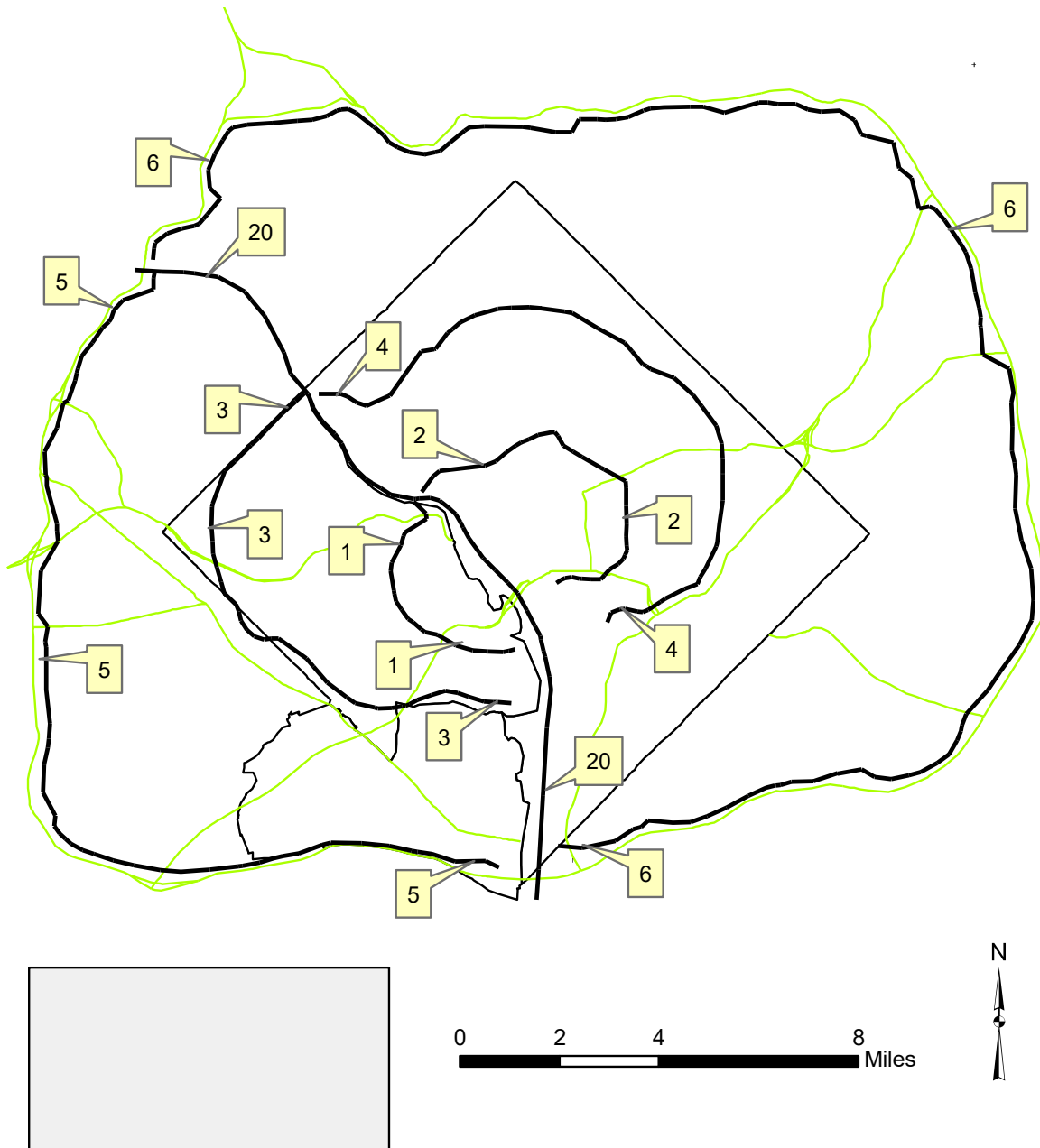
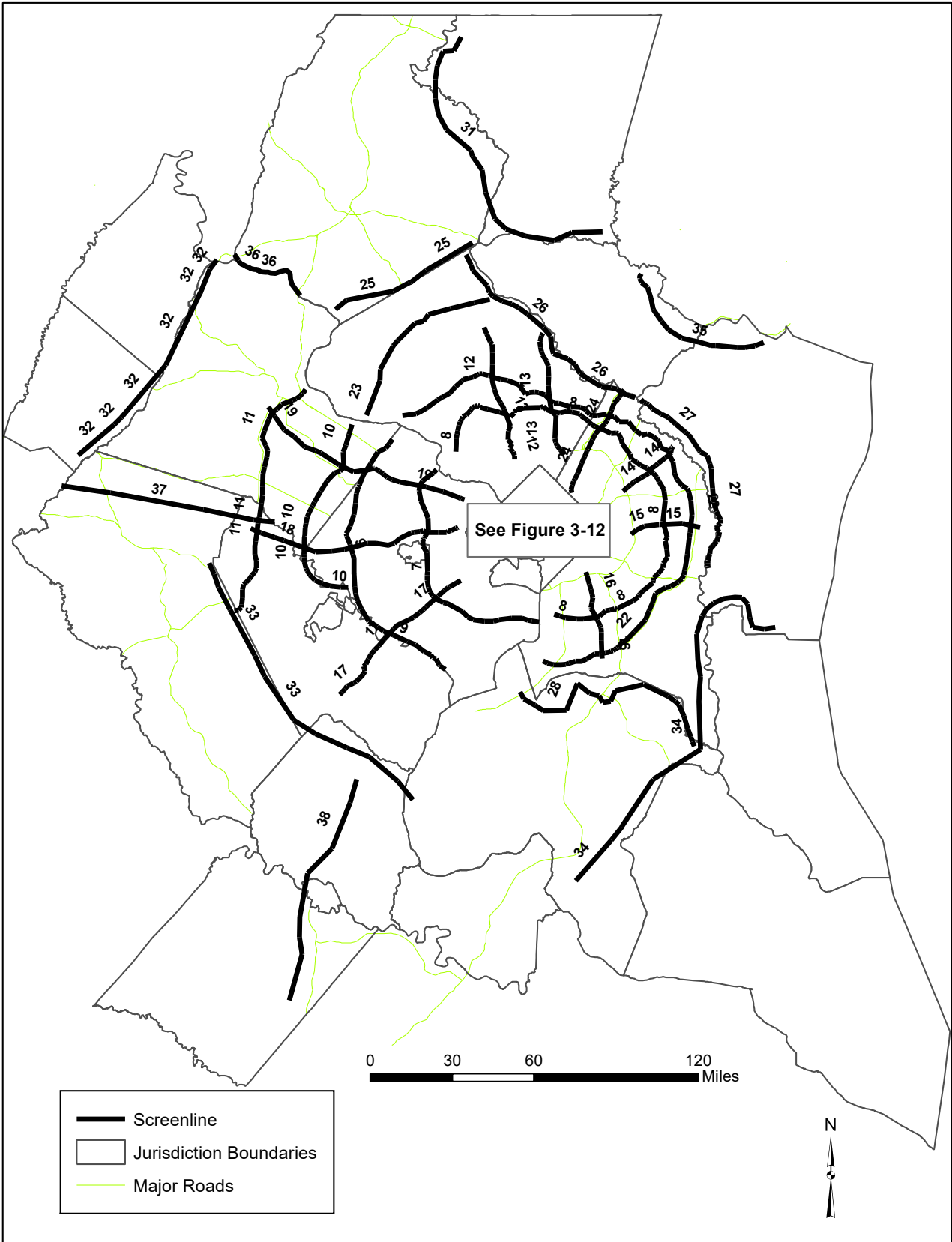


Figure 3-16 Highway network screenlines: Outside the Beltway



Ref: "I:\ateam\docum\fy22\Version2.4_2022Update_Visualize2045_Network_Report\ Screenline_Map_Rev_March9_2022.emf

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 3-14.

Table 3-14 Listing of Gen3 Model transit network input files

File Name	Description	Type	Source
<per>_TRN.FAC	<per> PT Factor File	Text	COG proposed specifications for PT Multipathing
<per>_TRN_BM.FAC	<per> PT Fare BM File	Text	
<per>_TRN_CR.FAC	<per> PT Fare CR File	Text	
Bus_Factor_File.DBF	Local Bus Time Degradation Factors	DBF	Gen2/Ver.2.4 Model
fare_<per>.dat	<per> PT Fare File	Text	PT fares specified based on WMATA Tariff#45 Metrorail and Metrobus fares, MARC and VRE fare rate tables obtained from their official websites, and staff's professional judgment
i4_Assign_Output.net	Loaded Highway Network	Binary	Gen2/Ver.2.4 Model
MARC_Fare.dat	MARC fare matrix	Text	MARC fare rate tables obtained from their official websites. Current 2024, Published in 2021 station-to-station fares
MetLnkM1.TB	Metrorail Links	Text	Unified Geodatabase
MetNodM1.TB	Metrorail Nodes	Text	Unified Geodatabase
MFare1.a1	Metrorail Sta XYs scaled to 1/100ths of miles	Text	Unified Geodatabase
mfare1_Sta_Disc.ASC	Metrorail Sta fare discount array in cents	Text	Unified Geodatabase
MODE1<per>...Mode10<per>.LIN	Transit line files	Text	Unified Geodatabase
Rail_Links.DBF	Rail Link File	DBF	Unified Geodatabase
STATION.DBF	Station file: Metrorail, Comm.Rail, LRT stations/PNR lots & bus PNR lots	DBF	Unified Geodatabase
tariff.txt	WMATA Transit fare (tariff) policy	Text	Analyst-generated
TRNPEN.DAT	Metrorail network turn penalty file	Text	Analyst-generated
TSYSD.PTS	PT system file	Text	Unified Geodatabase
VRE_Fare.dat	VRE fare matrix	Text	VRE fare rate tables obtained from their official website Published in 2020 farezone-to-farezone

<per> =AM, MD, PM, and NT

Ref: " I:\ateam\docum\fy25\Gen3_Network_Report_Vizualize2050\Report_Tables\Gen3_Trn_Network_Input_Files_Rev.xlsx "

1. Listing of external transit and visitor trip tables are shown in Table 3-15. Transit on-board survey data was primarily used to develop Traffic Analysis Zone (TAZ)-level External-Internal (EI), Internal-External (IE), External-External (EE), and Visitor trip tables. There were three on-board transit surveys used for this purpose:
2. A 2016 Metrorail Passenger Survey collected by the Washington Metropolitan Area Transit Authority (WMATA) in 2016 (April 7 through June 4, 2016) at all the 91 stations during all time periods of weekdays and weekends.
3. A Maryland Area Regional Commuter (MARC) Train Service 2016 On-Board Survey.

4. A 2019 Virginia Railways Express (VRE) survey administered to riders on northbound trains in the AM peak period only.²⁶

Table 3-15 Listing of Gen3 model External and Visitor Transit Trip Files

Filename	Description	Type	Source
<per>_External.omx	AM External Transit Visitor Trip Tables	Binary	TRANSIT ON-BOARD SURVEY Processed by RSG
<per>_External.TRP			
<per>_Visitor.omx			
<per>_Visitor.TRP			

<per> =AM, MD, PM, and NT

Ref: " I:\ateam\docum\fy25\Gen3_Network_Report_Vizualize2050\Report_Tables\Gen3_Trn_Network_Input_Files_Rev.xlsx "

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), which 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 light rail 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 3-16.

²⁶ Chapter 3, RSG with Baseline Mobility Group, “GEN3 Data Development Report”. Prepared for Metropolitan Washington Council of Governments, December 29, 2021.

Table 3-16 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

There are currently about 28 transit agencies represented in the transit networks used by the TPB travel demand forecasting model, as shown in Table 3-17. For each transit agency, this table shows the agency abbreviations, the main services offered by each agency, and the modes of travel offered. 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 2023 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 3-18 provides an equivalency between transit modes and transit services.

