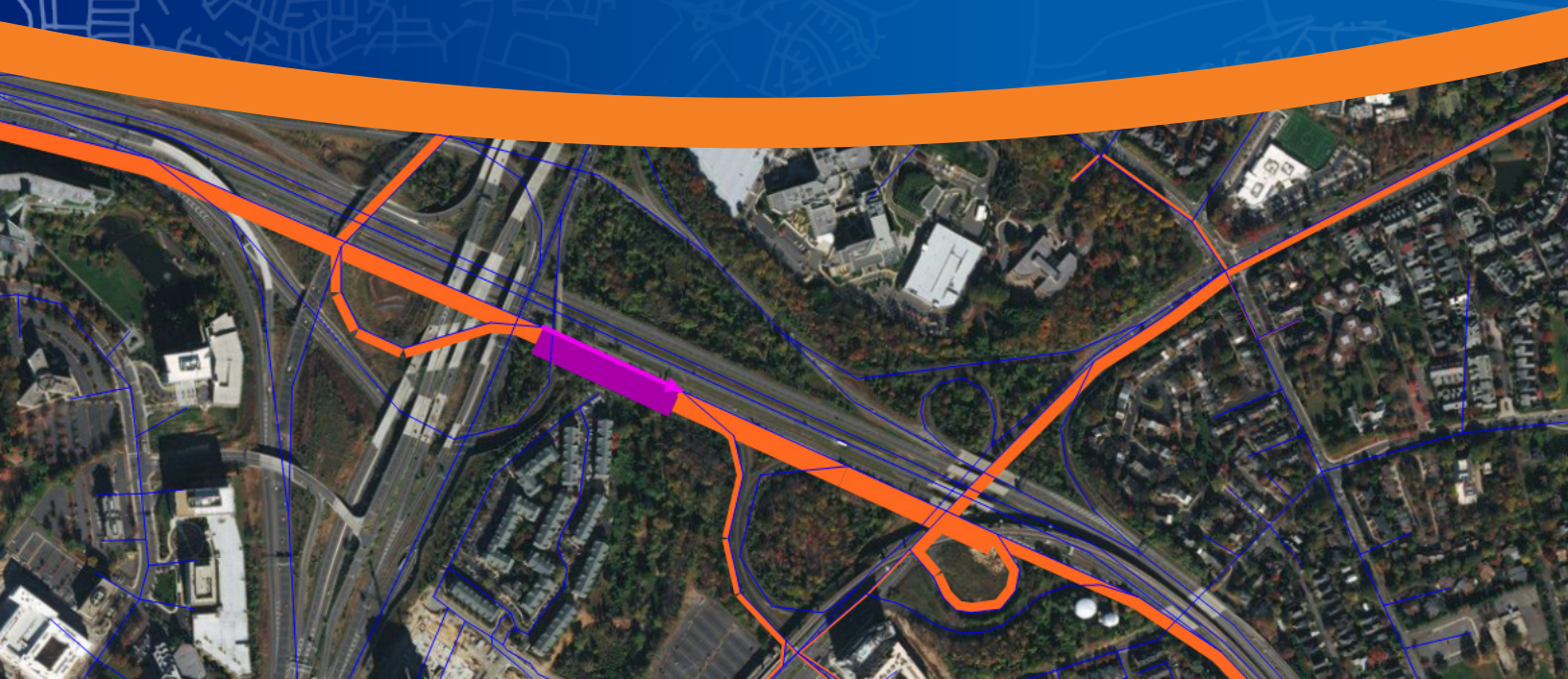




# Traffic Forecasting Guidebook

VERSION 1.0 | MAY 2020







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Version 1.0

May 2020

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## TECHNICAL ADVISORY COMMITTEE

VDOT created a technical advisory committee (TAC) to collaborate in the development of this guidebook. The TAC consisted of engineers, designers, transportation planners, and researchers from throughout the state both from the private and public sectors. Development of this guidebook was based on current VDOT policies and guidelines, industry best practices, and research findings. The TAC was responsible for discussing and vetting issues throughout the manual development process.

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## LIST OF ABBREVIATIONS

AADT	Average Annual Daily Traffic	NEPA	National Environmental Protection Act
AASHTO	American Association of State Highway and Transportation Officials	NHS	National Highway System
AAWDT	Annual Average Weekday Daily Traffic	NVTA	Northern Virginia Transportation Authority
ADT	Average Daily Traffic	O-D	Origin and Destination
APP	Arterial Preservation Program	ODME	O-D Matrix Estimation
BRT	Bus Rapid Transit	P4P	Pathways for Planning
CE	Categorical Exclusion	PDCs	Planning District Commissions
CV/AV	Connected and Autonomous Vehicles	PHF	Peak Hour Factor
D-Factor	Directional Distribution Factor	PSI	Potential for Safety Improvement
DDOT	District Department of Transportation	QA	Quality Assurance
DHV	Design Hourly Volumes	QC	Quality Control
DDHV	Directional Design Hourly Volumes	RCUT	Restricted Crossing U-Turn
D-LITE	Design Level Intersection Traffic Estimation	RTC	Richmond Tri-Cities
DOT	Department of Transportation	SPS	Statewide Planning System
EA	Environmental Assessment	SSE	Sum of Squares for Error
EIS	Environmental Impact Statement	STARS	Strategically Targeted Affordable Roadway Solutions
FHWA	Federal Highway Administration	SYIP	Six-Year Improvement Program
GIS	Geographic Information System	TAZ	Traffic Analysis Zone
GPS	Global Positioning System	TDM	Transportation Demand Management
HOV	High-Occupancy Vehicle	TIA	Traffic Impact Analysis
HOT	High-Occupancy Tolling	TMC	Turning Movement Counts
IIM	Instructional and Informational Memoranda	TMPD	Transportation Mobility and Planning Division
IJR	Interchange Justification Report	TOSAM	Traffic Operations and Safety Analysis Manual
IMR	Interchange Modification Report	TPO	Transportation Planning Organization
ITE	Institute of Transportation Engineers	TRB	Transportation Research Board
ITS	Intelligent Transportation System	VDOT	Virginia Department of Transportation
L&D	Location and Design	VMT	Vehicle Miles Traveled
LBS	Location Based Services	vpd	Vehicles per Day
LPR	License Plate Recognition	VTM	Virginia Transportation Modeling and Accessibility Program
LRS	Linear Referencing System	VTRC	Virginia Transportation Research Council
LRT	Light Rail Transit	V/C	Volume-to-Capacity
MPO	Metropolitan Planning Organization		
MWCOG	Metropolitan Washington Council of Governments		
NCHRP	National Cooperative Highway Research Program		

## GLOSSARY

**Access management:** The systematic control of the location, spacing, design, and operation of entrances, median openings, traffic signals, and interchanges to provide vehicular access to land development in a manner that preserves the safety and efficiency of the transportation system.

**American Association of State Highway and Transportation Officials (AASHTO):** An organization that advocates transportation-related policies and provides technical services to support states in their efforts to efficiently and safely move people and goods.

**Area:** An interconnected set of transportation facilities serving movements within a specified geographic space as well as movements to and from adjoining areas.

**Arterial Preservation Network:** Segments of selected major highways that are part of the Corridors of Statewide Significance system or are functionally classified as principal or other principal arterials.

**Arterial Preservation Program (APP):** A program under which VDOT aims to preserve and enhance the capacity and safety of the critical transportation highways included in the Arterial Preservation Network.

**Average annual daily traffic (AADT):** The total volume of vehicle traffic of a roadway divided by 365 days.

**Average travel speed:** Speed (expressed in mph) on a segment computed by the length of a highway segment divided by the average travel time of all vehicles traversing the segment.

**Background traffic:** Development traffic projection without development trips.

**Base year:** The initial year of the forecast period. *(See also model base year.)*

**Bus rapid transit (BRT):** A permanent, integrated transportation system that uses buses or specialized vehicles on roadways or dedicated lanes to transport passengers more quickly and efficiently than traditional bus service.

**Calibration:** The exercise to modify travel demand model input parameters so that model outputs (e.g., assigned volumes and speed) closely match observed data.

**Corridor:** A set of parallel transportation facilities, such as a freeway and one or more parallel arterial streets.

**Design hourly volume (DHV):** Thirtieth highest hourly traffic count for a design year.

**Design year:** The year for which a project is designed.

**Directional Distribution Factor (D-Factor):** Portion of traffic volume traveling in the peak direction during the peak hour.

**Diurnal curves:** The distribution of traffic volumes over a 24-hour period. Diurnal curves can be developed using hourly or sub-hourly traffic counts collected over multiple days for different vehicle classes (e.g., cars or trucks).

**Engineering judgment:** The evaluation of available information and the application of appropriate principles, provisions, and practices to decide on the applicability and proper use of traffic operations and safety analysis tools and related methodologies.

**Facility:** A roadway, bike path, or pedestrian walkway composed of a connected series of points and segments and are defined by two endpoints.

**Federal Highway Administration (FHWA):** An agency within the U.S. Department of Transportation that supports state and local governments in the design, construction, and maintenance of the nation's highway system (Federal Aid Highway Program) and various federal- and tribal-owned lands (Federal Lands Highway Program).

**Free-flow speed:** Speed (expressed in mph) on a segment computed by the length of a highway segment divided by the average travel time of all vehicles traversing the segment.

**High-occupancy vehicle (HOV) lane:** A restricted travel lane reserved for the exclusive use of vehicles with a driver and one or more passengers.

**Horizon year:** Time from the base year to the design year.

**Input parameter:** Parameter that is collected and/or measured directly in the field and is used to build the base model. For example, input parameters consist of the number of lanes, lane widths, traffic volume, free-flow speed, etc. It is not customary to change input parameters; however, if there is a need for an adjustment, then the VDOT project manager should be consulted along with documented justification.

**Instructional and Informational Memorandum (IIM):** Documents providing instructions for VDOT policies and procedures.

**Intelligent transportation system (ITS):** Transportation infrastructure that is used to collect, store, process, and distribute information relating to the movement of people and goods.

**Interchange Justification Report (IJR):** An operational analysis prepared in accordance with both VDOT and FHWA guidelines for a proposed new interchange. The IJR process applies to all access additions and FHWA's approval is required on all interstate projects greater than or equal to \$1 million in construction costs.

**Interchange Modification Report (IMR):** An operational analysis prepared in accordance with both VDOT and FHWA guidelines for access modifications that are needed to improve operations and safety of an existing interchange. The IMR process applies to access modifications on the interstate system, non-interstate National Highway System (NHS), and non-NHS.

**Interim year:** Future forecast year between the base year and design year.

**K-Factor:** The proportion of AADT occurring during the 30<sup>th</sup> highest hour of the year.

**Light rail transit (LRT):** An electric railway system that operates single or multiple car trains along a fixed guideway. LRT guideways can be in streets, on elevated platforms, or along exclusive rights-of-way.

**Model base year:** The year the model was calibrated. The model base year is typically different than the opening year of an analysis.

**National Cooperative Highway Research Program (NCHRP):** A program for coordinated and collaborative transportation research administered by the Transportation Research Board (TRB) and sponsored by FHWA, AASHTO, and individual state departments of transportation.

**Opening year:** Future horizon year when a project is open to traffic.

**Parameter:** Any value assigned or input into an analysis tool by a user to configure the analysis tool to produce results.

**Peak hour factor (PHF):** Hourly traffic volume during maximum volume hour of the day divided by the peak 15-minute flow rate within the peak hour. PHF is a measure of traffic demand fluctuation within the analysis hour.

**Peak hour spreading:** Conditions that occur when the peak hour traffic demand exceeds the available traffic capacity throughout the entire peak hour. This excess traffic then “spreads” to either side of the computed peak hour which creates a peak period of two or more hours as opposed to just one hour. Also called peak spreading.

**Percent of free-flow speed (PFFS):** Average travel speed (*see average travel speed*) divided by free-flow speed (*see free-flow speed*).

**Planning District Commissions (PDCs)<sup>1</sup>:** Associations of local governments intended to foster intergovernmental cooperation by bringing together local elected and appointed officials and involved citizens to discuss common needs and determine solutions to regional issues. Virginia has 21 PDCs.

**Point:** A place along a facility where either (a) conflicting traffic streams cross, merge, or diverge; (b) a single traffic stream is regulated by a traffic control device; or (c) there is significant change in the segment capacity (e.g., lane drop, lane addition, narrow bridge, significant upgrade, and/or start or end of a ramp influence area).

**Project area type:** Project characteristic expressed according to the type of growth in the area based on historical counts or land use data.

**Project impact (i.e., low, medium, or high):** Changes in traffic volumes or travel patterns to a surrounding area due to a new project or development.

**Project scoping:** Review of the responsibilities, schedule, and budget to determine if adequate time and funding are available to accomplish all required project development activities and to fulfill the project’s stated purpose.

**Project size:** The scale of a project expressed according to non-land development in terms of project impact to surrounding network and land development projects in terms of new trips generated.

**Public transit facilities:** Roadway infrastructure that accommodates public transit modes, such as buses, trolleys, and trains. Facilities can also refer to immovable facilities, such as bus transfer sites, bus shelters, and other amenities like benches and signage.

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<sup>1</sup> <https://www.dhcd.virginia.gov/pdcs>

**Quality control (QC):** Measures taken within a project to produce work to acceptable standards that meet project requirements.

**Queue length:** The distance between the upstream and downstream ends of a traffic queue (expressed in feet).

**Screenline:** An imaginary line that intercepts traffic flows through a region, splitting the study area into parts. Screenlines typically follow along physical boundaries (e.g., rivers or creeks). Screenlines are not usually roads that cross the study area since traffic may change at these locations.

**Site-specific traffic:** Traffic projection for proposed development traffic.

**Speed:** Rate of motion expressed as distance per unit of time (expressed in mph).

**Strategically Targeted and Affordable Roadway Solutions (STARS) Program:** A program led by the VDOT Transportation Mobility and Planning Division (TMPD), in collaboration with localities, to develop comprehensive, innovative transportation solutions to relieve congestion bottlenecks and solve critical traffic and safety challenges throughout the Commonwealth.

**System:** All transportation facilities and modes within a particular region.

**Traffic analysis zone (TAZ):** Geographic boundaries that are developed to represent demographics, use, and access to transportation network as well as provide a basis for traffic/person flows between these boundaries.

**Traffic impact analysis (TIA):** A traffic operations analysis that assesses the effect of a proposed land development project on a transportation system and recommends improvements to reduce the impacts.

**Traffic operations analysis:** An evaluation of how a roadway or a set of roadways functions under existing and/or projected traffic and geometric conditions.

**Traffic Operations and Safety Analysis Manual (TOSAM)<sup>2</sup>:** VDOT governance document that establishes consistent and uniform direction and guidance for scoping, conducting, and reporting traffic and safety analyses in Virginia.

**Traffic safety analysis:** An evaluation of safety components on a roadway or a set of roadways under existing and/or projected traffic and geometric conditions.

**Transportation demand management (TDM):** Strategies that increase system efficiency by focusing on affecting traffic demand. TDM provides travelers with travel choices, such as work location, route, time, and mode. TDM also is known as traffic demand management.

**Transportation Research Board (TRB):** A major division of the National Research Council. The mission of the TRB is to promote innovation and progress in transportation through research.

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<sup>2</sup> <http://www.virginiadot.org/business/resources/TOSAM.pdf>

**Travel time:** The average time spent by vehicles traversing a highway segment, including control delay (expressed in seconds).

**Travel time routes:** Routes taken to traverse a set of contiguous links and connectors that is part of a vehicle path, which may be wholly or partially within a full vehicle route. Travel time routes are defined based on project needs and goals.

**Validation:** An analysis of a travel demand model based on traffic count data. A validation is usually less extensive than a calibration.

**VDOT project manager:** Lead individual responsible for overseeing and directing the project from scoping through project delivery. The VDOT project manager is responsible for ensuring the direction and guidance presented in this guidebook is followed and should consult with VDOT District and/or Central Office planning staff, as needed, throughout the project process.

**Volume-to-capacity (V/C) ratio:** The ratio of the actual or expected (depending upon context) flow rate to the theoretical maximum capacity for a system component.

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# 1 INTRODUCTION AND OVERVIEW

## SECTION HIGHLIGHTS

### Section 1.1: Background

Overview of traffic forecasting in Virginia.

### Section 1.2: Purpose

Overview of the guidance provided in this guidebook.

### Section 1.3: Outline

A brief description of the details provided in each chapter of this guidebook.

## 1.1 Background

The Virginia Department of Transportation (VDOT) is tasked with planning, designing, constructing, maintaining, and operating the state's roads, bridges, and tunnels. With more than 57,000 miles of roadways and millions of miles traveled in Virginia each year, transportation projects vary in size and complexity. To effectively achieve its mission, VDOT must be able to find solutions that meet current needs within budgetary constraints while also providing capacity and efficiency to accommodate future demand.

Since federal, state, and local laws require that transportation planning, programming, and project development assess current and short- and long-range years, traffic forecasting plays an integral role and often is the basis for decision making in the overall transportation planning and design process. Through the traffic forecasting process, planners, engineers, and other transportation professionals must estimate the amount of traffic that will exist on the transportation system in the future and assess the short- and long-term impacts that traffic will have on the transportation network.

Traffic forecasting is not a one-size-fits-all process. There are various analysis methods that depend on factors such as the complexity and size of the project, the surrounding environment and access to the project, and prospective density and growth of the study area. Planners and engineers apply forecasting techniques to projects of all sizes and complexities, ranging from single intersections to statewide recommendations. Regional differences also play a key role in the forecasting process, as traffic patterns differ from dense urban centers to less populated rural areas.

*The traffic forecasting process will directly impact results from traffic analyses since traffic forecasting outputs become inputs for traffic analyses and the basis for decision making.*

Establishing clear project goals and traffic forecasting parameters will help planners and engineers to estimate and understand future traffic conditions. It is important to the success of VDOT projects that forecasting is done in a consistent, logical manner and that all decisions are well corroborated and documented during the project development cycle from planning to construction. As a result, this

guidebook will facilitate the statewide implementation of a consistent traffic forecasting approach and process, acknowledging the challenges and needs for rural, suburban, and urban areas.

## 1.2 Purpose

The purpose of this guidebook is to provide guidance on techniques applicable to the vehicular traffic forecasting process for various project types. Since this guidebook cannot account for all project types, it is recommended that the forecasting methodologies be appropriately documented and agreed upon by the VDOT project manager.

This guidebook documents a process for selecting a forecasting methodology based on project type and project characteristics, providing engineers and planners unfamiliar with traffic forecasting applications the recommended resources to consistently develop, document, and review project traffic forecasts.

Project traffic forecasts are developed by projecting traffic volumes for future horizon years for developing transportation projects. Project traffic forecasts are developed for planning, design, construction projects, and environmental studies and may be used by various divisions for different purposes. For example, the Location and Design Division uses project traffic forecasts to guide the design of construction projects.

*The focus of this guidebook is on vehicular traffic forecasting applications.*

This guidebook does not address the development of traffic forecasts for environmental traffic needs; close coordination with the VDOT Environmental Division is required for that purpose. Traffic forecast data required for environmental documentation should be

developed following the techniques outlined in this document to satisfy traffic and road design parameters.

In addition, this guidebook does not cover requirements and guidance found in the *VDOT Travel Demand Modeling Policies and Procedures Manual* or the *VDOT Traffic Operations and Safety Analysis Manual (TOSAM)*. There are, however, references to these manuals in this guidebook, as each document plays an important role in the overall transportation engineering and planning process. This guidebook refers to the *VDOT Travel Demand Modeling Policies and Procedures Manual* for subjects relating to modifying travel demand models and the *TOSAM* for subjects that affect both project traffic forecasting and traffic analysis.