Highway and Transit Networks Developed for the Gen3 Travel Model

Table 3-17 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?	2023 Annual Trips	5 digit NTD ID
1 Washington Metropolitan Area Transit Authority	WMATA	WMA	WM	Metrorail, Metrobus, Metroway, REX	HR, MB, CB, BRT	Multiple	Multiple	y	y	229,629,638	30030
2 District Department of Transportation	DDOT	DCT	DC	DC Circulator, DC Streetcar	MB, SR	Washington	DC	y	y	2,591,448	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, MB, CB, BRT	Multiple	MD	y	y	4,565,272	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), OmniRide, OmniLink	CR, CB, MB	Multiple	VA	y	y	1,576,743	30070
6 Northern Virginia Transportation Commission	NVTC	NVT	NV	Virginia Railway Express (VRE)	CR	Multiple	VA	y	y	1,466,250	30073
7 Montgomery Co. Dept. of Transportation, Div. of	MCDOT	MCT	MC	Ride-On	MB	Montgomery Co.	MD	y	y	14,359,817	30051
8 Fairfax Co. Dept. of Transportation	FFXDOT	FFX	FC	Fairfax Connector, US 1 BRT, Tysons Circulator	MB, BRT	Fairfax Co.	VA	y	y	8,365,190	30068
9 Prince George's Co.	PGCO	PGC	PG	TheBus	MB	Prince George's Co.	MD	y	y	1,762,469	30085
10 Arlington Co.	ART	ART	AR	Arlington Transit (ART)	MB	Arlington Co.	VA	y	y	2,049,102	30080
11 Alexandria Transit Company	ALEX	ALX	AL	DASH Bus	MB	Alexandria	VA	y	y	4,540,860	30071
12 City of Fairfax	CUE	CUE	CU	City. University. Everyone. (CUE) Bus	MB	City of Fairfax	VA	y	y	845,194	30058
13 Transit Services of Frederick County	TransIT	FRM	FM	Transit Services of Frederick County	MB	Frederick Co.	MD	y	y	641,014	30072
14 Loudoun County	LCTrans	LCT	LC	Loudoun Co. Commuter Bus (LC Transit)	CB, MB	Loudoun Co.	VA	y	y	511,845	30081
15 Annapolis Department of Transportation	ANDOT	ANN	AN	Annapolis Transit	MB	Annapolis	MD	y	y	303,385	30040
16 Howard Transit	HT	HOW	HT	Howard Transit	MB	Howard Co.	MD	y	n		
17 Columbia Transit System	COLUM	COL	CO		MB	Columbia	MD	y	n		
18 FREDericksburg Regional Transit (FRED)	FRED	FRD	FV	FRED	MB	Fredericksburg	VA	y	y	288,349	30079
19 Carroll Transit System	CARR	CAR	CA		MB	Carroll Co.	MD	y	y	23,661	30092
20 City of Winchester	WinTran	WNT	WN	WinTran	MB	Winchester	VA	y	y	168,083	30099
21 Martz Group	NCW	NCW	NC	National Coach Works of Virginia, MTA Commuter	CB	Multiple	Multiple	y	n		
22 Metropolitan Washington Airports Authority	MWAA	MWA	MW	Washington Flyer	SB	Multiple	VA	y	n		
23 Anne Arundel County	AAR	AAR	AA		MB	Anne Arundel Co.	MD	y	y	79,658	30129
24 Calvert County, Maryland	CALV	CAL	CL	Calvert Co. Bus	MB	Calvert Co.	MD	y	y	70,759	30131
25 Regional Transportation Agency of Central Maryland	RTA	RTM	RM	City of Laurel Bus	MB	Multiple	MD	y	y	712,722	30205
26 City of Bethesda	BethCirc	BEC	BC	Bethesda Circulator	MB	Bethesda	MD	y	n		
27 Transportation Association of Greater Springfield	TAGS	TAG	TG	TAGS (along with WMATA)	MB	Springfield	VA	y	n		
28 Charles Co.	CHAR	CHS	CH	Vango	MB	Charles Co.	MD	y	y	492,846	30088
Modes											
Rail modes: heavy rail (HR), commuter rail (CR), light rail (LRT), and streetcar (SR)											
Bus modes: local bus (MB), commuter/express bus (CB), Bus Rapid Transit (BRT), shuttle bus (SB)											

If the transit agency is part of the National Transit Database (NTD), the 2023 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.

Ref: "I:\ateam\docum\fy25\Gen3_Network_Report_Vizualize2050\Report_Tables\DC_Area_Transit_Agencies_2023_PGEditions.xlsx"

Table 3-18 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)
9	Other Secondary - Express Bus	"LC"	Lee Coaches Commuter Bus
		"LCS"	Loudoun Co. Commuter Bus
		"LINK"	Washington Flyer- Dulles/WFC (MWA)
		"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\fy25\Gen3_Network_Report_Vizualize2050\Report_Tables\Transit_NetWrk_Mode_Codes.xlsx Tab Gen3_Report "

The PT transit network contains highway links and nodes as well as transit-only links and nodes for Metrorail, commuter rail, LRT and other exclusive guideway routes (e.g., BRT and streetcar lines typically coded as mode 10 in the current modeling process). The PT network contains park-n-ride (PNR) lot nodes for all transit modes that permit park-n-ride access. PNR nodes are connected to the highway network using a PNR driveway link (mode 11) and to the corresponding station or transit stop using a PNR walkway link (mode 15). PNR driveway links and PNR walkway links are used by PT to find park-n-ride access paths to these stations from any location in the PT network.

The PT network also includes kiss-n-ride (KNR) driveway links (mode 14) connecting the highway network to those transit stations which are not located on highway network links (e.g., Metrorail, commuter rail, and bus stops which support bus PNR locations). PT uses KNR driveway links (mode 14) to build kiss-n-ride and walk-access paths to these stations. Walk access links (mode 12) are included in the PT network to create better walk accessibility for those transit stops located in areas where highway link density is sparse (e.g. suburban areas). Bus park-n-ride driveway support links that connect bus park-n-ride lots to highway nodes (Mode=17) are also included.

These supplemental highway links are added to the basic highway network to support PT path building. 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 the Gen2 Model, transit path-building and assignment are conducted in production/attraction format, so a transit trip goes from a production zone to an attraction zone. By contrast, in the Gen3 Model, transit path-building and assignment are conducted in origin/destination format, and a transit trip goes from an origin zone to a destination zone. At the origin of a transit trip, it is assumed that one will access the transit service via one of two access modes: walking or driving. Walking here includes all non-motorized modes including walking and biking. At the destination end of a transit trip, there are also two alternative egress modes: walking and driving. In the Gen3 Model, transit paths are built for 5 combinations of access/egress modes: walk access/walk egress, PNR access/walk egress, KNR access/walk egress, walk access/PNR egress, and walk access/KNR egress. For commuter rail, though, PNR and KNR are combined so only three access/egress combinations are considered: walk access/walk egress, PNR access/walk egress, and walk access/PNR egress. Again, biking is considered part of walking. In addition, 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. Table 3-19 provides a summary of transit support links (non-transit links) and their key link attributes in a PT network developed for the Gen3 Model. Note that nodes 15000-15999 are used for bus stops at bus PNR parking lots in PT only.

Table 3-19 Non-transit mode codes and link attributes in PT

Link Type	Mode Code	From Node	ToNode	Mode Type	Direction	Ftype	Limit Code	Speed (mph)
PNR Driveway Links	11			Drive	1	4	0	30
Metrorail		20000-54999	11001-11999					
Commuter Rail		20000-54999	12001-12999					
Bus		20000-54999	13001-13999					
Special walk-access links	12			Walk	2	0	0	3
Metrorail		1 - 3675	8001-8999					
		8001-8999	1 - 3675					
Commuter Rail		1 - 3675	9001-9999					
		9001-9999	1 - 3675					
Pedestrian Tunnel Links	13			Walk	2	0	0	3
Metrorail / Commuter Rail		8001-8999	9001-9999					
		9001-9999	8001-8999					
KNR Drive/walk access links	14			Drive&Walk	2	4	0	25
Metrorail		8001-8999	20000-54999					
		20000-54999	8001-8999					
Commuter Rail		9001-9999	20000-54999					
		20000-54999	9001-9999					
PNR lot-to-station/Bus Stop Node	15			Walk	1	0	0	3
Metrorail PNR Lot		11001-11999	8001-8999					
Commuter PNR Lot		12001-12999	9001-9999					
Bus PNR Lot		13001-13999	15001-15999					
Bus Stop								
Unused	16							
Bus PNR Driveway Link	17	15001-15999	20000-54999	Drive	2	4	9	15
		20000-54999	15001-15999					

Ref: I:\ateam\docum\fy25\Gen3_Network_Report_Vizualize2050\Report_Tables\PT_NonTrn_links_Attributes.xlsx

Figure 3-17 shows how transit stops not located on highway network links are coded in the Unified Geo-database. PNR driveway (mode 11) and PNR walkway (mode 15) links are only necessary for transit stops that permit park-n-ride access. Figure 3-17 also shows a pedestrian tunnel link (mode 13) connecting two Metrorail stations. Special walk-access links (mode 12) are also coded for transit stations that are not reasonably accessible from the highway network.

Figure 3-17 PT Network Design for Transit Stops Off the Highway Network²⁷

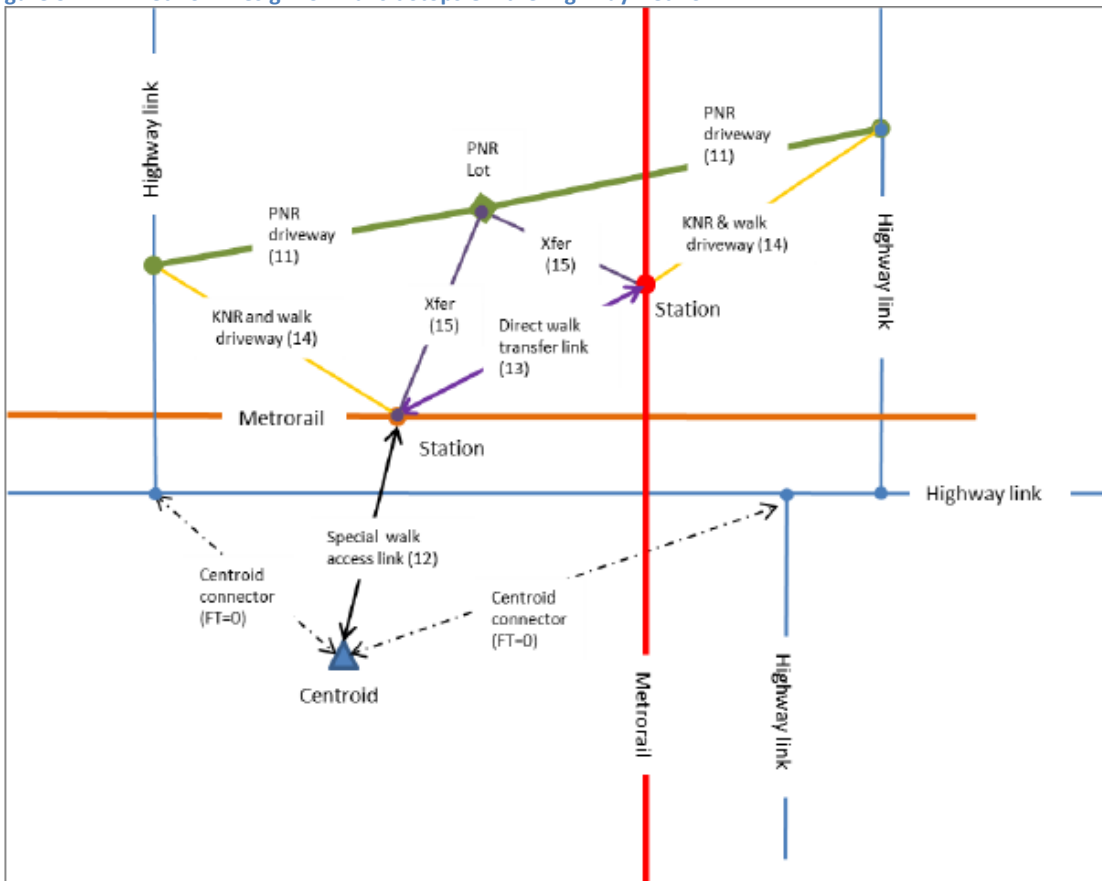
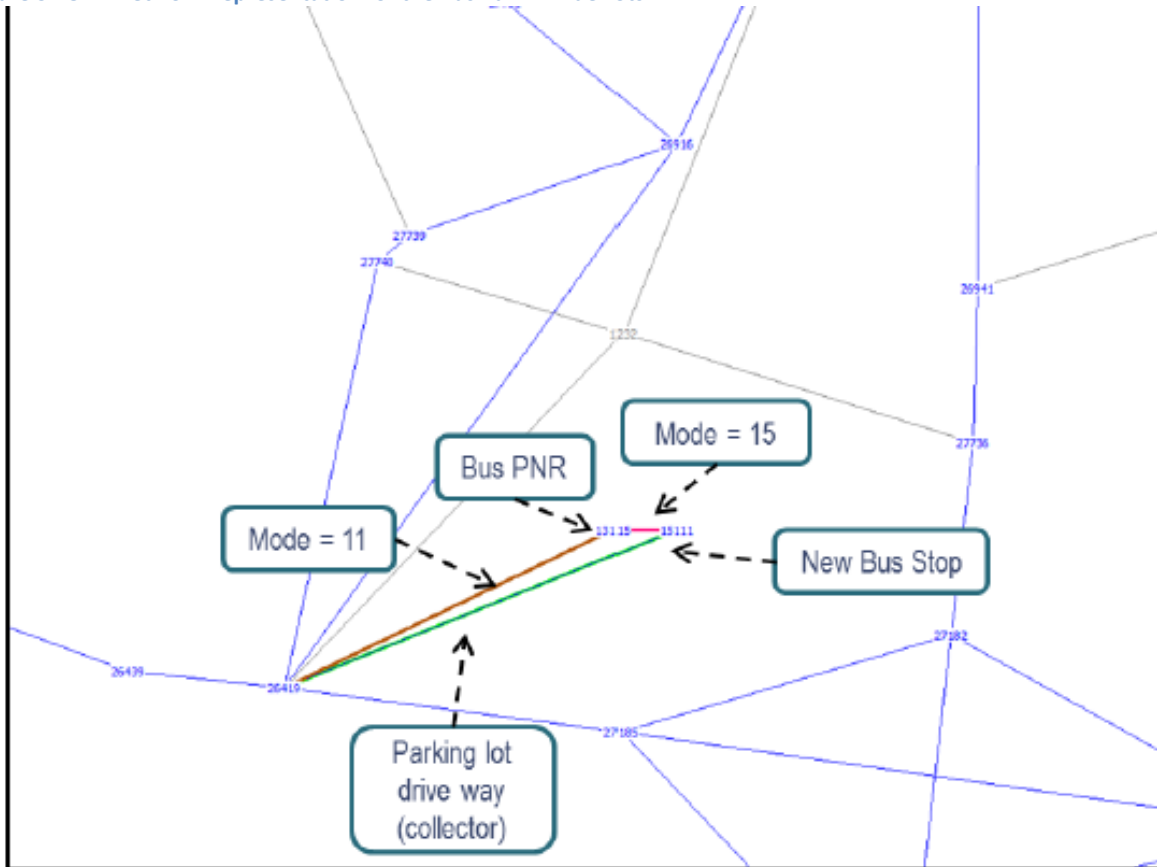


Figure 3-18 shows a bus-only driveway (Mode= 17 green link), which allows the bus to reach the bus stop; and a short horizontal walk/transfer (Mode=15 pink link) between the bus park-n-ride lot and the bus stop. The bus park-n-ride lot is reached via the Mode=11 drive-access link (the slanted brown link) which is not traversed by any transit routes.