## 1.3 Outline

This guidebook consists of seven chapters. The following information outlines a summary of each chapter.

- **Chapter 1: Introduction and Overview.** This chapter provides an overview of the background and purpose of the *VDOT Traffic Forecasting Guidebook*. It includes direction on what the guidebook does and does not include as well as its relationship with other policy and guidance documents.
- **Chapter 2: The VDOT Traffic Forecasting Process.** This chapter offers an overview of the three-step traffic forecasting process, which includes project scoping, data collection, and forecast activities and documentation. Specific project types, desired outputs, and VDOT review roles and responsibilities from the forecasting process are provided.

- **Chapter 3: Scoping for Traffic Forecasting.** This chapter emphasizes the importance of identifying and documenting project traffic forecasting assumptions during project scoping and initiation. Discussions of project objectives and characteristics are provided for various project types. A flow chart that highlights the scoping process and forecasting method selection is included.
- **Chapter 4: Data Sources for Traffic Forecasting.** This chapter provides an overview of appropriate data sources for traffic forecasting. It focuses on available and emerging traffic and planning data, including the available travel demand models in Virginia. This chapter also introduces a common repository of project traffic forecasts maintained by the VDOT Transportation Mobility and Planning Division (TMPD) and Traffic Engineering Division (TED).
- **Chapter 5: Traffic Forecasting Fundamental Techniques.** This chapter details the assumptions, factors, and data required to perform a traffic forecast without applying a travel demand model for detailed analysis (e.g., travel demand model outputs are readily available).
- **Chapter 6: Traffic Forecasting with a Travel Demand Model.** This chapter details the assumptions, factors, and data required to perform a traffic forecast with a travel demand model.
- **Chapter 7: Other Techniques and Applications.** This chapter provides guidance on specific traffic forecasting techniques to improve the accuracy of forecasts based on statewide and nationwide best practices and needs. The guidelines and techniques are organized based on the project study area and forecasting methodology.
- **Appendix A: Reference List**
- **Appendix B: Traffic Forecasting Prompt List.** This document outlines the suggested traffic forecasting steps to ensure consistent methodology and documentation.

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## 2 THE VDOT TRAFFIC FORECASTING PROCESS

### SECTION HIGHLIGHTS

#### Section 2.1: Project Types

Overview of project types that utilize traffic forecasts.

#### Section 2.2: Roles and Responsibilities

Overview of roles and responsibilities for the Virginia Department of Transportation (VDOT) during the forecasting process.

Selecting a traffic forecasting method is dependent on the characteristics of a project, purpose of the project, and data resources, including the availability of a travel demand model. The type, scale, and objective of a project determines the necessary forecasting outputs and, thus, the data requirements and preferred traffic forecasting method(s). The VDOT Traffic Forecasting Process is presented in **Figure 1** and includes the following stages:

Figure 1: VDOT Traffic Forecasting Process



- Scoping.** Traffic forecasting is a critical component of the project scoping process.<sup>3</sup> The VDOT project manager, staff from other agencies (e.g., localities, Planning District Commissions (PDCs), and Metropolitan Planning Organizations [MPOs]), and agency partners (e.g., consultants), if applicable, should discuss the traffic forecasting process and preferred forecasting method(s) and establish assumptions and data needs at the project scoping meeting. All traffic forecasts should begin with an inventory of available data from sources described in **Chapter 4**, and the project team should document how each data source is being used to assist with traffic forecasting. Once the project scope is approved, VDOT or the locality will instruct the project team to proceed with data collection and analysis, including any forecasting efforts.
- Data Collection.** Staff conducting traffic forecasting should review as many data sources as possible, including any previous forecasts done at the project location or in nearby areas, to understand historical trends and future projections of traffic volumes, demographics, and land uses. Any additional field data collection to support the project should be completed during this stage.
- Forecasting Analysis and Documentation.** Traffic forecasts can be developed using techniques presented in **Chapters 5–7**. Forecasts may include daily or hourly volumes; volumes in one or both directions; and/or link volumes or intersection turning-movement volumes. All techniques,

<sup>3</sup> Refer to Chapter 9 of the *VDOT Traffic Operations and Safety Analysis Manual (TOSAM)* for guidance on the traffic project scoping process.

including methodologies and supporting calculations, should be thoroughly documented so the process can be repeated by a third party. Documentation of the forecasting process should be conducted concurrently with the forecast development. Documentation should be maintained for future reference by uploading files to a central repository, such as the Statewide Planning System<sup>4</sup> (SPS) or Pathways for Planning (P4P)<sup>5</sup>. The VDOT project manager and/or their designee should upload project traffic forecasts and supporting documentation to the central repository.

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## 2.1 Project Types

There are several types of transportation studies executed at the state, regional, and local levels, each with varying objectives, characteristics, and complexity. A description of these project characteristics and how they relate to the traffic forecasting process is provided in **Chapter 3**. This section focuses on the objectives of each project type and how each relates to the desired outputs of traffic forecasting. Specific examples by project type, such as typical forecast horizon year, forecasting outputs, applicable guidance documents, and review requirements, are provided in **Table 1**.

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<sup>4</sup> The VDOT SPS is an official data warehouse maintained by TMPD that includes historical traffic data, traffic forecasts, and roadway geometrics for all roadways classified as minor collectors and above in Virginia. Refer to Section 4.1.2 for additional information.

<sup>5</sup> P4P is a web application for visualizing and analyzing planning data. Refer to Section 4.1.2 for additional information.

Table 1: Traffic Forecasting Project Type Matrix

Project Type	Example Project Types	Typical Forecast Horizons	Typical Desired Forecast Outputs	Guidance/Policy Documents	Typical Responsible Traffic Forecast Reviewer	
					VDOT-Maintained Road	National Highway System (NHS)
<b>Statewide and Regional Planning</b>	<ul style="list-style-type: none"> <li>- VTrans Multimodal Transportation Plan (VTrans Plan)</li> <li>- Comprehensive Plan</li> <li>- MPO Long-Range Transportation Plan</li> </ul>	<ul style="list-style-type: none"> <li>- Existing</li> <li>- Near-term year (5 to 10 years)</li> <li>- Long-term year (20 to 25 years)</li> </ul>	<ul style="list-style-type: none"> <li>- Daily link volumes</li> <li>- Peak-hour link volumes</li> </ul>	<ul style="list-style-type: none"> <li>- <i>VDOT Travel Demand Modeling Policies and Procedures Manual</i></li> </ul>	<ul style="list-style-type: none"> <li>- VDOT district planning manager, or</li> <li>- Designee</li> </ul>	<ul style="list-style-type: none"> <li>- VDOT district planning manager and</li> <li>- State planner, or</li> <li>- Designee</li> </ul>
<b>Corridor and Project Planning</b>	<ul style="list-style-type: none"> <li>- Strategically Targeted Affordable Roadway Solutions (STARS) projects</li> <li>- Corridor studies</li> </ul>	<ul style="list-style-type: none"> <li>- Existing</li> <li>- Near-term year</li> <li>- Long-term design year (if applicable)</li> </ul>	<ul style="list-style-type: none"> <li>- Daily volumes</li> <li>- Peak-hour link volumes</li> <li>- Peak-hour turning movement volumes</li> </ul>	<ul style="list-style-type: none"> <li>- <i>VDOT TOSAM</i></li> </ul>	<ul style="list-style-type: none"> <li>- VDOT district planning manager, or</li> <li>- Designee</li> </ul>	<ul style="list-style-type: none"> <li>- VDOT district planning manager and</li> <li>- State planner, or</li> <li>- Designee</li> </ul>
<b>Traffic Impact Analysis (TIA)</b>	<ul style="list-style-type: none"> <li>- New development</li> <li>- Expansion of existing development</li> <li>- Zoning change</li> </ul>	<ul style="list-style-type: none"> <li>- Refer to the <i>Administrative Guidelines for the VDOT Traffic Impact Analysis Regulations (24VAC30-155)</i></li> </ul>	<ul style="list-style-type: none"> <li>- Daily volumes (possibly)</li> <li>- Peak-hour link volumes (typically)</li> <li>- Peak-hour turning movement volumes</li> </ul>	<ul style="list-style-type: none"> <li>- <i>Administrative Guidelines for the VDOT Traffic Impact Analysis Regulations (24VAC30-155)</i></li> <li>- <i>TOSAM</i></li> </ul>	<ul style="list-style-type: none"> <li>- VDOT area land use engineer*, or</li> <li>- Designee</li> </ul>	<ul style="list-style-type: none"> <li>- VDOT district planning manager and</li> <li>- VDOT area land use engineer and</li> <li>- State planner, or</li> <li>- Designee</li> </ul>
<b>Design and Implementation Project</b>	<ul style="list-style-type: none"> <li>- Major roadway widening</li> <li>- Interchange reconfiguration</li> <li>- New transportation facility</li> </ul>	<ul style="list-style-type: none"> <li>- Existing</li> <li>- Opening year</li> <li>- Interim year (if applicable)</li> <li>- Design year (advertisement date plus 22 years unless an alternate year is selected)</li> </ul>	<ul style="list-style-type: none"> <li>- Daily volumes</li> <li>- Peak-hour link volumes</li> <li>- Peak-hour turning movements</li> <li>- Hourly volumes and speeds</li> </ul>	<ul style="list-style-type: none"> <li>- <i>VDOT TOSAM</i></li> </ul>	<ul style="list-style-type: none"> <li>- VDOT district planning manager, or</li> <li>- Designee</li> </ul>	<ul style="list-style-type: none"> <li>- VDOT district planning manager and</li> <li>- State planner, or</li> <li>- Designee</li> </ul>

\*The VDOT district planning manager, state planner, or their designee should review all studies and projects where a travel demand model is used.

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## 2.1.1 Planning Projects

### Statewide and Regional Planning



Statewide planning studies examine the existing, short-term, and long-term needs of Virginia's transportation system, such as economic growth, safety, congestion, air quality, and mobility. These plans are typically updated every three to five years to reflect geometric and operational changes in transportation systems and socioeconomic and land-use activity projections. Statewide planning helps define the direction of transportation improvements within the Commonwealth and is often the first step in identifying needs on key roadways. The most significant statewide planning study in Virginia is the VTrans Plan.

Like statewide planning, regional planning studies identify transportation needs but at a regional level. MPOs are responsible for long-term planning within their boundaries, while regional PDCs develop transportation plans outside of the MPO boundaries.

The traffic forecasting effort for statewide and regional planning projects focuses on daily or peak-hour link-level projections to develop planning performance metrics (e.g., volume-to-capacity [V/C] ratio, vehicle miles traveled [VMT], vehicle hours traveled). The Virginia Statewide Model is used to produce performance metrics for VTrans and other statewide planning efforts, while regional MPO travel demand models, introduced in **Section 4.2**, are used to support regional planning studies.

### Corridor and Project Planning



Corridor and project planning studies are conducted to establish a clear plan of improvements to satisfy a purpose and need identified by stakeholders. Once completed, these studies should be living documents that are routinely referenced to guide future development efforts and/or determine if a project or alternative should be advanced to the design phase and, ultimately, construction.

Corridor studies are typically analyzed for no-build and build conditions that result from forecasted peak-hour traffic volumes. The VDOT STARS and Arterial Preservation Program (APP) are examples of programs under which corridor and project planning studies are conducted.

### Traffic Impact Analysis

A TIA is conducted to determine the impacts a proposed development project would have on the surrounding roadway network and identify potential mitigations to offset increases in traffic volumes and changes in traffic patterns. According to Section 15.2-2222.1 of the *Code of Virginia*, VDOT has the authority to analyze and provide comments to local governments on development projects that may have a significant impact on state-controlled highways. Thresholds defining these impacts are provided in the *Administrative Guidelines for the VDOT Traffic Impact Analysis Regulations (24VAC30-155)*.

The *Administrative Guidelines for the Traffic Impact Analysis Regulations*<sup>6</sup> should be consulted for guidance when forecasting site-generated traffic for TIAs, rezoning, and comprehensive plan amendments. The traffic forecasting methodology for TIAs is influenced by the size of the development. Future daily and peak hour site trips are typically calculated using the Institute of Transportation Engineers (ITE) Trip Generation method. Background traffic growth can be forecasted using daily traffic historical growth rates or future data following the guidance provided in **Chapter 5**. The forecast horizon for TIAs is typically six years after the anticipated opening day, although it could be greater depending on the scale of the proposed development.

### 2.1.2 Design and Implementation Projects

Traffic forecasting is critical in the project design process because facilities must be designed to meet the needs of future traffic volumes. Daily traffic volume forecasts are used to ensure adequate pavement strength, bridge specifications, and/or cross section requirements, whereas peak-hour traffic forecasts are typically needed for intersection geometric improvements to ensure that adequate capacity is provided. Regardless of the forecasting scenario, a thorough, methodical approach and detailed documentation of the forecasting steps are important to the success of the project development process.

When interstates and/or roadways within the U.S. National Highway System (NHS) are part of a project, traffic forecasting must be analyzed and documented according to the *VDOT IIM-LD-200: Interstate, Non-Interstate and Non-NHS Guidance (IJR/IMR)*, a state-specific guidance to supplement the Federal Highway Administration (FHWA) *Interstate System Access Information Guide*.<sup>7</sup> Analysis years should include an existing year, opening year, interim year (if applicable), and design year (advertisement date plus 22 years, unless an alternate year is selected). Forecast traffic volumes should include link volumes for daily and peak hours and intersection turning movement volumes for the peak hours. In areas where congestion may extend for multiple hours (e.g., Hampton Roads District and Northern Virginia District), traffic analyses should include a review of daily volume distributions to complete hourly factors and develop hourly volumes for a peak period, which may extend beyond one hour.

Scoping traffic forecasting for non-interstates and roadways not within the NHS should follow the guidelines provided in **Chapter 3**. The traffic forecasting procedures and techniques, driven by project purpose and need, are not hinged upon interstate or NHS designations.

#### *Traffic Operations and Safety Studies*

Since traffic engineering, operations, and safety studies—such as traffic signal timing plans, signal system improvements, and traffic calming projects—examine short-term needs of a roadway network, improvements tend to be localized and can be implemented without forecasting traffic volumes.

#### *Construction Projects and Maintenance of Traffic Plans*

Construction projects may require short-term or multi-year lane closures in cases such as a bridge replacement or rehabilitation project. If closures are short-term, maintenance of traffic (MOT) plans typically use existing traffic volumes and do not require traffic forecasting. If a construction project is

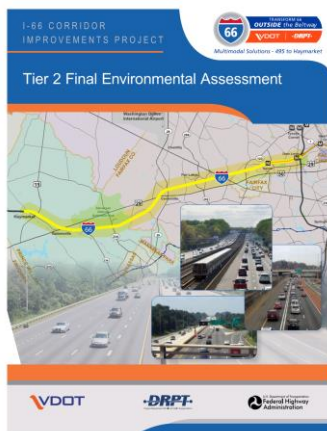
<sup>6</sup> [http://www.virginiadot.org/projects/resources/TIA\\_Administrative\\_Guidelines.pdf](http://www.virginiadot.org/projects/resources/TIA_Administrative_Guidelines.pdf)

<sup>7</sup> <https://www.fhwa.dot.gov/design/interstate/pubs/access/access.pdf>

expected to occur over several years, however, traffic forecasts may be needed to determine how travelers' reactions to lane and road closures impact surrounding facilities.

As lane closures extend for multiple hours, analysis is not limited to peak hours; therefore, development of hourly volume distributions over a 24-hour period—also referred to as diurnal curves—to compute hourly factors is a necessary step. Guidance on this topic is provided in **Section 7.3**.

### 2.1.3 Environmental Study



Projects conducted on the NHS or using federal funds must conform to the National Environmental Policy Act (NEPA) regulatory framework. There are three types of NEPA documents: Environmental Impact Statements (EIS), Environmental Assessments (EA), and Categorical Exclusions (CE).

An EIS or EA is typically coupled with a separate study that analyzes traffic operations, such as a capital improvement project, Interchange Justification Report (IJR), Interchange Modification Report (IMR), or corridor analysis. Depending on the overall study process, the two studies can be completed sequentially or in parallel.

CEs are typically completed for projects deemed with less significant impact. Most CEs do not include capacity improvements, and, therefore, do not require a traffic operational analysis. Traffic

forecasting is still needed to fulfill design requirements, such as pavement and/or bridge design processes.

#### *Air and Noise Study*

NEPA regulates that air and noise impacts must be analyzed for alternatives under evaluation; environmental traffic data is a critical component necessary to facilitate these analyses. VDOT provides a sample list of traffic forecast data for air and noise analyses in the document titled *Traffic Analyses to Support NEPA Studies*.<sup>8</sup> The *Quick Reference Guide for Traffic Modelers for Generating Traffic and Activity Data for Project-Level Air Quality Analyses*<sup>9</sup> is a recommended resource for generating traffic data for air quality studies. Close coordination with the VDOT Environmental Division Air and Noise Section is required for all NEPA studies, as the traffic requirements for each project can vary substantially for both air and noise. Coordination with the VDOT Environmental Division Air and Noise Section is recommended early in the traffic development process to ensure that environmental traffic data needs have been clearly identified.

Noise analyses typically require the use of the VDOT Environmental Traffic Data (ENTRADA) spreadsheet, which provides hourly volume and speed data. This is contrary to air quality study traffic requirements that are based on average daily traffic (ADT), peak hourly volumes, truck percentages, and pollutants. Nonetheless, traffic forecast data required by VDOT for environmental documentation should reasonably follow techniques outlined in this document for developing project forecasts for

<sup>8</sup> [http://www.virginiadot.org/projects/resources/Chapter\\_1\\_NEPA\\_Tiering\\_Process.pdf](http://www.virginiadot.org/projects/resources/Chapter_1_NEPA_Tiering_Process.pdf)

<sup>9</sup> <http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=3971>

traffic and roadway design. The focus of this guidebook is on traffic forecast data used to support project development.

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## 2.2 Roles and Responsibilities

There are many roles that support the successful execution of a project. Below are identified roles and specific responsibilities related to traffic forecasting tasks that should be considered prior to the project scoping meeting. Coordination with other VDOT staff (e.g., the district planning manager and/or state planner) may be required to satisfy review requirements. Refer to **Table 1** in **Section 2.1** for a list of typical responsible traffic forecast reviewers, by project type.

### 2.2.1 Role of the VDOT Project Manager

The VDOT project manager is the individual leading a project on behalf of VDOT. The VDOT project manager facilitates and oversees the project working group, often consisting of representatives from a locality or agency, groups within VDOT, and an agency partner, such as a consultant. A detailed list of the project manager's responsibilities for traffic analyses is included in Chapter 9 of the *TOSAM*.

The role of the VDOT project manager during the traffic forecasting process is to:

- Ensure the direction and guidance presented in this guidebook are followed
- Oversee traffic forecasting activities
- Organize and facilitate project meetings to support traffic forecasting activities
- Ensure appropriate traffic data sources are selected and used to develop traffic growth rates
- Approve and facilitate reviewer input on traffic growth rates and forecasted traffic volumes
- Upload project traffic forecasts and supporting documentation to the Statewide Planning System (SPS) and Pathways for Planning (P4P)

### 2.2.2 Role of the VDOT Central Office Planning Division

Support from the VDOT Central Office Transportation and Mobility Planning Division (TPMD) may be needed throughout the traffic forecasting process. If requested, TPMD staff should provide the project team with access to data sources (e.g., SPS and P4P) and guidance on travel demand model interpretations and growth rate development.

### 2.2.3 Role of the VDOT District Planner

The VDOT district planner has local insight and knowledge to a project area. As such, the district planner should be actively involved in the traffic forecasting process to identify any potential issues before major scheduling and/or cost concerns arise.