²⁷ AECOM, FY 2014 Final Report COG Contract 12-006: Submitted to TPB/MWCOG, August 18, 2014.

Figure 3-18 PT Network Representation for the Bus Park-n-Ride Lots²⁸



3.3.2 Generate Non-transit Legs

PT creates transit paths between origins and destinations by alternating between non-transit and transit legs. PT's non-transit legs are virtual links connecting zone centroids to transit stops (access legs), transit stops to other transit stops (transfer legs), and transit stops to zone centroids (egress legs). PT's GENERATE statement builds actual network paths between origin nodes defined by "FROMNODE" and transit stops, or destination nodes defined by "TONODE", and saves virtual links connecting the origin and destination nodes with a user-defined mode and the actual path's cost. The total number of virtual non-transit (NT) legs created by PT is a function of the maximum number of paths allowed ("MAXNTLEGS"), the maximum path cost ("MAXCOST"), and the "SLACK" value. PT takes the SLACK value and adds it to the cost of the best path found for each interchange and drops paths with higher cost.²⁹

Figure 3-19 shows an excerpt from a Cube script "PT_NetProcess_PT.s" that generates non-transit access and egress legs. Specifically, the excerpt shows how KNR access/egress NT legs for Metrorail stations are generated using PT's Generate command. The flowchart in Figure 3-20 illustrates the

²⁸ Ibid, Page 6-4

²⁹ Ibid, Page 6-13

process to generate non-transit leg files used for PT skim and assignment process in the Gen3 Travel Model.

Figure 3-19 Example to generate Access and Egress Non-transit legs

```

;; *****
;; ***** C. Create kiss-n-Ride Legs
;; *****
;RSG 01/20/2020: generate access and egress NT Legs by reversing direction
;;
;; Step 1a **** Create KNR Access links for Metrorail stations
;;
RUN PGM=PUBLIC TRANSPORT
FILEI NETI = "outputs\trn_net\@itr@_@TIME_PERIOD@_PT.NET"
FILEI LINEI[1] = "outputs\trn_net\@TIME_PERIOD@_Bus_Lines.lin"
FILEI LINEI[2] = "outputs\trn_net\@TIME_PERIOD@_MRL_Lines.lin"
FILEI FACTORI[1] = "Inputs\trn\@TIME_PERIOD@_TRN.FAC"
FILEI SYSTEMI = "Inputs\trn\TSYSD.PTS"

FILEO NTLEGO = "outputs\trn_net\Acc_KNR_MR_@TIME_PERIOD@.LEG", XN=N

PARAMETERS TRANTIME = lw.GENTRSTIME

PROCESS PHASE = LINKREAD
lw.GENTRSTIME = li.TRANTIME
LW.LIMIT = 0 ; Set link restriction code "LIMIT"
[] lw.NCT9 = li.NCT9 ; Label links with NCT restrictions
[] @AM_MODE@ IF (LI.AMLIMIT= 9) LW.LIMIT = 9
[] @MD_MODE@ IF (LI.OPLIMIT= 9) LW.LIMIT = 9[]
[] @PM_MODE@ IF (LI.PMLIMIT= 9) LW.LIMIT = 9
[] @NT_MODE@ IF (LI.OPLIMIT= 9) LW.LIMIT = 9[]
ENDPROCESS

PROCESS PHASE = DATAPREP
GENERATE,
NTLEGMODE = 18,
COST=li.TRANTIME + (li.toll+li.distance*@_opcost@)/100*@_MinPerDoll@,
MAXCOST=10*15, ; gallop
FROMNODE=1-3722,
TONODE=8000-8999,
DIRECTION = 1,
EXCLUDELINK = (li.Mode = 1-10, 11,15)|| (LW.LIMIT = 9)|| (LW.NCT9=1),
MAXNTLEGS = 10*5, ;gallop
SLACK = 10*5, ; gallop
LIST = Y
ENDPROCESS
====>

;;
;; Step 1b **** Create KNR Egress links for Metrorail stations
;;
RUN PGM=PUBLIC TRANSPORT
FILEI NETI = "outputs\trn_net\@itr@_@TIME_PERIOD@_PT.NET"
FILEI LINEI[1] = "outputs\trn_net\@TIME_PERIOD@_Bus_Lines.lin"
FILEI LINEI[2] = "outputs\trn_net\@TIME_PERIOD@_MRL_Lines.lin"
[] @AM_MODE@
FILEI FACTORI[1] = "Inputs\trn\@TIME_PERIOD@_TRN.FAC"
FILEI SYSTEMI = "Inputs\trn\TSYSD.PTS"

FILEO NTLEGO = "outputs\trn_net\Egr_KNR_MR_@TIME_PERIOD@.LEG", XN=N

PARAMETERS TRANTIME = lw.GENTRSTIME

PROCESS PHASE = LINKREAD
lw.GENTRSTIME = li.TRANTIME
[] LW.LIMIT = 0 ; Set link restriction code "LIMIT"
[] lw.NCT9 = li.NCT9 ; Label links with NCT restrictions
[] @AM_MODE@ IF (LI.AMLIMIT= 9) LW.LIMIT = 9
[] @MD_MODE@ IF (LI.OPLIMIT= 9) LW.LIMIT = 9[]
[] @PM_MODE@ IF (LI.PMLIMIT= 9) LW.LIMIT = 9
[] @NT_MODE@ IF (LI.OPLIMIT= 9) LW.LIMIT = 9[]
ENDPROCESS

PROCESS PHASE = DATAPREP
GENERATE,
NTLEGMODE = 18,
COST=li.TRANTIME + (li.toll+li.distance*@_opcost@)/100*@_MinPerDoll@,
MAXCOST=10*15, ; gallop
FROMNODE=1-3722,
TONODE=8000-8999,
DIRECTION = 2,
EXCLUDELINK = (li.Mode = 1-10, 11,15)|| (LW.LIMIT = 9)|| (LW.NCT9=1),
MAXNTLEGS = 10*5, ;gallop
SLACK = 10*5, ; gallop
LIST = Y
ENDPROCESS

```

Figure 3-20 Non-transit Access and Egress legs creation process in the Gen3 Travel Model

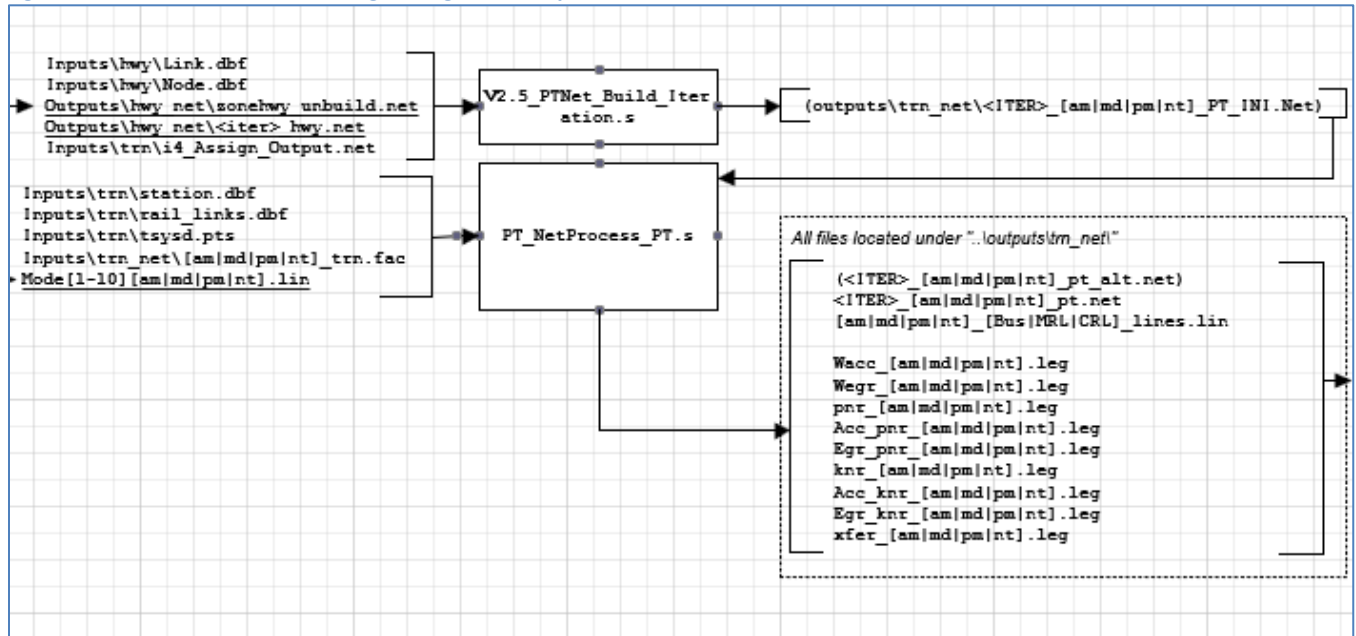


Table 3-20 shows non-Transit mode IDs generated in the “PT_NetProcess_PT.S” process (as shown in Figure 3-20) based on the origin (production) and destination (attraction) of non-transit, drive and walk-access/egress links. Mode 18 and Mode 19 are two sets of drive-access or drive-egress legs generated by the PT generate process. Mode 18 and Mode 19 represent KNR and PNR non-transit legs connecting zone centroids and transit stops, respectively. As shown in Figure 3-19, the mode codes indicated in Table 3-20 are specified in the Cube Voyager script using the statement “NTLEGMODE =”. All the walk and drive access/egress legs shown in Table 3-20, except mode 20 and 21, are two-way legs and connect transit stops. Mode 20 and Mode 21 connect zone centroids to transit stops of different transit modes. Mode-20 legs are walk-access legs and Mode 21 is walk-egress legs to transit stops. Modes 22, 33, and 44 in Table 3-20 represent bidirectional walk transfers between transit stops of the same mode. If the first digit and second digit of a mode ID are different, the first digit represents the mode number transferred from, and the second digit represents the mode number transferred to. For example, Mode 32 represents transfer links from mode 3 (Metrorail) to mode 2 (bus), while Mode 43 represents transfer links from mode 4 (commuter rail) to mode 3 (Metrorail). The direction of a transfer link is also defined by “From”, “To” and “Direction Code” as shown in the table. When the Direction Code is “Forward”, it is a transfer from the “From” mode to the “To” mode, while when the Direction Code is “Reverse”, it represents a transfer from the “To” mode to the “From” mode.

Table 3-20 List of Non-Transit (NT) Mode IDs Generated in the " PT_NetProcess_PT.S" Process

Mode ID	Access/Egress Mode	From	To	Direction Code	Description
18	KNR access/egress	Zone centroids	Metro/CR/LRT/BRT stations	1- Forward 2- Reverse	KNR access/egress NT legs to/from transit
19	PNR access/egress	Zone centroids	Metro/CR/LRT/BRT stations	1- Forward 2- Reverse	PNR access/egress NT legs to/from transit
20	Walk access	Zone centroids	Trasnit stop nodes	1 - Forward	Walk access NT legs to transit
21	Walk egress	Zone centroids	Trasnit stop nodes	2- Reverse	Walk egress NT legs from transit
22	Walk transfer	Bus/BRT/streetcar stops	Bus/BRT/streetcar stops	3- Both Directions	Walk transfer NT legs between buses
23	Walk transfer	Metrorail stations	Bus/BRT/streetcar stops	2- Reverse	Walk transfer NT legs from bus to Metrorail
24	Walk transfer	Commuter rail stations	Bus/BRT/streetcar stops	2- Reverse	Walk transfer NT legs from bus to commuter rail
25	Walk transfer	Light rail stations	Bus/BRT/streetcar stops	2- Reverse	Walk transfer NT legs from bus to light rail
32	Walk transfer	Metrorail stations	Bus/BRT/streetcar stops	2- Forward	Walk transfer NT legs from Metrorail to bus
33	Walk transfer	Metrorail stations	Metrorail stations	3 - Both Directions	Walk transfer NT legs between Metrorail stations
34	Walk transfer	Metrorail stations	Commuter rail stations	1 - Forward	Walk transfer NT legs from Metrorail to commuter rail
35	Walk transfer	Metrorail stations	Light rail stations	1 - Forward	Walk transfer NT legs from Metrorail to light rail
42	Walk transfer	Commuter rail stations	Bus/BRT/streetcar stops	1 - Forward	Walk transfer NT legs from commuter rail to bus
43	Walk transfer	Metrorail stations	Commuter rail stations	2 - Reverse	Walk transfer NT legs from commuter rail to Metrorail
44	Walk transfer	Commuter rail stations	Commuter rail stations	3 - Both Directions	Walk transfer NT legs between commuter rail stations
45	Walk transfer	Light rail stations	Commuter rail stations	2 - Reverse	Walk transfer NT legs from commuter rail to light rail
52	Walk transfer	Light rail stations	Bus/BRT/streetcar stops	1 - Forward	Walk transfer NT legs from light rail to bus
53	Walk transfer	Metrorail stations	Light rail stations	2 - Reverse	Walk transfer NT legs from light rail to Metrorail
54	Walk transfer	Light rail stations	Commuter rail stations	1 - Forward	Walk transfer NT legs from light rail to commuter rail

Ref: I:\ateam\docum\fy25\Gen3_Network_Report_Vizualize2050\Report_Tables\ List of NT Mode IDs.xlsx

3.3.3 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 3-21.