### 2.2.4 Role of the VDOT Area Land Use Engineer

Like the VDOT district planner, the VDOT area land use engineer has local insight and knowledge to a project area, which includes knowledge of local land use and zoning requirements. The VDOT area land use engineer should be actively involved in reviewing and approving growth rates and traffic forecast volumes for traffic impact analyses (TIAs) along VDOT-maintained roads. The VDOT district planning manager, state planner, or a designee, should review and approve traffic forecasts if a TIA impacts the NHS.

### 2.2.5 Role of Stakeholders

Stakeholders should include individuals with relevant experience or familiarity with a project. When identifying stakeholders, the VDOT project manager should also consider individuals from localities and agencies adjacent to the study area who are familiar with regional traffic and land use trends.

Stakeholders may be from partnering departments within an agency, community members, subject matter experts, and/or elected officials. The role of stakeholders during the traffic forecasting process is to:

- Participate in project meetings related to traffic forecasting activities
- Be involved in the development of traffic growth rates
- Provide input on regional land use trends that affect traffic forecasting

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## 3 SCOPING FOR TRAFFIC FORECASTING

### SECTION HIGHLIGHTS

#### Section 3.1: Considerations During Project Scoping

Overview of topics that should be considered prior to and during the project scoping meeting.

#### Section 3.2: Forecast Analysis Scenarios

Overview of forecast analysis scenarios, including guidance on selecting a horizon year based on project type.

#### Section 3.3: Selecting a Traffic Forecasting Method

Overview of traffic forecasting methods, including guidance on selecting a methodology based on project characteristics.

#### Section 3.4: Mini Case Study 1: Traffic Forecast Scoping

Overview traffic forecast scoping, including a mini case study.

It is important that the traffic forecasting team, consisting of the Virginia Department of Transportation (VDOT) District and/or Central Office planning staff, agency partners (such as consultants), and/or representatives from local governments, meet with the VDOT project manager during the overall project scoping process to discuss the traffic forecasting methodology.

**Figure 2** outlines the traffic forecasting scoping framework, including assumptions to be discussed at the scoping meeting including the project purpose and goals (which dictate many of the forecasting analysis assumptions), study limits, data collection requirements, horizon year(s), environmental traffic data needs, proposed traffic forecasting methodology, stakeholder involvement, and review requirements. Project documentation requirements should also be discussed among the traffic forecasting team. The VDOT Traffic Forecasting Prompt List (**Appendix B**) can be used as a guide when scoping for traffic forecasting. Guidance on the complete traffic analysis scoping process (e.g., data collection, traffic analysis tools, and measures of effectiveness) is provided in the VDOT *Traffic Operations and Safety Analysis Manual (TOSAM)*.

### 3.1 Considerations During Project Scoping

Consider the following elements when establishing the forecasting methodology during the project scoping process.

- **Available traffic forecasts from other studies.** *Were previous traffic forecasts developed for a study in or near the project study area?* If so, previous methodologies and assumptions should be reviewed, and the study team should determine if any of the information can be used. If a previous study in or near the project study area with traffic forecasts is not used in the development of the new traffic forecasts, explanations should be provided as to why these were not used or deemed appropriate. All available data and studies used to develop traffic forecasts should be documented.
- **Availability and suitability of a travel demand model(s).** *What, if any, travel demand models are available in the study area?* VDOT's stated preference is to use the regionally-recognized

Metropolitan Planning Organization (MPO) travel demand model. If a different model is used, such as a jurisdiction-specific model or a custom-built subarea model, rationale for use should be documented and must be approved by the VDOT project manager. Conversely, if a travel demand model is available in a study area but is not used, rationale should be documented and approved by the VDOT project manager. Lastly, some studies may require the modification, calibration, and/or application of a travel demand model, rather than just simply using the outputs from a default year and/or scenario model run. These topics are discussed further in **Chapter 6**.

- **Horizon year(s).** *Is the horizon year stipulated by an overarching regulation?* Some projects, such as traffic impact analyses (TIAs) and traffic analyses in support of National Environmental Protection Act (NEPA) studies, require horizon years be selected according to a regulation. Projects may have more than one horizon year. In the case of TIAs, the horizon year should be selected based on the build-out year (for a proposed development) and/or the year when major alterations to the transportation network are expected.<sup>10</sup> The project manager should ensure the forecast horizon year is carefully selected to prevent under- or over-forecasting of traffic.
- **Documentation Requirements.** *What should be documented?* Consideration should be given to reporting requirements established in this guidebook. Forecasting documentation, at a minimum, should address assumptions—such as horizon years and scenarios in meeting policy requirements—forecasting methodology and techniques, supporting data sources, and forecasting analysis results in tabular and graphic format to illustrate projected growth rates and traffic volumes for the study area facilities. If a travel demand model is applied and requires project-specific validation, documentation on the model validation approach and results should be included.

Forecasting documentation should be retained by VDOT and uploaded to a central repository, such as the Statewide Planning System (SPS) or Pathways for Planning (P4P).

- **Review Requirements.** *Who will review the selected growth rates and project traffic forecasts?* Review requirements may vary depending on the type of project and roadway designation. Recommended reviewers are listed in **Table 1**.

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<sup>10</sup> Refer to the *Administrative Guidelines for the VDOT Traffic Impact Analysis Regulations (24VAC30-155)*.



Figure 2: Traffic Forecasting Scoping Process

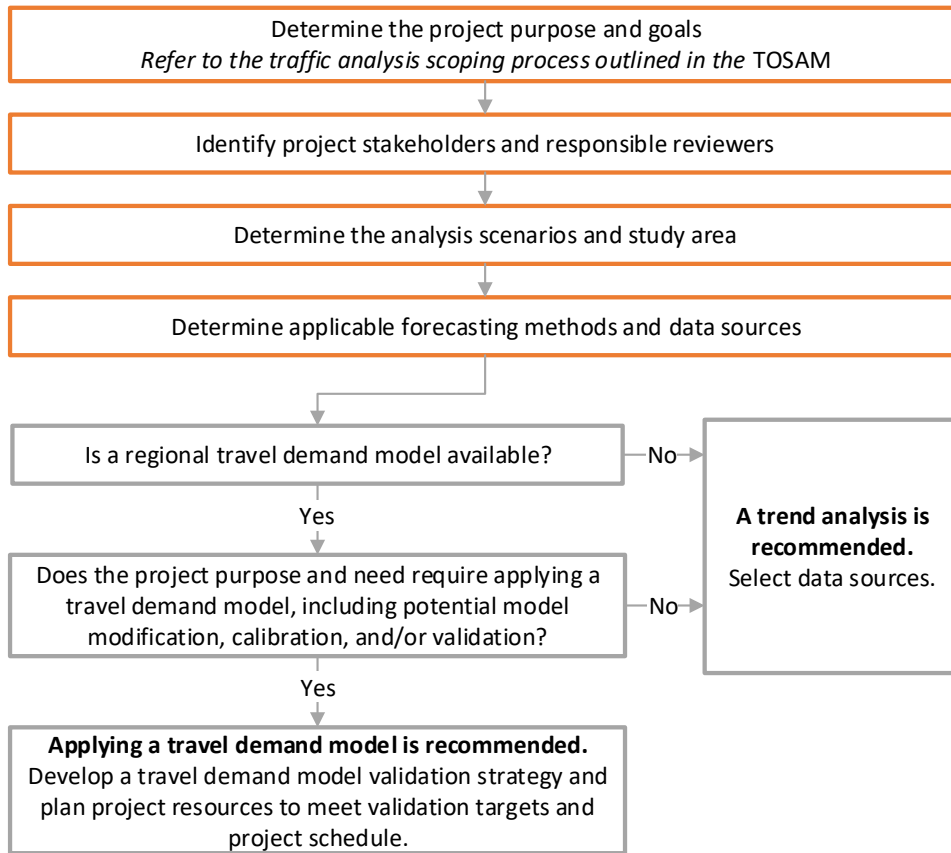
**TRAFFIC FORECASTING SCOPING**

**DATA COLLECTION**

**FORECASTING ANALYSIS AND DOCUMENTATION**

The complete traffic analysis scoping process is described in the *TOSAM*. Related to traffic forecasting, the project team, VDOT Central Office planning staff, VDOT district planner, VDOT area land use engineer, and/or stakeholders will discuss the traffic forecasting process and preferred forecasting method(s) at the project scoping meeting. Once the scope is approved, the VDOT project manager may instruct the traffic forecasting staff (whether at VDOT, a local jurisdiction, and/or consultant) to proceed with the data collection and forecasting tasks.

**Before the Project Scoping Meeting**



**At the Project Scoping Meeting**

Discuss the analysis scenarios, data sources, and preferred forecasting method(s) with project stakeholders.

**After the Project Scoping Meeting**

Submit scope to the VDOT project manager for approval

Continue to Data Collection

### 3.2 Forecast Analysis Scenarios

The study team should first determine the forecast base year, which is the starting year for traffic forecasts. Depending on the traffic data and tools selected for forecasting, the forecast base year may not be the same as the project existing conditions base year. For example, the base year scenario of a travel demand model may be prior to the existing conditions year of the project; therefore, the base year travel demand model must reflect the land use and transportation network assumptions that are appropriate for that year. Likewise, for future horizon years, project assumptions should be examined so programmed and planned improvements assumed in the traffic forecasting effort reflect the conditions approved by the project team. Including appropriate projects in the base and forecast horizon years helps to validate the base travel demand model and understand the impact of planned projects on future conditions.

Forecast analysis scenarios are based on the purpose of the project and vary by project type and location. While planners and engineers on some projects may analyze one horizon year, others may look at multiple forecast horizons. **Table 2** presents the suggested forecast horizon years by project type. Traffic forecasts should be developed for no-build and build scenarios. In some cases, one set of traffic forecasts may be developed for both scenarios. Details for developing traffic forecast for future no-build and build scenarios are provided in **Section 6.4**.

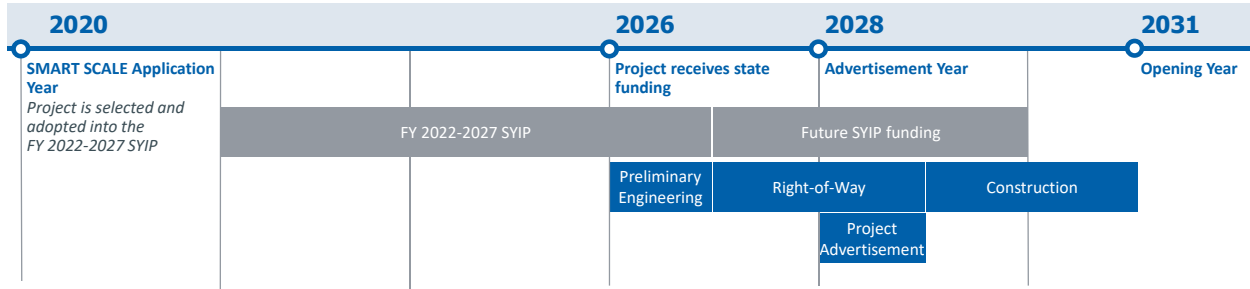
**Table 2: Forecast Horizon by Project Type**

Project Type	Typical Forecast Horizon
Statewide Planning Studies	20–25 years
Regional Planning Studies	5–25 years
Corridor Studies	Study year, typically 15–25 years
TIAs	Opening year, six years after opening year
Design and Implementation Project	Opening year, interim year, design year
Environmental Studies	Small project, 10 years Large project, advertisement date plus 22 years

For projects that are funded by Virginia’s SMART SCALE, the future horizon year should be selected considering the anticipated timeframe for the project to enter the Six-Year Improvement Program (SYIP) plus the time for project design advertisement, and construction. **Figure 3** shows an example SMART SCALE project timeline. The example project is selected for funding in the 2020 SMART SCALE application cycle and adopted into the fiscal year (FY) 2022-2027 SYIP. The project is assumed to receive state funding in the fifth year of the program (2026). After considering for preliminary engineering (one year), right-of-way (two years), project advertisement (one year), and design and construction (two years), the forecast year for analysis should be 11 years out from the application year, which corresponds to the project’s approximate opening year.

Funding for particular phases of projects may be pulled forward by VDOT. In addition, the preliminary engineering stage could start earlier if the project receives local funding.

Figure 3: Example SMART SCALE Project Timeline



### 3.3 Selecting a Traffic Forecasting Method

*Applying a travel demand model herein is defined as:*

- 1. Applying a model using default model inputs which should include post-processing model outputs to meet the needs of the analysis*
- 2. Applying and modifying a model which should include validating and calibrating the model and post-processing model outputs*

The forecasting methods, which are generally distinguished by the application of a travel demand mode, should be determined based on how the selected method adequately fulfills the project purpose and goals. The project team should examine several factors and parameters, such as project characteristics, project impact, and the availability and sufficiency of travel demand models when selecting forecasting methods during the scoping process.

Moreover, the project manager should use his or her professional judgment when deciding on which forecasting tools to use and how to use them. Data

requirements for the selected forecasting methods should also be discussed during the scoping process. Guidance on data sources is provided in **Chapter 4**.

#### 3.3.1 Project Impact and Project Characteristics

Projects can be primarily characterized by their anticipated project impact and project characteristics. Regardless of the size and/or type of project (e.g., proposed transportation improvement or land development project), varying degrees of impact can occur to the existing and future traffic flow on a transportation network. Descriptions of low-, medium-, and high-impact projects and corresponding guidance on when to apply a travel demand model are provided in **Table 3**.

*A trend analysis, using multiple data sources, is always recommended. The project manager should use engineering judgement when deciding whether to apply a travel demand model for a given project.*

VDOT recommends conducting a trend analysis for low-impact projects; however, if a validated travel demand model is available from a project in the vicinity, the model outputs can be used for traffic forecasting. For medium-impact projects, the decision to apply a travel demand model is dependent upon the project purpose and goals as well as other factors to be assessed during the scoping process (e.g., cost

and technical resources such as model availability). The decision should be made by the VDOT project manager and agreed upon by the study team and project stakeholders. For high-impact projects, VDOT recommends applying a validated travel demand model that has been deemed sufficient for the forecasting task. **Chapter 6** includes information about models available in Virginia and the output from each model.

The degree of impact also correlates to the amount of data required to conduct a traffic forecast. High-impact projects that involve transit (e.g., bus rapid transit [BRT] and light rail transit [LRT]) and high-occupancy vehicle (HOV)/high-occupancy tolling (HOT) lanes typically require more data than other roadway projects. For example, a BRT project on a major arterial facility may be classified as high-impact since it will impact existing travel patterns. Transit ridership and mode share data would be required to accurately forecast traffic. As a result, for rail and BRT projects, the project team should collaborate with the Department of Rail and Public Transportation (DRPT) and local stakeholders to address the transit forecasting component.

**Table 3: Guidance on Applying Travel Demand Models in Relation to Anticipated Project Impact**

Project Impact	Description	Guidance on Applying a Travel Demand Model
Low	<p>Project improvements are not expected to significantly impact existing travel patterns.</p> <p>Project Examples: Intersection turn lane improvement, freeway ramp acceleration lane extension, signal timing improvement, or land development projects in suburban or rural areas with limited alternative access</p>	<p>Applying a travel demand model is not recommended, but if a model is readily available from a nearby project, the model outputs may be used for traffic forecasting.</p>
Medium	<p>Project improvements are expected to impact existing travel patterns and future traffic growth.</p> <p>Project Examples: Roadway widening, transportation network improvement (e.g., one-way/two-way conversion), corridor wide intersection improvement (e.g., innovative intersections), or land development projects in urban areas or in suburban/rural area with several access points</p>	<p>Applying a validated travel demand model may be needed and the decision should be based upon the purpose and needs of the project.</p>
High	<p>Project improvements are expected to significantly impact existing travel patterns and future traffic growth. An extra amount of data needs to be collected for traffic forecasting.</p> <p>Project Examples: High-capacity or high-quality transit project (e.g., LRT or BRT), HOV/HOT lanes, or corridor improvements that affect both mainline capacity and interchange access</p>	<p>Applying a validated travel demand model is recommended.</p>

**Table 4** provides secondary guidance for selecting a traffic forecasting method according to project size and project area type. Although a trend analysis can be used for any project size or area type, it is the most adequate forecasting method when the project size is small and in a stable growth area.

Nonetheless, a trend analysis should still be considered as an additional data source for large projects and projects in high-growth areas while the project team assesses whether to apply a travel demand model based on the project purpose and goals.

In both cases, the guidance on applying a travel demand model is a recommendation. The project manager should use engineering judgement when deciding to apply a travel demand model for a given project.

**Table 4: Guidance on Applying Travel Demand Models in Relation to Project Characteristics**

Project Characteristics		Description	Guidance on Applying a Travel Demand Model
<b>Project Size</b>			
Non-Land Development Project	Small Project	Isolated or multiple intersection project (operations, safety improvement)	Not Recommended
	Large Project	Corridor or network project or interchange modification with impact on surrounding transportation network	Recommended
Land Development Project*	Small Project	Proposed land use generates less than 5,000 vehicular trips per day	Not Recommended
	Large Project	Proposed land use generates 5,000 or more vehicular trips per day	Recommended
<b>Project Area Type</b>			
Stable Growth Area		Growth less than or equal to two percent per year based on historical counts or land use data and limited number of approved or planned land use changes and transportation network projects**, excluding large land development projects	Not Recommended
High-Growth Area		Growth greater than two percent per year based on historical counts or land use data and several approved or planned land use changes, including large land development projects	Recommended

\*Site-related trip generation and forecasting should follow the *VDOT Traffic Impact Analysis Administrative Guidelines*. Background traffic forecasting should follow the guidance outlined in this guidebook.

\*\*New transportation facilities will often drive or be developed due to land use changes. Transportation network improvements can be separate from land use changes in dense or built-out areas.

## 3.4 Mini Case Study 1: Traffic Forecast Scoping

The below example outlines the traffic forecasting scoping process methodology.

### 3.4.1 Project Background

Motorists using the I-81 and Route 75 interchange (I-81 Exit 17) in the Town of Abingdon and Washington County experienced congestion due to population growth in the area. Route 75 (Cummings Street), a primary arterial, was identified as a key retail corridor for both new and redevelopment opportunities due to its proximity to I-81; however, geometric constraints limited the growth and development potential of the corridor and created a potentially hazardous conditions for motorists. As a result, VDOT identified the need to improve the interchange and evaluate alternatives.

#### *Project Scoping Traffic Forecasting Considerations*

Consider the following questions prior to the scoping meeting:

- 1) What is the defined study area?
- 2) What are applicable polices for this project?
- 3) What is the forecast horizon year(s)?
- 4) Who should be involved during the project scoping process?
- 5) What data sources or other studies are available?

### 3.4.2 Traffic Forecasting Scoping Process

The following sections outline topics to be discussed at the scoping meeting. Members of the study work group should be identified prior to the scoping meeting.

#### *Determine Project Objective*

VDOT identified the need to improve the I-81 Exit 17 interchange due to the existing and anticipated operational and safety deficiencies. The objective of the study was to develop cost-effective, implementable improvements that addressed the projected safety and operational issues on both Route 75 and I-81 mainline near the interchange ramps.

Since the project included an interstate interchange maintained by VDOT, an Interchange Modification Report (IMR) was required, which had to be prepared according to *VDOT IIM-LD-200* and the Federal Highway Administration (FHWA) *Interstate System Access Informational Guide*.