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 3-21. The access distance code (“NCT”) that is included in the station file for the Gen2 Model to control the number, extent, and directionality of PNR/KNR access links generated for each parking lot is no longer needed for the Gen3 Model, as PT uses the “GENERATE” keyword to create non-transit legs.

Table 3-21 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)
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
STAZ	N	For the purposes of path building, the TAZ (1-3722) 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, 2007 cents)
STAOPCOST	N	Off-peak parking cost (hourly cost, 2007 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)
STWALKTM	N	Metrorail station escalator time (in minutes) ³⁰ (currently not used)

³⁰ Ron Milone to Files, “Metrorail Escalator Time Estimation,” Memorandum, December 2, 2016.

Figure 3-22 Time period definition for calculation of average headway and run time

	Most transit service
AM Peak	7:00 AM - 7:59 AM (1 hour)
Midday	10:00 AM - 2:59 PM (5 hours)
PM Peak	5:00 PM - 5:59 PM (1 hour)
Night-Time	7:00 PM - 11:59 PM (5 hours)

A transit line file is divided into a series of transit lines/routes. For example, Figure 3-21 shows two bus routes for the DC Circulator: the 98 south and Congress Heights/Union Station WB. 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 3-22.

Table 3-22 Header section for each transit route in a PT transit line file

File Name	Variable Name	Description
Mode<No. ><per>.LIN	LINE NAME	Abbreviation of transit service provider name
	LONGNAME	The LONGNAME 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
	OPERATOR	Operator ID ranges from (1-3,11-15, and 51,61)
	ONEWAY	Y/N (Y= Yes and N=No)
	MODE	Transit mode codes (1 - 10)
	HEADWAY[1]	Average time between successive arrivals (or departures) of transit vehicles on a given route for AM/PM peak periods or an average of five hours for Midday/Night-time off-peak periods not to exceed 60 minutes. 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/PM peak periods or Midday/Night-time OP periods)

Key: <No.> = 1-10
 <per> = AM/PM peak or MD/NT off-peak

After the route header information, there is a node itinerary, which is a list of nodes through which the route passes. The file extension of “LIN,” is a more standard file extension for these types of files which stands for transit line/route.

Note: WMATA is reorganizing all metrobus routes as part of the “Better Bus” initiative launched in June 2025. Routes will be renamed, starting with a letter to indicate the area served. COG staff will modify the network database accordingly for future modeling work.

3.4 Transit Path Building

This section is largely extracted from a memo documenting the implementation of Public Transport (PT) Multipathing with a partial fix to the hyperpath issue for Gen3 Travel Model.³¹

The Gen3 Model adopts the PT multipathing algorithm, which builds multiple transit paths and finds the respective probabilities of using them. A PT best-pathing algorithm was implemented by consultants in a developmental Gen2/Ver. 2.5 Model.³² While the Gen3 Model largely adopted the PT implementation from the Gen2/Ver. 2.5 Model, it also switched from PT best-pathing to PT multipathing. This switch was made largely due to the theoretical appeal of the multi-routing algorithm (i.e., PT is designed as a multi-path path builder to provide a more realistic representation of an urbanized environment with multiple transit options) and the significant runtime reduction associated with it.

On the top of the existing PT best-pathing setup, PT multipathing was implemented by modifying the PT factor files (.FAC) that are included as part of the transit inputs files (\inputs\trn). Specifically, the following changes were made to the factor files:³³

- Route enumeration parameters (e.g., **AONMAXFERS**, **MAXFERS**, **EXTRAXFERS1**, **EXTRAXFERS2**, **SPREADFACT**, **REWAITMAX**, **RECOSTMAX**, etc.) and route evaluation parameters (e.g., **ALPHA**, **LAMBDAAW**, **LAMBDAA**, **CHOICECUT**, **SERVICEMODEL**, etc.) were either added or modified to enable multi-routing in PT. The specifications for those parameters were borrowed from those in the PT Arlington Model.³⁴
- Mode-to-mode transfer penalties (**XFERPEN**, **XFERCONST** and **XFERFACTOR**) were added. Penalty values were specified per suggestion from RSG.
- Value of time (**VALUEOFTIME**) by mode, which was originally uniform across all transit modes, was updated per suggestion from RSG to reflect the higher value of time for Metrorail and commuter rail riders.
- On-board transit runtime factors (**RUNFACTOR**) by mode were kept the same as those in the base model, except for light rail (Mode 5), whose runtime factor was updated to be consistent with Bus Rapid Transit (Mode 10).

³¹ Feng Xie to Files. “Implementing Public Transport (PT) Multipathing with a Partial Fix to the Hyperpath Issue for Gen3 Travel Model” Memorandum, September 29, 2022.

³² 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>.

³³ page 3, Feng Xie to Files. “Implementing Public Transport (PT) Multipathing with a Partial Fix to the Hyperpath Issue for Gen3 Travel Model” Memorandum, September 29, 2022.

³⁴ The PT Arlington Model includes multiple user classes, and the route enumeration/evaluation parameters slightly differ by user class. The Gen3 Model, which includes a single user class in PT, adopts the parameters for the most representative user class (i.e., User Class 1) in the PT Arlington Model.

- Boarding penalties (**BRDPEN**) by mode were kept unchanged, except that the boarding penalty for Metrorail (Mode 4) was changed from 4 minutes to 5 minutes for off-peak periods. In the Gen3, Phase 1, Model, the boarding penalty for Metrorail was the only difference between the peak-period factor files (AM_TRN.FAC|PM_TRN.FAC) and off-peak factor files (MD_TRN.FAC|NT_TRN.FAC). This change made PT factor files identical across all time periods.
- Different initial and transfer wait curve definitions (**IWAITCURVE**, **XWAITCURVE**) specified in the PT factor files and system file (TSYSD.PTS) were tested per suggestion from RSG but were not adopted due to problematic pathtracing results. Instead, the original wait curve definitions from the TPB's developmental Gen2/Ver. 2.5 Model were used. The testing resulted in a different time stamp for the system file, but its content did not change relative to the base model.
- PT fare specifications (**FARESYSTEM**, **OPERATOR**), which were proposed by COG staff in a developmental Gen2/Ver. 2.3 Model³⁵ and were later incorporated into the Gen3 Model, are kept unchanged.
- Specifications for the **MUSTUSEMODE** keyword³⁶ by transit submode were kept unchanged during the implementation of PT multipathing. However, they were modified later as part of the partial fix to the hyperpath issue.

In addition to the PT factor files that were specifically created for commuter rail and “Bus + Metrorail” submodes, the implementation of the partial fix also involved updating five Cube scripts in the Gen3 Model. Specifically,

- The “Transit_Skims_PT_AB.s” script and “Transit_Skims_PT_MR.s” script include minor, aesthetic changes that don’t affect modeling results.
- The “Transit_Skims_PT_CR.s” script was modified to address the hyperpath issue found in commuter rail path building.
- The “Transit_Skims_PT_BM.s” script was modified to partially address the hyperpath issue found in “Bus + Metrorail” path building.

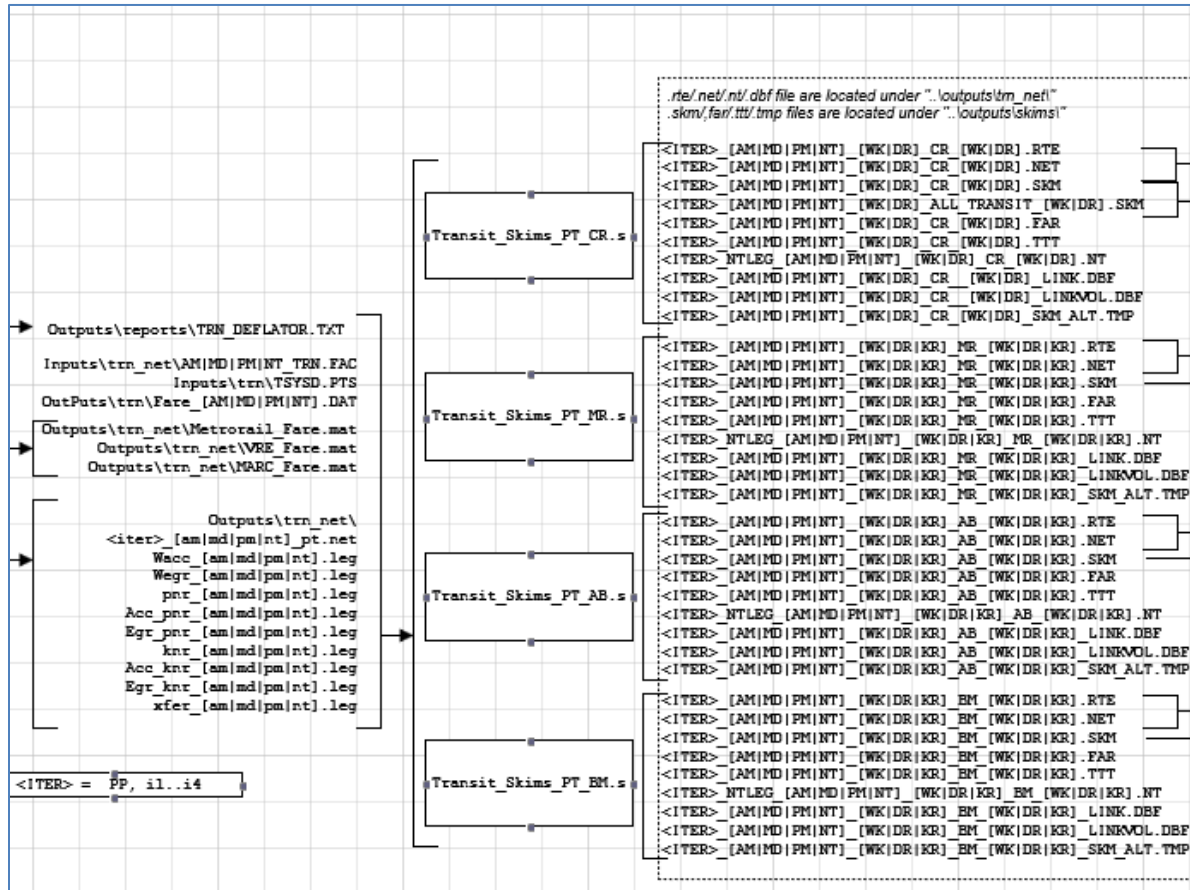
The “PT_asgn_CR.s” script was modified to address an issue arising from the above-mentioned change to the “**MUSTUSEMODE**” specification for commuter rail. Due to the change, PT can no longer build any path for a small number of external commuter rail trips (fewer than 800) and thus reports a fatal error during transit assignment. COG staff fixed this issue by removing the few unassigned external commuter rail trips from transit assignment.

The transit path building and path skimming process involves the development of 44 sets of level-of-service (LOS) skims (matrices) corresponding to four time-of-day period (AM, MD, PM, and NT), by four transit sub-modes: bus only (AB), Metrorail only (MR), bus-Metrorail combination (BM), and commuter rail (CR), by five combinations of three access/egress modes (walk, PNR, KNR). Although one might expect 80 sets of skims (4 x 4 x 5), there are only 72 path sets since PNR and KNR are combined for commuter rail mode. This process is shown schematically in Figure 3-23 and is covered in more detail in Chapter 6 Section 6.3 of the Gen3 Travel Model User’s Guide.

³⁵ See, Feng Xie to Mark Moran, “Proposed Cube Public Transport (PT) Fare Systems in the TPB Ver. 2.3 Travel Model”, MWCOG/TPB Memorandum, September 2, 2020.

³⁶ **MUSTUSEMODE** specifies required transit modes in a route for enumeration or evaluation,

Figure 3-23 Process for conducting transit path building



3.5 Transit Fare Files

This section is largely extracted from a memo documenting 2024 Transit Fares for Public Transport (PT).^{37 38}

Based on a review of the fare structures for various transit providers in this region, TPB staff proposed ten fare systems as shown in Table 3-23.³⁹ For the Gen3 model the fare inputs reflect regular cash fares, and fare discounts are considered in separate model components or procedures such as the transit pass subsidy model and the mode choice models.