#### *Determine Traffic Forecasting Stakeholders*

The following stakeholders were identified to provide the project team with knowledge and local input of the study area, and to meet approval processes and requirements:

- VDOT Central Office Location and Design (L&D)
- Bristol District L&D
- VDOT Central Office Traffic Engineering Division
- FHWA
- Town of Abingdon
- Washington County

### Determine Study Area

According to VDOT IIM-LD-200, study limits must meet two criteria:

- 1) As a minimum, in urbanized areas the analysis must extend through at least the first adjacent existing or proposed interchange on either side. If rest areas or welcome centers are located between adjacent interchanges, they will be incorporated into the analysis.
- 2) As a minimum, in urbanized areas the analysis must extend through at least the first adjacent existing or proposed major intersection on either side of the interchange.

Even though the criteria required that the adjacent Old Jonesboro Road (Exit 14) and Lee Highway (Exit 19) interchanges be included in the operational analysis, these two adjacent interchanges were considered operationally isolated, so VDOT and FHWA agreed to focus the analysis only on the Exit 17 interchange.

Since the proposed access modification was at the eastbound ramp's termini, the other required intersections included the westbound ramp's termini to the north and the Commerce Drive intersection to the south.

The recommended study area on I-81, shown in **Figure 4**, was defined as eastbound I-81 between Milepost 16.75 and Milepost 17.75; westbound I-81 between Milepost 16.75 and Milepost 17.75; and Route 75 from Cook Street to Vances Mill Road/Fairways Drive. The study limits on Route 75 were extended north to Cook Street and south to Vance Mill Road/Fairway Drive to capture peak-hour queuing impacts and provide a comprehensive analysis of the surrounding area.

Figure 4: IMR Study Area



### Data Availability

- Request previously collected 2014 data from VDOT and adjust the traffic count data to be consistent with the 2015 analysis base year
- Collect historic traffic count data and land use data consisting of major programmed and planned developments

### Determine If a Travel Demand Model is Available

The Virginia Travel Demand Model Responsibility Map<sup>11</sup> may be consulted to determine if a travel demand model is available for use. Refer to Section 4.2.1 for guidance on determining a travel demand model coverage area

### Determine Analysis Scenarios and Forecast Years

Select the following analysis scenarios, outlined in the VDOT IIM-LD-200, for analysis:

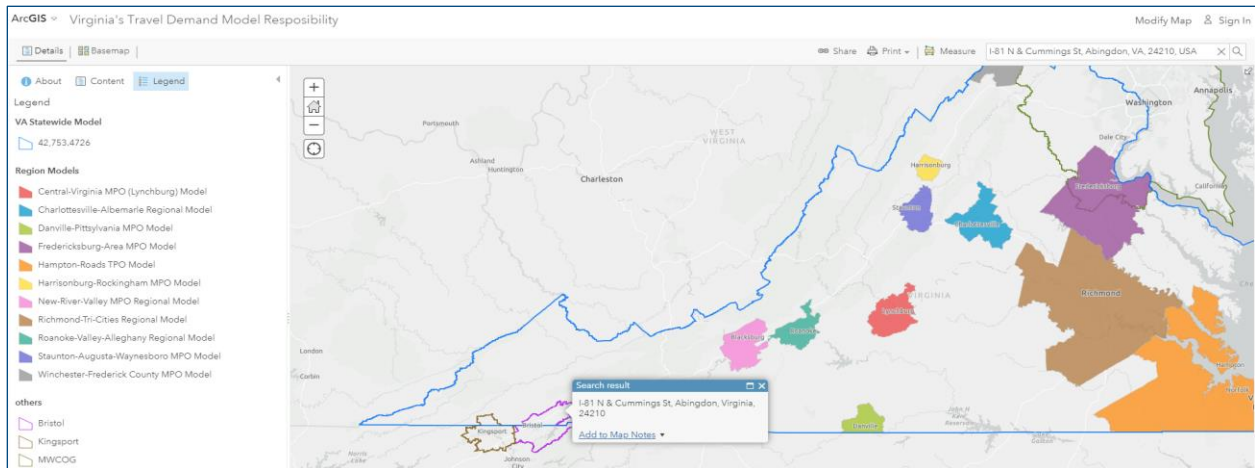
- Existing Conditions (2015)
- No-Build — Opening Year and Design Year
- Concept 1 — Opening Year and Design Year
- Concept 2 — Opening Year and Design Year

The advertisement date and opening year for the improvements were expected to be 2018 and 2020, respectively. Calculate the design year according to guidance in VDOT IIM-LD-200 as 2040, which equals the advertisement date plus 22 years.

### Determine Applicable Forecasting Methods and Data Sources

The project should be classified as a high-impact project because the project includes interchange improvements that will affect existing travel patterns. According to Table 3, the recommended forecasting methodology is to apply a validated travel demand model. Since the study is located within the Bristol Travel Demand Model area, as depicted in Figure 5, the model may be used for the development of traffic forecasts on this project.

Figure 5: Virginia Travel Demand Model Responsibility Map



<sup>11</sup> <https://www.virginiadot.org/projects/vtm/vtm.asp>



## 4 DATA SOURCES FOR TRAFFIC FORECASTING

### SECTION HIGHLIGHTS

#### **Section 4.1: Traffic Volume Data**

Overview of field data collection traffic data, and the Virginia Department of Transportation (VDOT)-maintained and publicly available traffic and planning data sources.

#### **Section 4.2: Travel Demand Models**

Overview of the available travel demand models in Virginia.

#### **Section 4.3: Planning Data**

Overview of planning data, including Census data, other planning data, and a new, evolving suite of big data analytics.

To develop reasonable and defensible traffic forecasts, it is important to rely on multiple data sources because there are inherent strengths and weaknesses with each. These sources may include traffic counts, vehicle classification data, turning-movement counts, transit ridership, bicycle and pedestrian counts, origin-destination data, land use data, socioeconomic data, travel demand models, and emerging big data sources. Data is not only used to develop a baseline of existing traffic conditions but also to support calculations for future traffic growth and changes in future forecasted conditions.

VDOT recommends using as many data sources as possible when developing a traffic forecast. The VDOT Research Library<sup>12</sup> provides information on planning-related data sources introduced in this chapter. Wherever possible, it is best to validate data sources with existing field data. A list of known traffic forecasting data sources and availability is provided in **Table 5**.

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<sup>12</sup> <https://library.virginiadot.org/guides/planning-data>

Table 5: Traffic Forecasting Data Source Availability

Data Source		Availability		
		VDOT Staff Only	Publicly Accessible with VDOT Permission	Publicly Available
Data Maintained by VDOT	VDOT Annual Traffic Summary Publications <sup>13</sup>			✓
	VDOT Traffic Monitoring System (TMS) <sup>14</sup>	✓		
	iPeMS <sup>15</sup>		✓	
	VDOT Statewide Planning System (SPS) <sup>16</sup>	✓		
	Strategically Targeted Affordable Roadway Solutions (STARS) Map <sup>17</sup>			✓
	Pathways for Planning (P4P) <sup>18</sup>		✓	
	Design Level Intersection Traffic Estimation (D-LITE) <sup>19</sup>		✓	
Data Not Maintained by VDOT	Economic and Demographic Data (U.S. Census Bureau) <sup>20</sup>			✓
	OnTheMap (Census) <sup>21</sup>			✓

<sup>13</sup> <http://www.virginiadot.org/info/ct-trafficcounts.asp>

<sup>14</sup> <http://tedweb/tms/jsp/> (VDOT Network Only)

<sup>15</sup> <https://vdot.iteris-pems.com/>

<sup>16</sup> The SPS database is a desktop application available to VDOT staff.

<sup>17</sup> <http://www.virginiadot.org/projects/stars.asp>

<sup>18</sup> <https://vdotp4p.com/>

<sup>19</sup> D-LITE is a module within VDOT P4P: <https://vdotp4p.com/>

<sup>20</sup> <https://www.census.gov/data.html>

<sup>21</sup> <https://onthemap.ces.census.gov/>

## 4.1 Traffic Volume Data

Depending on the availability of traffic counts within the project area, additional calculations may be needed to determine daily and/or peak-hour traffic volumes. Traffic counts collected from permanent count stations are commonly reported as average annual daily traffic (AADT) since an annual average can be calculated from the continuous data. For locations where continuous traffic counts are not available, counts during a shorter period (e.g., one week or one month) are typically used. The AADT may be estimated by multiplying the average observed daily count, also referred to as the average daily traffic (ADT), by the known or estimated seasonal adjustment factors.

VDOT annually publishes AADTs and other associated factors (e.g., K-factor) for segments where permanent count stations exist. K-factor is the proportion of AADT occurring during the 30<sup>th</sup> highest hour of the year and may be used to calculate the design hourly volume (DHV) that is the single hour of the day with the highest traffic volume. The DHV is used for design projects and capacity analyses and can be calculated using AADT and the design hour factor (k) as follows:

$$DHV = AADT * k$$

### 4.1.1 Field-Collected Data

The following field data collection methods are applicable for obtaining the existing conditions' count data that can be used as a baseline for traffic forecasts.

- **Roadway segments traffic counts:** These may be collected using a variety of methods, including video and radar, to determine the ADT and DHV of roadway segments within the project area. AADTs are required to accompany all rezoning applications and site plan submittals. This data is often readily available on the VDOT traffic monitoring program website but also can be collected using field devices.
- **Classification counts:** These are a subset of roadway segment traffic counts and typically collected when there is a desire to identify the number of heavy vehicles within the project area. Classification counts are typically collected by automated devices, such as tube counters or electronic (non-intrusive) devices, which can record speed and interpret the standard 13-vehicle Federal Highway Administration (FHWA) classification system. These counts are typically performed on arterials (away from the influence of intersections or other impedances), freeway mainline segments, and ramp segments. Field personnel are only needed during the set-up, take-down, and data processing steps. Data is typically reported in five- or fifteen-minute increments.

It is recommended that classification counts be obtained from VDOT's permanent count stations when a station exists near the project area. When a count station is unavailable, most studies collect a 48-hour or 72-hour data collection process to meet project needs; however, classification counts over a longer period is preferred for the data collection process if understanding day-to-day variability, such as weekday-versus-weekend traffic, is desired.