³⁷ Feng Xie to Mark Moran, "Proposed Cube Public Transport (PT) Fare Systems in the TPB Ver. 2.3 Travel Model," Memorandum September 2, 2020

³⁸ Jane Posey and Nazneen Ferdous to Files, "2024 Transit Fares for Public Transport (PT)," Memorandum, September 19, 2024

³⁹ Jane Posey and Nazneen Ferdous to Files, "2024 Transit Fares for Public Transport (PT)," Memorandum, September 19, 2024

Table 3-23 2024 PT Fare Structure

No	Description	PT Fare Structure	Fare Inputs
1	Metrorail	FAREMATRIX (FROMTO)	Station-to-station AM/OP fares calculated by MFARE1.s
2	VRE	FAREMATRIX (FROMTO)	Published in 2020 farezone-to-farezone fares
3	MARC	FAREMATRIX (FROMTO)	Current 2024, Published in 2021 station-to-station fares
4	WMATA Compact Area (WCA)* Local Buses & BRT	FLAT (\$2.25)	WMATA Tariff #45, effective June 30, 2024
5	WMATA Compact Area (WCA)* Express Buses	FLAT (\$4.80)	WMATA Tariff #45, effective June 30, 2024
6	WCA local buses with free or reduced fare **	FLAT (\$1.00)	Estimated rough average- provider websites
7	Other Local Buses	FLAT (\$.50)	Estimated rough average- provider websites
8	Other Express Buses	FLAT (\$9.00)	Estimated rough average- provider websites
9	Light Rail (Placeholder)	FLAT (\$5.00) (Placeholder)	(Placeholder- will be used for Purple Line in forecast years)
10	DC Streetcar	FREE	DC streetcar website

* The WMATA Compact Area (WCA) includes the District of Columbia, the cities of Alexandria, Falls Church, and Fairfax and the counties of Arlington, Fairfax, and Loudoun in the Commonwealth of Virginia, and the counties of Montgomery and Prince George's in the State of Maryland.

** WCA buses with free or reduced fares (relative to WMATA fares) include: Alexandria DASH, Fairfax City CUE, Loudoun County Local Bus, Montgomery County Ride-On, PG The Bus, and DC Circulator (for now)

The corresponding transit service/providers for each fare system are as follows:

1. WMATA Metrorail
2. VRE Trains
3. MARC Trains
4. Regular Metrobus, Arlington Transit (ART), Fairfax Connector Regular bus, Bus Rapid Transit (BRT) services (currently operating are Metroway in Virginia and US 29 Flash Bus in Maryland)
5. Express Metrobus, Fairfax Connector Express bus, Loudoun Express bus
6. Alexandria DASH, Fairfax City CUE, Loudoun Regular bus, Montgomery County Ride On, Prince George's The BUS, DC Circulator (for now)
7. Frederick Bus, Howard County Bus, Calvert County Bus, OmniRide within Prince William County, Fredericksburg Bus
8. MTA Commuter Bus, Loudoun Commuter Bus, OmniRide Commuter Bus, Mom & Pop express bus services
9. Light Rail Placeholder - Purple Line
10. DC Streetcar

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 45, which was effective June 30, 2024.⁴⁰

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 Visualize 2050 L RTP is documented in a memo.⁴¹

3.5.2 Calculating Zone-to-zone Fares Used by the Model

Fare System #1: the Metrorail fares for the Gen3 model were calculated from the MFARE1.s process, exported to a fare matrix, and then read into the fare matrix in PT using the FAREMATRIX (FROMTO) function. The same inputs for the MFARE1 process used for the Gen2 Model (in the tariff.txt file) in the air quality conformity analysis of Visualize 2050 were provided for the Gen3 model runs. The current MFARE1.s inputs were from the Washington Metropolitan Area Transit Authority (WMATA) Tariff 45, which was effective June 30, 2024.⁴² The Metrorail fares from Tariff 45 are shown in Table 3-24.

Table 3-24 Metrorail Fares in WMATA Tariff 45 (input to tariff.txt file for the MFARE1 process)

Metrorail Fare Structure (Effective June 26, 2023)	Regular Fare	Late Night and Weekend
Base fare (First 3 composite miles)	\$2.25	\$2.25
Each additional composite mile more than 3	\$.45	\$.45
Maximum fare (Exclusive of Surcharge and Differentials)	\$6.75	\$2.25

Source: WMATA. Washington Metropolitan Area Transit Authority, “The Washington Metropolitan Area Transit Authority Tariff on Chapter 1 METRO FARES & RATES, Tariff Number 45”, Effective June 30, 2024, Page 10.

"I:\ateam\docum\FY25\Gen3_Travel_Model_Network_Report\Report_Tables\Tariff-45.pdf

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

⁴⁰ Washington Metropolitan Area Transit Authority, “The Washington Metropolitan Area Transit Authority Tariff on Chapter 1 METRO FARES & RATES, Tariff Number 45”, Effective June 30, 2024 <https://www.wmata.com/about/records/upload/Tariff-45.pdf>

⁴¹ William Bacon and Wanda Owens to Files, “2024 Update to Visualize 2050 Bus Fare Matrix Documentation,” Memorandum, July 10, 2024.

⁴² Washington Metropolitan Area Transit Authority, “The Washington Metropolitan Area Transit Authority Tariff on Chapter 1 METRO FARES & RATES, Tariff Number 45”, Effective June 30, 2024 <https://www.wmata.com/about/records/upload/Tariff-45.pdf>

destination stations and (b) the distance traveled in a straight line or “as the crow flies” between the two stations.⁴³

MFARE1 estimates station-to-station Metrorail fares using 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.
- Output final fares to a station-to-station matrix.⁴⁴

One of the key inputs to the MFARE1 process is the section of the WMATA Tariff dealing with Metrorail fares (see, for example, Table 3-24). From this table, we can see that there are peak and off-peak fares and there are maximum peak and off-peak fares (\$6.75 and \$2.25) exclusive of surcharge and differentials. The WMATA metrobus fares coded in the tariff.txt file are summarized in Table 3-25 Metrobus Fares in WMATA Tariff 45.)

Figure 3-24 Metrorail fares (peak and off-peak) and the rail-to-bus discounts (Tariff.txt)

```

;; WMATA Tariff 45 effective June 30,2024 fare structure input to MFARE2.S
;; plus $2.25 rail-to-bus discount
;;
;;
;; (Prepared July 30, 2024/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 = 225.0  Op_Fare_Rate1 = 0.0    Op_Fare_Dist1 = 3.0 ;

Pk_Fare_Incr2 = 0.0    Pk_Fare_Rate2 = 45.0   Pk_Fare_Dist2 = 3.0 ;
Op_Fare_Incr2 = 0.0    Op_Fare_Rate2 = 45.0   Op_Fare_Dist2 = 3.0 ;

Pk_Fare_Incr3 = 0.0    Pk_Fare_Rate3 = 45.0   ;
Op_Fare_Incr3 = 0.0    Op_Fare_Rate3 = 45.0   ;

Pk_Fare_Max   = 675.0   ;
Op_Fare_Max   = 675.0   ;

;;-----
;; Rail-to-Bus discounts in current year cents based on selected tariff  ;;
;;
;;
DC_RailBus_Disc = 225.0 ; Area defined by Jur='0' in the zone file input ;; Discount available to SmartTrip card holders only
MD_RailBus_Disc = 225.0 ; Area defined by Jur='1' in the zone file input ;;
VA1_RailBusDisc = 225.0 ; Area defined by Jur='2' in the zone file input ;;
VA2_RailBusDisc = 225.0 ; Area defined by Jur='3' in the zone file input ;;

```

Fare Systems #2 and #3: The Virginia Railway Express (VRE) and the Maryland Area Regional Commuter (MARC) fare rate tables can be found on their official websites. The current MARC fares were set in 2021. The current VRE fares are from July 1, 2024, but the VRE fares used for the Visualize 2050 air

⁴³ Ibid, Page 9.

⁴⁴ Allen, 3.

quality conformity analysis were from 2020 because the bus fare matrices were developed prior to July 2024. For consistency between the conformity analysis and the Gen3 parallel modeling, the 2020 VRE fares were used for this activity. The VRE and MARC fare tables are documented as an attachment to a memo.⁴⁵ The VRE and MARC fare inputs are read in PT using different FAREMATRIX (FROMTO) functions.⁴⁶

Fare Systems #4 and #5: Consistent with the Metrorail fares, the Local (regular) and Express Metrobus fares for the WMATA Compact Area (WCA) are from the WMATA Tariff #45, as shown in Table 3-25. The WCA includes the District of Columbia, the cities of Alexandria, Falls Church, and Fairfax and the counties of Arlington, Fairfax, and Loudoun in the Commonwealth of Virginia, and the counties of Montgomery and Prince George’s in the State of Maryland. Several local providers within the WCA have recently significantly lowered their bus fares. To address this, these providers have been moved into Fare System #6 (discussed below). Local Bus providers with similar fares as Metrobus such as Arlington ART and Fairfax Connector are included in Fare Systems #4 and #5. Different fares for the Airport Shuttle Service were not considered. Bus Rapid Transit (BRT) service has a similar fare structure as WMATA local bus, so is included in Fare System #4. The current BRT service operating in the region includes Metroway (in Alexandria and Arlington) and US 29 Flash Bus in Montgomery County. Visualize 2050 includes several other proposed BRT routes in forecast years.⁴⁷

Table 3-25 Metrobus Fares in WMATA Tariff 45

Metrobus fares are valid for single trip service		
Metrobus Service	Regular Fare	Senior/Disabled/ Metro Lift Fare
Regular Metrobus Service	\$2.25	\$1.10
Metrobus Express Service (Designated routes only)	\$4.80	\$2.40
Airport Shuttle Service (Designated airport routes)	\$8.45	\$4.20

Source: WMATA. Washington Metropolitan Area Transit Authority, “The Washington Metropolitan Area Transit Authority Tariff on Chapter 1 METRO FARES & RATES, Tariff Number 45”, Effective June 30, 2024, Page 7.

Fare System #6: As mentioned above, several local providers within the WCA have recently significantly lowered their bus fares. To address this, these providers are now included in Fare System #6, which was previously reserved for the DC Circulator. These include Alexandria DASH (free) Fairfax City CUE (free), Loudoun County Bus (\$1), Montgomery County Ride-On (\$1), and Prince George’s County TheBus (\$1). While it might seem reasonable to include the free bus service in Fare System #10 (discussed later), that would complicate the defining of the Operator IDs associated with each Fare System in the network database. The Operator IDs are defined using both provider name and transit mode and it is more straightforward to keep the buses together in their own category instead of including them with streetcar. DC Circulator service is being terminated at the end of 2024 and will likely be taken over by

⁴⁵ Jane Posey and Nazneen Ferdous to Files, “2024 Transit Fares for Public Transport (PT),” Memorandum, September 19, 2024

⁴⁶ Feng Xie to Mark Moran, “Proposed Cube Public Transport (PT) Fare Systems in the TPB Ver. 2.3 Travel Model,” Memorandum September 2, 2020

⁴⁷ Page 3, Jane Posey and Nazneen Ferdous to Files, “2024 Transit Fares for Public Transport (PT),” Memorandum, September 19, 2024

WMATA, so while the DC Circulator service is still included in the networks for Visualize 2050 and is still included in Fare System #6, it is no longer the main element of Fare System #6, and it will likely be completely removed in the next update of the long-range transportation plan.

Fare Systems #7 and #8: All other local and express bus services that are not coded in Fare Systems #4-6 are represented in Fare Systems #7 and #8, respectively. These bus services mostly serve Maryland and Virginia suburbs outside the WCA. Due to the wide variability in their geographic coverage and fare structures, a rough average fare had to be estimated for either of the fare systems based on TPB staff's professional judgment.

Fare System #9: There is currently no light rail operating, but the Purple Line is included as a future project in Visualize 2050. Staff selected \$5.00 as a placeholder fare until more light rail fare information becomes available.

Fare System #10: This fare system is designated for DC Streetcar which is free.⁴⁸

3.5.3 Fare Discounts

PT fare specifications are further complicated by the wide range of fare discount schemes seen in this region. Transit subsidies, such as those provided by employers, as well as transit passes, are addressed in a transit pass ownership sub-mode included in the Gen3 Model⁴⁹ which explicitly considers the partially and fully subsidized purchase of transit passes. To keep fare modeling relatively simple for implementation and maintenance, there is no consideration of discounts for special groups such as those for seniors, students, and persons with disabilities. The Gen3 Model does account for transfer discounts in the fare specifications which are shown in Table 3-26. The fare transfer discounts reflect conditions in 2024. The \$2.25 in the table reflects the regular fare discount transferring to and from Metrobus and other bus services with similar fares within the WCA. The \$1.00 in the table reflects the fare discount transferring to and from bus services within the WCA that have reduced (relative to regular Metrobus fare) or free fares.⁵⁰

⁴⁸ Ibid, page 3.

⁴⁹ RSG with Baseline Mobility Group and Metropolitan Washington Council of Governments: "Gen3 Model User Guide", Washington, D.C.: Metropolitan Washington Council of Governments, National Capital Region Transportation Planning Board, January 31, 2024. Page 114 (https://www.mwcog.org/assets/1/6/Gen3_Model_Phase_2_Model_User_Guide_final.pdf).

⁵⁰ Page 4, Jane Posey and Nazneen Ferdous to Files, "2024 Transit Fares for Public Transport (PT)," Memorandum, September 19, 2024.

Table 3-26 Proposed Bus-to-Bus, Bus-to-Rail and Rail-to-Bus Transfer Discounts

Transferring From	Transferring To			
	Fare System #1 (Metrorail)	Fare System #4 (WCA Local Buses)	Fare System #5 (WCA Express Buses)	Fare System #6 (free and reduced)
Fare System #1 (Metrorail)		\$2.25	\$2.25	\$1.00
Fare System #4 (WCA Local Buses & BRT)	\$2.25	\$2.25	\$2.25	\$1.00
Fare System #5 (WCA Express Buses)	\$2.25	\$2.25	\$2.25	\$1.00
Fare System #6 (WCA free or reduced fare buses)	\$1.00	\$1.00	\$1.00	\$1.00

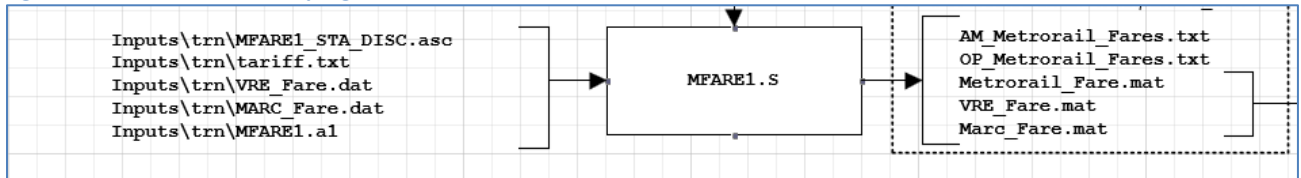
TPB staff implemented the proposed fare specifications by making modifications to the following modeling files:⁵¹

- **VRE_fares.dat:** input file created to represent fare zone-to-fare zone VRE fares in text format
- **MARC_fares.dat:** input file created to represent station-to-station MARC fares in text format
- **node.dbf:** three node attributes, “MRFZONE”, “CRMZONE” and “CRVZONE” added in the node file to indicate the fare zone numbers used in the Metrorail, MARC and VRE fare matrices, respectively.
- **Mode*am/MD/PM/NT.lin:** modified to add **OPERATOR** subkeyword in the Unified Geodatabase.
- **TSYSD.PTS:** PT system file modified to define the operators specified in the line files, associating each OPERATOR value with a descriptive operator name.
- **fare_ am/MD/PM/NT.dat:** PT fare files modified to specify the PT fare structures (“STRUCTURE=”) for the proposed 10 fare systems.
- PT fare files also specify transfer discounts between the 10 fare systems (“FAREFROMFS=”)
- **AM/MD/PM/NT_trn.fac:** PT factor files modified to define FARESYSTEM by OPERATOR.⁵²
- **MFare1.s:** as shown in Figure 3-25 the MFARE1 program was
 - Modified to export calculated Metrorail **AM/MD/PM/NT** fare matrices to Metrorail_fares.mat
 - Also modified to read VRE and MARC fare inputs in text format and export them in binary fare matrix format (VRE_fares.mat and MARC_fares.mat)
- **Transit_Skims_PT_MR|BM|AB|CR.s:**
 - Modified to read Metrorail, VRE and MARC fare matrices in binary format (“FILEI FAREMATI”) for transit path building (as shown in Figure 3-23).

⁵¹ Page 7, Feng Xie to Mark Moran, “Proposed Cube Public Transport (PT) Fare Systems in the TPB Ver. 2.3 Travel Model,” Memorandum September 2, 2020

⁵² According to Citilabs, “Cube Voyager Reference Guide, Version 6.4.1”, 9/30/2015, Page 750, FARESYSTEM can be defined either by MODE or by OPERATOR. The PT program then allocates fare systems to lines through their modes or operators. The MODE and OPERATOR subkeywords, however, need to be mutually exclusive, as “mixing the two could produce ambiguous allocations”.

Figure 3-25 Modified MFARE1 program



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

The network inputs to the TPB travel model are maintained and managed in a multi-year, multi-modal spatial database, implemented as a personal geodatabase (PGDB). While MWCOG is transitioning to an activity-based regional travel model (Gen3 Model) which adopts Cube Public Transport (PT) for transit modeling, COG/TPB staff will continue to support the Gen2 Model, which uses Cube TRNBUILD for transit modeling. In support of the network development activities associated with both Gen2 and Gen3 travel models, COG staff have developed the Unified network Geodatabase (UGDB), which combines TRNBUILD and PT networks in one database, and have been using it since 2021. The Unified Geo-Database (UGDB) interacts with a customized network editing program, known as COGTools, that runs within ArcGIS (currently Version 10.8). The COGTools application is developed to help with network editing tasks such as processing network data, exporting highway and transit network files in Cube Voyager or personal geodatabase formats, and generating dynamic layers (e.g., base network layer, travel direction layer and transit layer).⁵³ COGTools has also been updated recently to work with the UGDB.

This chapter starts with some background information on the geodatabase (GDB) and recent changes made to the geodatabase in terms of its design, structure, and operation. It then introduces the unified geodatabase (UGDB) and explains how it handles the differences between TRNBUILD and PT networks. This chapter also provides an overview of recent enhancements made to COGTools and a description of how TPB staff utilize digital, machine-readable transit information that is now publicly available to update the regional transit networks every year.

4.1 Unified Geodatabase Overview

The TPB's transportation network unified geodatabase (UGDB) serves as a central repository for highway and transit network 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 (e.g., links and nodes) to be viewed and edited in the ArcGIS environment. The UGDB also includes link attribute data that is required by the Gen2 and Gen3 travel models. The use of a structured, time-series network geodatabase (GDB) offers several key advantages:

- 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

⁵³ Jim Yin, "COGTOOLS User Guide, Revision 4.0" (Washington, D.C.: Metropolitan Washington Council of Governments, National Capital Region Transportation Planning Board, May 2, 2022).

highway network result in updates to the associated transit network. This linkage is also available in Cube Base.⁵⁴

- Consistency and accuracy of link screenline and jurisdiction codes are enforced over time. 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, highway inventory data, observed speed data and transit routing information exist in some type of geo-referenced format.
- The recent development of the UGDB enables the user to maintain one unified geo-database and export network files in either TRNBUILD or PT format.

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

- The current geo-database does not allow the coding of multiple scenarios for the same network year. This is generally not a problem since the Air Quality Conformity (AQC) and other planning processes at COG usually do not involve multiple alternatives for a specific analysis year. But when they do, the network coding for additional alternatives must be handled outside the network database.⁵⁵
- Edits to the highway network are propagated to the transit network in a limited way.
- Although highway networks can be generated for any year between the base and horizon year, transit networks must be coded for individual years and are typically available only for the milestone years coded in the air quality conformity analyses.

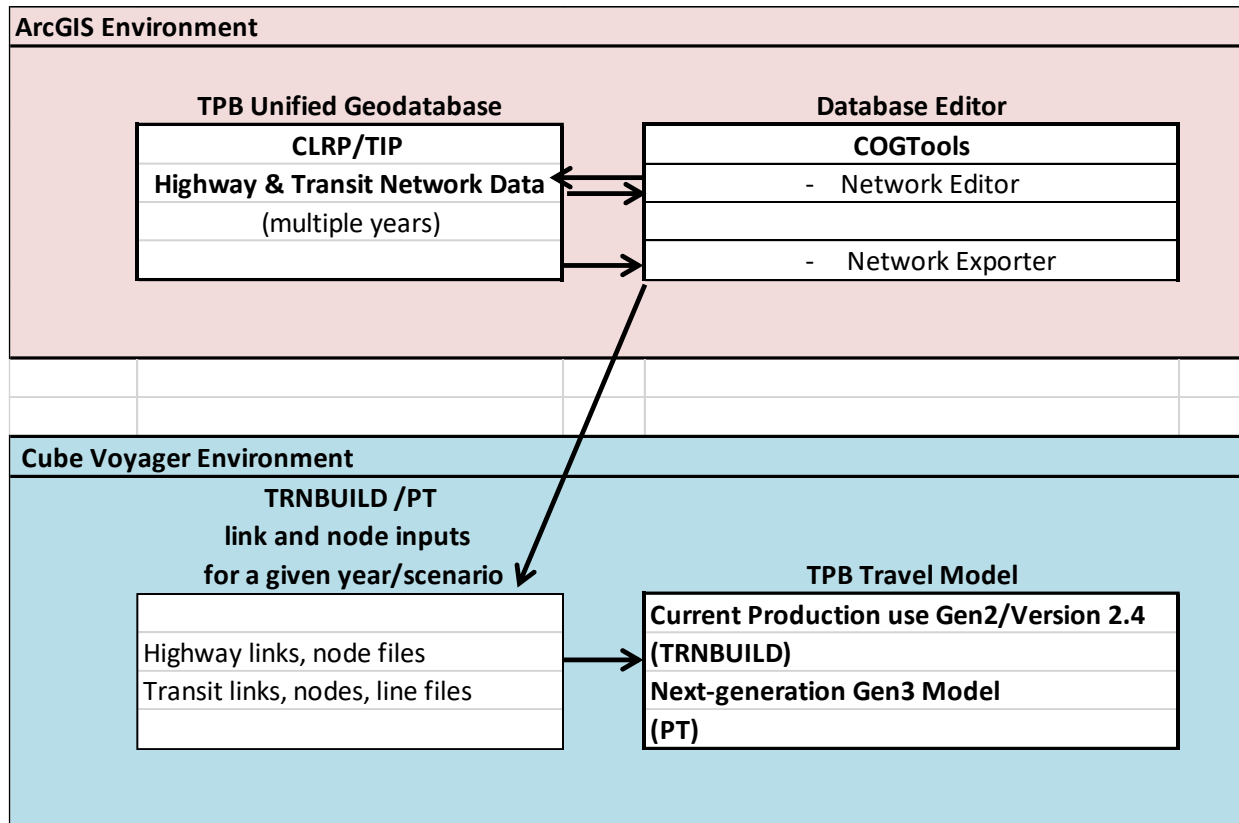
The last two of these shortcomings are discussed in more detail later in the chapter.

TPB staff produces a new version of the multi-year GDB with each update of the LRTP, such that it reflects the project assumptions of the latest 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. The UGDB that combines TRNBUILD and PT networks has been used since 2021. A macro-scale view of the relationship between the UGDB and the COG/TPB travel model is shown in Figure 4-1. The figure indicates that the UGDB development occurs in the ArcGIS environment.

⁵⁴ 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).

⁵⁵ Network development staff plan to investigate a work-around solution that could allow the geodatabase to handle multiple network scenarios for the same network year.

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



Ref: " I:\ateam\docum\FY22\Version2.4_2022Uddate_Visualize2045_Network_Report\Report Tables \chapter4_overview_process.xlsx"

As shown in Figure 4-1, the UGDB is maintained in ArcGIS and is not an integrated component of the current production use travel modeling environment, which makes use of Bentley Systems Cube software and is normally launched from a Windows command prompt. Currently, the Gen3 Travel Mode makes use of ActivitySim software for travel demand modeling and Bentley’s PT software for transit modeling. The UGDB interacts with a customized and interactive program editor named COGTools. The program enables highway and transit network elements (nodes, links, and transit routes) in the database to be viewed and edited interactively. 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 UGDB and 2) the ability to export year-specific network files from the UGDB in Cube TRNBUILD or PT format that can be read directly into the travel model. The COGTools application also enables customized viewing and mapping of the highway and transit features in the UGDB.

4.2 Difference between TRNBUILD and PT Networks

To support Gen3 Model development process, COG staff combined both TRNBUILD and PT networks into one unified geo-database. While TRNBUILD and PT networks generally share transit links (modes 1-10) in the UGDB, their non-transit links are coded differently. The difference between the non-transit

links coded for TRNBUILD and PT networks is shown in Table 4-1.⁵⁶ The “Common” column indicates whether a group of links physically exist in both TRNBUILD and PT networks. If the “Common” column is checked as “N”, then the links exist in either TRNBUILD or PT. All “NA” values in the table correspond to a “blank” cell in the database.

Table 4-1 Comparison of Non-Transit Links Between TRNBUILD and PT Networks

Node Range		One Way/Two Way	Common	TRNBUILD	PT	FType	
A	B					TRNBUILD	PT
<=3722	>=15000	2	Y			0	0
>=15000	>=15000	2	Y			Various	Various
>=5001 and <=6999	>=20000	2	N	x		NA	NA
>=20000	>=11000 and <=13999	N/A	N			0	4
>=20000	>=8000 and <=10999	2	Y			0	4
>=13000 and <=13999	>=15000 and <=15999	1	N		X	NA	0
>=15000 and <=15999	>=20000	2	N		X	NA	4
>=8000 and <=8999	>=9000 and <=10999	2	Y			0	0
<=3722	>=8000 and <=9999	2	N		X	NA	0

The comparison in Table 4-1 indicates the following:

- Centroid connectors and highway links (the first two records in the table above) are found in both networks, and they share the same value for “FType”.
- Links between station dummy centroids (5001-6999) and highway nodes (>=20000, third row in table) are unique to TRNBUILD networks.
- Links between highway nodes (>=20000) and PNR nodes (11000-13999) are found in both networks, but they are two-way links in TRNBUILD vs. one-way links in PT.
- KNR drive-access links connecting highway nodes (>=20000) and rail stations (8000-10999) are common in both TRNBUILD and PT networks but with different ‘Mode’ values; So are the pedestrian transfer links, which provide connections between Metrorail (8000-8999) and commuter rail (9000-9999) stations.
- In a PT network, there are unique links between highway nodes and bus PNR access stops (15000-15999) and between bus PNR lots (13000-13999) and corresponding bus PNR access stops.

⁵⁶ Jim Yin to Feng Xie. “Difference between TRNBUILD and PT Network,” Memorandum, September 1, 2020.

- Also, in a PT network, Mode 12 links are defined as walk-access links between a TAZ Centroid (1-3722) and a rail station (8001-9999).⁵⁷ The definition of Mode 12 links is different in a TRNBUILD network.

For PT networks, four unique attributes of “Speed”, “TRANTIME”, “Mode” and “dr” are included in the exported highway network link file (link.dbf). All other link attributes that are not included in Table 4-1, such as “ATYPE”, “AMLANE”, “AMLIMIT”, etc., have the same values in both TRNBUILD and PT networks.⁵⁸

As noted earlier, long-haul transit links—such as Metrorail, commuter rail, light rail, and BRT—are identical in both the TRNBUILD and PT networks. However, in the exported **link.dbf** file, **only the PT network** includes these long-haul transit links.

4.3 Update and Changes to the Database and/or COGTools

The COGTools is a custom add-in application developed for ArcGIS that facilitates the management and editing of travel demand model networks. Integrated seamlessly into the ArcGIS environment, it offers an intuitive interface for transportation planners and modelers working on network-based modeling.

What sets the COGTool apart is its *living tool* nature—it is actively maintained and continuously improved based on user needs and feedback. Whether it's bug fixes or the introduction of new features, the tool evolves dynamically to meet the ever-changing demands of transportation analysis.

To ensure transparency and collaboration, all updates, enhancements, and bug fixes are tracked and documented on the project's GitHub repository: <https://github.com/MWCOG/COGTools>. This approach encourages contributions and helps users stay informed about the tool's development roadmap.

The following table lists the major updates made to the COGTools application and its associated database.

⁵⁷ Yin. Memorandum to Xie, Moran, Seifu, et al. “Issues and Questions on the Development of a Year-2007 Transit Network in Cube Public Transport (PT) Format.” May 28, 2020.

“I:\ateam\docum\FY20\memos\PT_Memo2007_findings_Final.docx”⁵⁸ In the exported transit line files, attribute name “FREQ” in TRNBUILD and “HEADWAY” in PT are different, although their values are the same.

⁵⁸ In the exported transit line files, attribute name “FREQ” in TRNBUILD and “HEADWAY” in PT are different, although their values are the same.

Table 4-2 Updates made to the geodatabase and COGTools

#	Description	Type of Update	Further Detail and Benefit
1	EdgeID	Database/COGTools	EdgeID is a unique number in the network links table. It serves as a unique identifier of physical, non-directional links in the network database. In order to avoid duplicate values for EdgeID, the datatype of EdgeID was changed from integer to double and the value of EdgeID was developed as follows: $EdgeID = 1,000,000 * [Node1] + [Node2]$, where [Node1] and [Node2] are the first and second nodes used when creating a non-directional link in the network database. For example, if we create a non-directional link by clicking Node 999 first and then Node 111, this link will have an EdgeID of 999000111, with [Anode]=999 and [Bnode]=111 in the baselink table.
2	“Static” attributes are created to hold the different values for TRNBUILD and PT (TMODE, PMODE, TFTType, PTFTType, etc)	Database/COGTools	During a network editing session in the UGDB, depending on the selected database format (PT or TRNBUILD), the “static” attributes will be copied to “dynamic” attributes and displayed in the ArcGIS map window.
3	Batch Update	COGTools	Batch Update function is useful to update multiple features at once. Updates were made to COGTools to resolve errors occurring in the UGDB when performing batch updates.
4	“Update Other direction” function	COGTools	A bug fix was made to the COGTools “Update Other direction” function which applies updates made on one direction of a link to the reverse direction as well.
5	Turn off the Automatic Loading of “NavMap” Layer	COGTools	COGTools was modified to turn off a map layer, “Nav_Map”, from loading automatically in the ArcGIS map window, because loading this layer slows down the network editing process. If interested, the user may turn on the layer manually. ⁵⁹

⁵⁹ NavMap was the term used when the base street network was from NAVTEQ. The NAVTEQ firm is now called HERE, but the NavMap variable name remains in use here.

6	Keep multiple selected links in the highway network editor window, after editing a particular link and confirming the edit	COGTools	The COGTools “Edit Master Network” function, pops up the highway “Network Editor window” and enables the editing buttons on the COGTools toolbar. A user may select and load multiple links in the network editing window. However, formerly, after making edits to a particular link and selecting the “confirm” button, all the other selected links would disappear from the network editor window. Consequently, the COGTools “Edit Master Network” function was updated to keep all selected links in the Network Editor window after editing and confirming the update made to the particular link.
7	Permanently delete a Link from the Database	COGTools	A function was added in COGTools to permanently delete a link from the UGDB. Originally, COGTools could only retire a link, meaning the physical link remained in the GDB, but could be neither seen nor edited. Any retired link can be restored in the network geodatabase at any time. However, a permanently deleted link cannot be restored and thus this function must be performed with caution.
8	Four time-of-day (TOD) period transit services	Database/COGTools	In support of the ongoing Gen3 Model development, four time of day (TOD) transit networks are developed in the UGDB. The existing trip-based Gen2/Ver.2.4 Model requires transit network inputs in Cube TRNBUILD format for two TOD periods: AM Peak (7:00 AM - 7:59 AM) and Off-peak (10: 00 AM - 2:59 PM). The Gen3 Travel Model requires transit network inputs in Cube PT format for four TOD periods, AM peak (7:00 AM -7:59 AM), Midday (10 AM-2:59 PM), PM (4:00 PM – 4:59 PM) and Nighttime (7:00 PM – 11:59 PM). Note that, to continue to support the Gen2 Model, which requires network inputs for the “AM” and “OP” periods, the Midday period is labelled as “OP” instead of “MD” in the UGDB. The PT Export function of COGTools was also updated to export PT transit mode files from the network database for all four time periods. It should be noted that when network files are exported in TRNBUILD format for a Gen2 Model run, they are still exported in two time-of-day periods (“AM” and “OP”). ⁶⁰
9	Station Management	COGTools	A new module, "Station Management," has been added to COGTools. Typically, new stations are created during a highway network editing session. Once a station is added, its basic information is automatically recorded in the database. The Station Management module allows users to edit all additional station attributes through an interactive user interface.

⁶⁰ Jim Yin to Feng Xie “Development of Transit Networks for four Time of Day (TOD) Periods in the MWCOCG Unified Network Database,” Memorandum, April 7, 2022.

10	QA/QC	COGTools	A new module, "QA/QC," has been added to COGTools to enhance the reliability of network data. Given the complexity of the network database, day-to-day editing by staff can inadvertently introduce logical errors into the network files. If these errors are present in files exported from the database and used as inputs for the travel demand model, they may lead to model crashes or inaccurate outputs. The QA/QC module systematically checks both highway and transit networks to ensure logical consistency. As a result, TRANBUILD and PT export files are now validated to prevent crashes during model runs and reduce the risk of erroneous results.
11	GTFS data processing	COGTools	<p>A new module, "GTFS Process," has been added to COGTools to support the processing of GTFS data. This module includes two sub-modules: GTFS Schedule Extractor and Generate GTFS Shapefile. Every other year, staff collect GTFS data from transit operators to extract schedule and headway information for each transit route. This information is used to update the COG Unified Database.</p> <p>The GTFS Schedule Extractor streamlines this process by efficiently parsing GTFS data to extract relevant scheduling details. Users also have the option to export the extracted information in various formats based on their needs. Once the schedule data has been processed, users can utilize the Generate GTFS Shapefile sub-module to create ESRI ArcGIS-compatible shapefiles for visual presentation and further spatial analysis.</p>

4.4 Unified Geodatabase COGTools

COGTools is used to edit the transportation network used by the regional travel model. COGTools has been updated to manage transportation networks in both the TRNBUILD and PT formats in the UGDB. The updated COGTools allows the user to choose to open the geodatabase either in Cube TRNBUILD or Cube Public Transport (PT) format using the "Format" pull down menu on the unified geodatabase login Interface.⁶¹ The "Format" attribute in the "Network Links" layer distinguishes between the PT network and the TRNBUILD network. COGTools filters the editable network features based on the choice of "Format". There are three values for "Format" attribute:

- "C" for common links;
- "P" for PT only links; and
- "T" for TRNBUILD only links.

⁶¹ Page 38, Jim Yin, "COGTOOLS User Guide, Revision 4.0" (Washington, D.C.: Metropolitan Washington Council of Governments, National Capital Region Transportation Planning Board, May 2, 2022).

For example, if a PT network is selected to be viewed and edited, all ArcGIS features with “C” and “P” values will be displayed in the ArcGIS map window, but all ArcGIS features with a “T” value in the “Format” attribute will be blocked from viewing and editing.

For each attribute that may assume distinct values on shared links between the PT and TRNBUILD networks, the UGDB schema defines two corresponding *static* fields—one for each format. For instance, the attribute FType is represented by PFTYPE for PT and TFTYPE for TRNBUILD. Upon opening the UGDB, COGTools determines the user’s selected network format and populates a shared *dynamic* attribute (FType) with the appropriate static value for display and editing within the ArcGIS interface. Any modifications made to the dynamic attribute during the network editing session are automatically written back to the format-specific static field (PFTYPE or TFTYPE). When exporting network files, COGTools references the selected format to extract values from the corresponding static attributes and writes them to the output files accordingly. Before the Esri geodatabase/COGTools approach was adopted, TPB staff used a “master” network stored in ArcInfo to manage the highway networks. In 2004, TPB staff developed a process 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. It automatically read the PROJECTID, LANES, FACILITY TYPE, and YEAR values listed in the air quality conformity project inputs table and updated those variables in the highway network database, thus saving a significant amount of staff time when updating networks for a new air quality conformity analysis cycle. In 2009, this process was revised and re-named as “PrepTIP,” i.e., prepare TIP batch update program.⁶² After transitioning to the UGDB, the COGTools batch update function was modified to update multiple features at the same time.

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

- Add new facilities in two alternative ways:
 - Copy the link from a HERE street centerline file and add it to the geodatabase⁶³, or
 - Manually draw the link on the screen via a mouse or other pointing devices
- Split highway links (by inserting a node on an existing highway link)
- Retire highway links
- Edit highway link attributes
- Permanently delete a link from the database

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)

⁶² Robert Snead, Charlene Howard, and Jane Posey, “Highway Network Database Batch Updates: PrepTIP Program,” Memorandum, March 11, 2009.

⁶³ 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.

- 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 alignment.⁶⁴ If a highway network link is deleted, the affected transit route(s) are not modified, although the user is prompted to manually reconfigure the transit route(s). 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 cases where there are 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 manages highway network editing within a multi-year framework. Edits to both highway and transit networks are tied to a specific network year, as indicated by a "year" attribute on each link. For example, in the ongoing Visualize 2050 update—part of the Long-Range Transportation Plan (LRTP)—highway networks were developed for six milestone years: 2025, 2026, 2030, 2040, 2045, and 2050. While these serve as key reference years, COGTools can generate highway networks for any year between the base year and the horizon year by applying all relevant edits up to that point.

Highway edits made for a specific year (e.g., 2025) are carried forward to all subsequent network years, including both milestone and intermediate years. In contrast, transit networks are developed independently for each milestone year. As a result, the system does not currently support propagating transit changes from one milestone year to subsequent years. However, all developed transit networks are stored collectively within the UGDB.

The COGTools toolbar also allows for exporting year-specific files from the UGDB to network 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 one of the following two formats may be selected:

- 1) *CUBE-Voyage DBF, Personal Geodatabase or PT Network 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 between the base year and the horizon year). The files exported comply with the input file format required by the Gen2/Version 2.4 or Gen3 Travel Model. The second format may be used to export highway network line and point feature classes from the geodatabase and to 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:

⁶⁴ This capability is also available in the Bentley Systems Cube Base graphical network editor, provided the user has both the highway and transit networks open at the same time.

- 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.

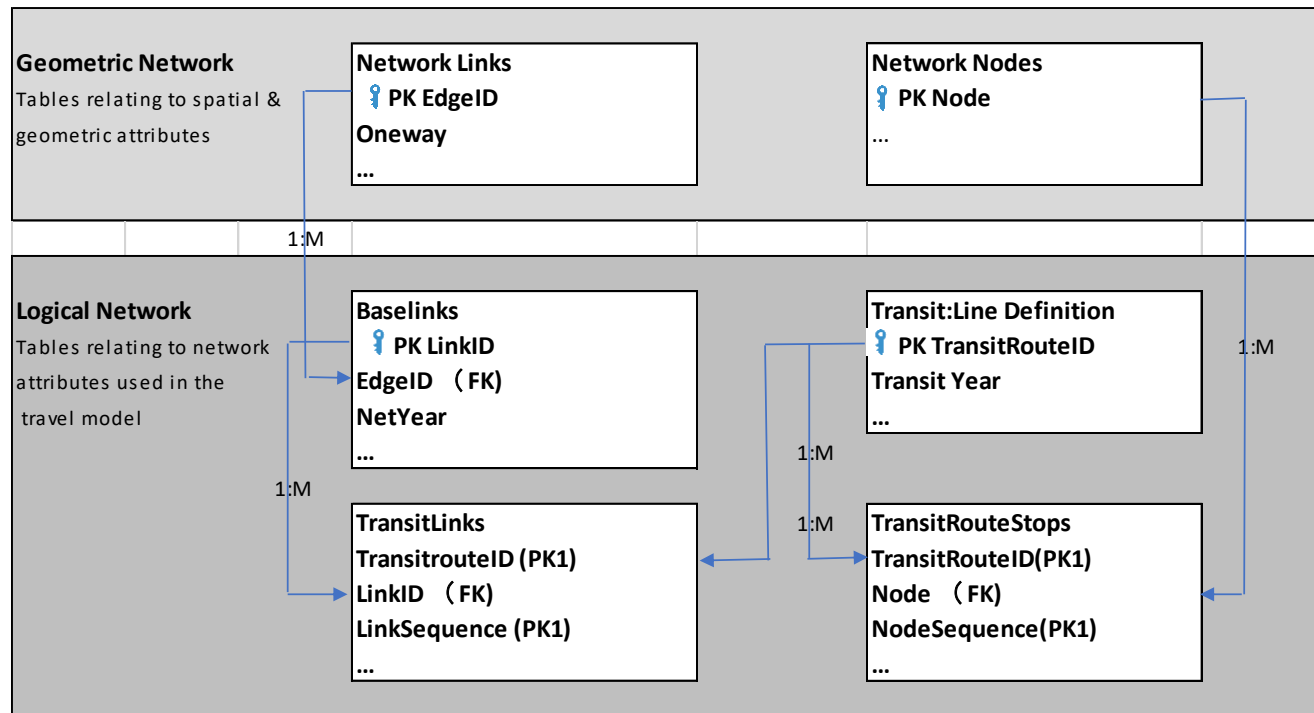
The transit exporting function generates transit link, node and route/line files for a transit year included in the database in either TRNBUILD (*.TB) or PT (*.LIN) format. In the UGDB, the transit files for the Gen2/ Version 2.4 Travel Model are stored in TRNBUILD format by two TOD periods based on typical service hours: AM (7:00 AM-7:59 AM) and OP (10:00 AM- 2:59 PM). For the Gen3 Travel Model, on the other hand, transit network files are stored in PT format by four TOD periods based on typical service hours: AM (7:00 AM-7:59 AM), OP (10:00 AM- 2:59 PM), PM (4:00 PM – 4:59 PM), and NT (7:00 PM – 11:59 PM).

4.5 Unified Geodatabase Tables: Overview and Highway Network Tables

A more detailed view of the tables that exist within the UGDB structure is shown in Figure 4-2. The UGDB is a collection of related MS Access tables that are of two general types: geometric network tables and logical network tables.⁶⁵ 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.

⁶⁵ See, for example, Esri, “Essential Geometric Networks Vocabulary,” ArcMap Documentation, 2021, <https://desktop.arcgis.com/en/arcmap/latest/manage-data/geometric-networks/essential-geometric-networks-vocabulary.htm>; OR Esri, “What Are Geometric Networks?,” ArcMap Documentation, 2021, <https://desktop.arcgis.com/en/arcmap/latest/manage-data/geometric-networks/what-are-geometric-networks-.htm>.

Figure 4-2 TPB Unified Geodatabase Structure



In Figure 4-2, “PK” means “primary key” and “FK” means “foreign key,” as described below. The geodatabase is a relational database, which means that 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 nor 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 have a composite key (labeled as PK1), which is composed of two variables: TransitRouteID and LinkSequence.

The network links attributes are shown in Table 4-3. Two notes about Table 4-3: 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 may seem 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 4-4.

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 4-5).
2. Transit Links: Transit network-related links (see Table 4-6).
3. Transit Route Stops: Transit route alignments, expressed as a network node sequence (see Table 4-7).
4. Transit Line Definition: The transit line attributes (see Table 4-8).

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 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). Entries in the logical network represent link records in 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. Note that LinkID is directional and year specific while EdgeID is neither.

In the transit network, TransitRouteID is a unique number assigned to identify transit routes 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 4-3 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	String	Geometry network link identifier (Pair node sequence)
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
		17. Hwy to Metro PNR
		18. Hwy to COMM PNR
		19. Hwy to LRT PNR
		20. Hwy to Metro KNR
		21. Hwy to COMM KNR
		22. Hwy to LRT KNR
23. BusPNR-to-BusSta		
ANode	Long Integer	A Node
BNode	Long Integer	B Node
FunctionClass	Long Integer	Link facility type code (0 - 6) <i>0/centroids, 1/Freeways, 2/Major Art., 3/Minor Art, 4/ Collector, 5/ Expressway, 6/ Ramp</i>
Format	String	"C" - Common Link, "P" - PT Link Only, "T" - TRNBUILD Link Only
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

Field Name	Data Type	Description
		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): <i>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</i>
Length	Double	Link Length in feet
Shape_Length	Double	ArcGIS auto-generated geometry length "true shape" in feet

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Table 4-4 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 PNR 12= BRT Street Node 13= Station Dummy Centroid Node
Jur	Text	Jurisdiction code (0 - 23) <i>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</i>
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

Field Name	Data Type	Description
NetYear	Long Integer	The year the network node becomes active in the database

Ref: "I:\ateam\docum\fy22\Version2.4_2022Update_Visualize2045_Network_Report\Report_Tables \gdb_tables_Rev4-4-2022.xlsx"

Table 4-5 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
StreetName	Text	Street Segment Name
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 (1-24) (Dynamic)
PLinkType	Long Integer	Link type code (1-24) (PT Network)
TLinkType	Long Integer	Link type code (1-24) (TRNBUILD Network)
Mode	Long Integer	Mode Code (1-16): (Dynamic) 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

Field Name	Data Type	Description
		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) (Dynamic) <i>0/Centroids, 1/Freeways, 2/Major Art., 3/Minor Art, 4/ Collector, 5/ Expressway, 6/ Ramp</i>
PFType	Long Integer	Link facility type code (0 - 6) (PT Network)
TFType	Long Integer	Link facility type code (0 - 6) (TRNBUILD Network)
LType	Text	Link type: <i>H=Highway links, T=Transit only links, and Z=TAZ connector</i>
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: <i>1= Active and 2= Retired</i>
COGStatus	Text	(Not Used)
UpdateDate	Text	The date and time of link attributes update
Jur	Long Integer	Jurisdiction code (0 - 23) <i>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</i>
Count	Long Integer	(Not Used)
Speed	Double	Dynamic
PSpeed	Double	(PT Network)
TSpeed	Double	(TRNBUILD Network)
Key		
<Period> =	AM	AM peak period (7:00 AM -7:59 AM)

Field Name	Data Type	Description
	PM	PM (4:00 PM – 4:59 PM)
	OP	Off-peak period (10:00 Am - 2:59 PM)
	NT	NT (7:00 PM – 11:59 PM)
BaseYear*	2000	Links entered into the database by DCI when first developed
	2001	Links subsequently entered into the database by DTP staff

4.6 Unified Geodatabase Tables: 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 4-6, Table 4-7, and Table 4-8, respectively.

Table 4-6 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 (7:00 AM -7:59 AM), 2= off-peak (10 AM-2:59 PM), 3= PM (4:00 PM – 4 :59 PM) and 4= NT (7:00 PM – 11:59 PM)

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Table 4-7 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 period code: 1= AM peak (7:00 AM -7:59 AM), 2= off-peak (10 AM-2:59 PM), 3= PM (4:00 PM – 4 :59 PM) and 4= NT (7:00 PM – 11:59 PM)
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

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Table 4-8 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 period code: 1= AM peak (7:00 AM -7:59 AM), 2= off-peak (10 AM-2:59 PM), 3= PM (4:00 PM – 4 :59 PM) and 4= NT (7:00 PM – 11:59 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

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4.7 General Transit Feed Specification (GTFS) Data

To support the Gen3 Model which uses Cube PT and simulates four time-of-day (TOD) periods in transit modeling, it is necessary for network staff to code four TOD transit services in the current UGDB. In the database, the existing two TOD periods (“AM” and “OP”) are kept the same to support the Gen2/Ver. 2.4 Model, which simulates only two TOD periods in transit modeling. Two additional time periods (“PM” and “NT”) were processed and added to the UGDB. One of the standard procedures in the network development process for a regular update of the long-range transportation plan is an update of the base-year transit network line files. The base-year transit network is the starting point for developing all 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 whether individual transit lines have been added or removed.

The regional travel model requires two variables for each transit route: Average run time and average headway, both in minutes. In the past, the update was done using paper or electronic 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).^{66 67} 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 represent 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 4-9. With the availability of the GTFS scheduling data, COG staff currently extract the scheduling information for about 90% of the regional transit services from GTFS. The information for the remaining 10% of transit services is derived based on their paper or electronic schedules. While the scheduling information for the existing two TOD periods (“AM” and “OP”) remains the same, those for the two additional time periods (“PM” and “NT”) were processed and added to the COG network database.⁶⁸ As of May 2025, staff have fully automated the GTFS data processing and line updating function and integrated it into COGTools.

⁶⁶ 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).

⁶⁷ 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).

⁶⁸ Jim Yin to Feng Xie “Development of Transit Networks for four Time of Day (TOD) Periods in the MWCOG Unified Network Database,” Memorandum, April 7, 2022.

Table 4-9 GTFS files

Filename		
<u>agency.txt</u>	Required	One or more transit agencies that provide the data in this feed.
<u>stops.txt</u>	Required	Individual locations where vehicles pick up or drop off passengers.
<u>routes.txt</u>	Required	Transit routes. A route is a group of trips that are displayed to riders as a single service.
<u>trips.txt</u>	Required	Trips for each route. A trip is a sequence of two or more stops that occurs at specific time.
<u>stop_times.txt</u>	Required	Times that a vehicle arrives at and departs from individual stops for each trip.
<u>calendar.txt</u>	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.
<u>calendar_dates.txt</u>	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.
<u>fare_attributes.txt</u>	Optional	Fare information for a transit organization's routes.
<u>fare_rules.txt</u>	Optional	Rules for applying fare information for a transit organization's routes.
<u>shapes.txt</u>	Optional	Rules for drawing lines on a map to represent a transit organization's routes.
<u>frequencies.txt</u>	Optional	Headway (time between trips) for routes with variable frequency of service.
<u>transfers.txt</u>	Optional	Rules for making connections at transfer points between routes.
<u>feed_info.txt</u>	Optional	Additional information about the feed itself, including publisher, version, and expiration information.

As noted above. GTFS information in the Washington, D.C. region is available for about 90% (87% to be specific) of the existing transit routes. As shown in Table 4-10, 14 of the 36 transit service providers included in the regional transit network currently post GTFS information. Although only about one third of transit agencies provide transit schedules 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 not to offer GTFS data.

Table 4-10 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	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	RTA Bus	Regional Transportation Agency for Central Maryland	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			24	12

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Note: Although Metrorail schedule information is *available* from GTFS, TPB staff generally use non-GTFS information for Metrorail, which is obtained 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 in text format directly from the primary transit providers or from the GTFS Data Exchange website (<http://transit.land/> or <http://transitfeeds.com/>) each fall. Upon finalization of the GTFS (General Transit Feed Specification) dataset, the GTFS Process module within COGTools performs a structured ingestion of stop_times.txt, trips.txt, routes.txt, and calendar.txt files. It constructs a temporal profile of each transit route by computing average in-vehicle travel times and inter-trip headways across predefined time-of-day categories—typically AM peak, midday, PM peak, and Night. Time aggregations are weighted by trip frequency to reflect operational service levels. Concurrently, the module processes spatial characteristics by mapping ordered stop sequences (from stop_times.txt) to geospatial representations, reconstructing route geometries using polyline interpolation or shape IDs where available. This information forms the geometric backbone for integrating transit services into the regional travel demand model

Algorithmic Flow: GTFS Process Module in COGTools

1. **Input Validation**
 - Load required GTFS files: agency.txt, routes.txt, trips.txt, stop_times.txt, stops.txt, calendar.txt, and optionally shapes.txt
 - Check for file integrity and required fields
2. **Trip Filtering**
 - Apply filters based on service calendar and date range
 - Subset trips by time-of-day bins (e.g., AM Peak, Midday, PM Peak, night)
3. **Route Aggregation**
 - Group filtered trips by route_id and time period
 - Compute average headways by counting trips and dividing service span
 - Compute average in-vehicle time by aggregating arrival_time - departure_time at each stop
4. **Spatial Reconstruction**
 - If shapes.txt is available, associate shape_id to each trip and extract polyline
 - Else, interpolate polylines from ordered stop_id sequences using spatial join with stops.txt
 - Generate GIS-ready route geometries
5. **Output Generation**
 - Export processed transit statistics (headways, run times)
 - Export route geometries as shapefiles or feature classes

After the GTFS data are added to the GDB, transit services from providers that do not provide GTFS scheduling data are manually coded into the UGDB using the schedule information published on those providers' websites. This completes the base-year transit network files upon which all forecast-year transit network files will be developed.