- **Intersection turning movement counts (TMCs):** TMCs may be collected using a variety of methods, including video, radar, and traffic count boards. Most studies require 3-hour AM and PM counts (for a total of six hours) to be collected with volumes reported in 15-minute increments; however, TIAs and signal warrant studies may require a 12-hour (or longer) period to be conducted. If typical values are desired, counts should be collected on a Tuesday, Wednesday, or Thursday during the school year and not on a holiday (or a day adjacent to a holiday) and under normal weather conditions. In some cases, however, atypical values may be desired. Such exceptions may include an amusement park (collect counts on weekends), a ski resort (collect counts during a holiday period), or a shopping mall (collect counts on a weekend in December).

Heavy vehicle and pedestrian counts also may need to be included in intersection counts. Coordination with VDOT should occur during the project scoping phase to gain consensus on data collection needs, including collection dates or seasonal adjustments. Discussions should occur with the VDOT project manager to obtain information regarding special events or special land use generators that may affect traffic patterns in and around the study area.

- **Origin-destination (O-D) data:** O-D data is occasionally used to supplement traffic volume data for estimating proportions of trips entering and exiting a network on various roadways. O-D data can be obtained using license-plate recognition (LPR), Bluetooth/WiFi readers, and/or manual surveys. Probe data platforms have emerged as other sources of O-D data with a much greater sample size. These sources are identified in **Section 4.3.1**.

### *Review of Field Data*

All collected field data should be reviewed and compared to observed field conditions prior to use. The following questions are examples of the topics that should be discussed when reviewing the data.

- Is all intersection turning movements at an intersection accounted for?
- Do the major traffic movements make sense?
- Are there allowable movements at an intersection with no traffic volume recorded in the TMC?
- Is the orientation of the raw TMC data (north/south/east/west) consistent with how the data is being used in the traffic forecasts?
- If overall traffic and/or classification counts are collected upstream of a TMC, do the counts generally balance?
- Do truck percentages along a freeway mainline and ramps generally balance?
- If counts are collected manually, are there sudden surges in 15-minute period volumes suggesting inattentiveness?
- Are there indications of data corruption or count equipment failure such as very high or very low counts relative to prior or next period that cannot be explained?
- Depending on the location of the study and time of year the data is collected, do seasonal factors need to be applied to the traffic volumes prior to starting the forecasts?

Additional care should be taken when collecting field data in areas of known congestion, queuing, and/or frequent crashes. VDOT does not recommend using tube counts on congested ramps or mainline segments that are known to have congestion since stopped vehicles will likely underreport the count. Raw data collected via tube should be quality checked for low and missing values, especially during known periods of congestion. A discussion of the completed field data review should be included in the forecast documentation or documented in the traffic analysis report.

#### 4.1.2 VDOT-Maintained Traffic Data Sources

The data sources included in this section should be considered to supplement field-collected data, all of which is either publicly available or can be obtained via request from VDOT. All data should be reviewed to determine overlaps with field data as follows:

- Are VDOT annual average daily estimates reasonably comparable to field counts at overlapping locations? If not, is there an explanation for the discrepancy (e.g., quality rating for the count book data, difference in locations, etc.)?
- Are traffic growth projections derived from the SPS generally in line with trends indicated in other data sources (e.g., historical counts, socioeconomic, and land use data)? If not, is there an explanation for the discrepancy?
- A discussion of the completed data review should be included in the forecast documentation or documented as part of the traffic analysis report.

#### VDOT Traffic Monitoring Program

VDOT publishes estimates for annual average daily traffic (AADT) and daily vehicle miles traveled (DVMT) based on data collected through continuous and short-duration traffic count collection systems across VDOT-maintained roadways.

- **VDOT Traffic Monitoring System:** AADTs published by VDOT are estimated based on raw traffic data accessible through VDOT’s Traffic Monitoring System (TMS), an internal source maintained by the Central Office Traffic Engineering Division (TED). Raw traffic volumes, class, and speed data can be requested from VDOT for a specific roadway segment, time duration and an interval level.

Figure 6: VDOT Traffic Monitoring System (TMS)

**VDOT Annual Traffic Summary Publications:** The VDOT Traffic Data website provides access to two categories of traffic volume summary reports: Annual Average Daily Traffic (AADT) and Daily Vehicle Miles Traveled (DVMT). Over 300 jurisdiction AADT publications and 16 DVMT, which include interstate and primary highway segments, secondary roads, and urban roads, are available on the website as individual PDFs and Excel spreadsheet files. In addition, there is one statewide AADT publication, which includes interstate and primary highway segments.

The AADT publications include annual AADT estimates, truck percentages, and estimates for k-factors and directional distribution factors (D-factors), where applicable. In addition, quality ratings of each AADT count are provided, ranging from an average of complete continuous count data to estimates based on similar links or factored short-term counts. If data is obtained from the VDOT Traffic Data website, the quality of AADT should be consulted to ensure only counted volumes are used for the trend analysis; estimated traffic volumes should be used with discretion.

The DVMT publications include daily vehicle miles traveled estimates summarized by federal functional class, physical or maintenance jurisdiction, federal vehicle class, etc.

The published traffic summary reports provide annual average estimates. It is recommended raw data be requested from VDOT for analysis when needed. Raw traffic count data collected at permanent count stations and through 48-hour short-duration count locations can be requested from VDOT in 15-minute intervals. The locations of the permanent traffic count stations can be found on the VDOT traffic data website.<sup>13</sup>

**Figure 7** shows an example report of the VDOT AADT volume estimates. The “QA” column defines the quality of AADT. It should be noted that both AADTs and annual average weekday daily traffic (AAWDT) for weekends are reported, although almost all travel demand models are weekday-only models.

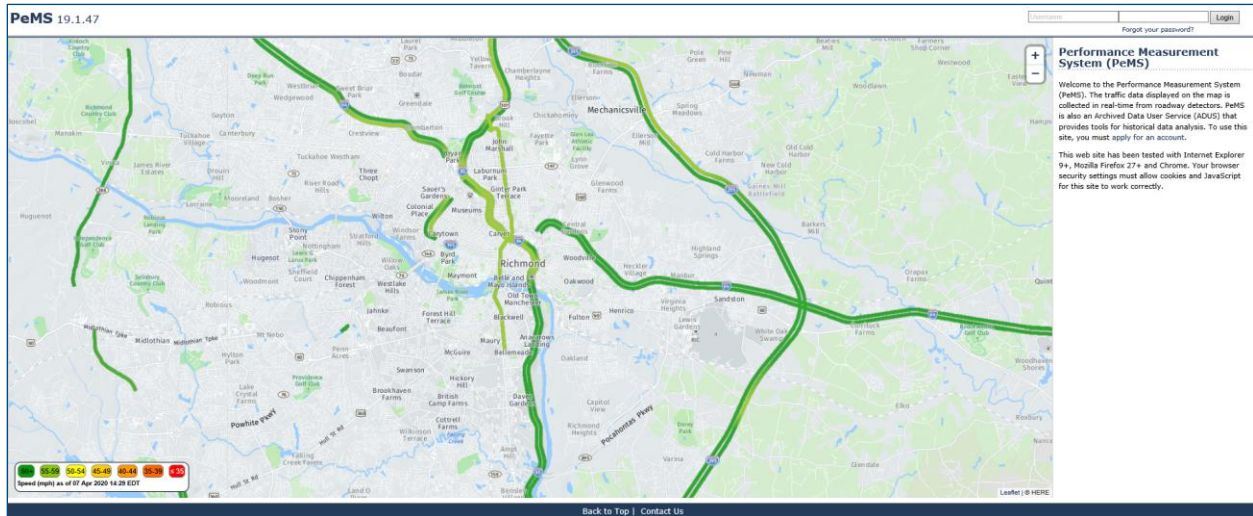
**Figure 7: VDOT AADT Volume Publication**

Virginia Department of Transportation Traffic Engineering Division 2017 Annual Average Daily Traffic Volume Estimates By Section of Route City of Richmond																
Route	Jurisdiction	Length	AADT	QA	4Tire	Bus	Truck				OC	K Factor	OK	Dir Factor	AAWDT	QW
							2Axle	3+Axle	1Trail	2Trail						
1 301 Jefferson Davis Hwy	City of Richmond	2.13	14000	G	96%	1%	1%	1%	2%	0%	F	0.080	0.568	15000	G	
1 301 Jefferson Davis Hwy	City of Richmond	0.86	13000	A	96%	1%	1%	1%	2%	0%	C	0.103	0.729	14000	A	
1 301 Jefferson Davis Hwy	City of Richmond	1.01	18000	G	96%	1%	1%	1%	2%	0%	F	0.087	0.516	19000	G	
1 301 Cowardin Ave	City of Richmond	0.39	21000	G	96%	1%	1%	1%	2%	0%	F	0.088	0.565	23000	G	
1 301 Lee Bridge	City of Richmond	0.76	30000	G	97%	1%	1%	0%	0%	0%	F	0.097	0.561	34000	G	
1 301 Belvidere St	City of Richmond	0.92	25000	G	97%	1%	1%	0%	0%	0%	F	0.093	0.547	28000	G	
1 301 Belvidere St	City of Richmond	0.15	38000	G	97%	1%	1%	0%	0%	0%	F	0.083	0.551	43000	G	
1 301 Belvidere St	City of Richmond	0.40	35000	G	97%	1%	1%	0%	0%	0%	F	0.084	0.586	39000	G	

### iPeMS

VDOT's Performance Measurement System provided by Iteris (iPeMS) is an online traffic data and traffic performance measure system that includes real-time and historical data collected from a variety of data sources, including probe data, traffic detectors, and traffic event and incident platforms. Raw data collected from traffic detectors maintained by the VDOT Traffic Management System (TMS) and traffic operations centers (TOCs) may be downloaded. In addition, various performance measures (e.g., VMT, VHT, and delay) are available for arterials and freeways. Access to iPeMS may be granted by VDOT based on project needs.

Figure 8: VDOT PeMS

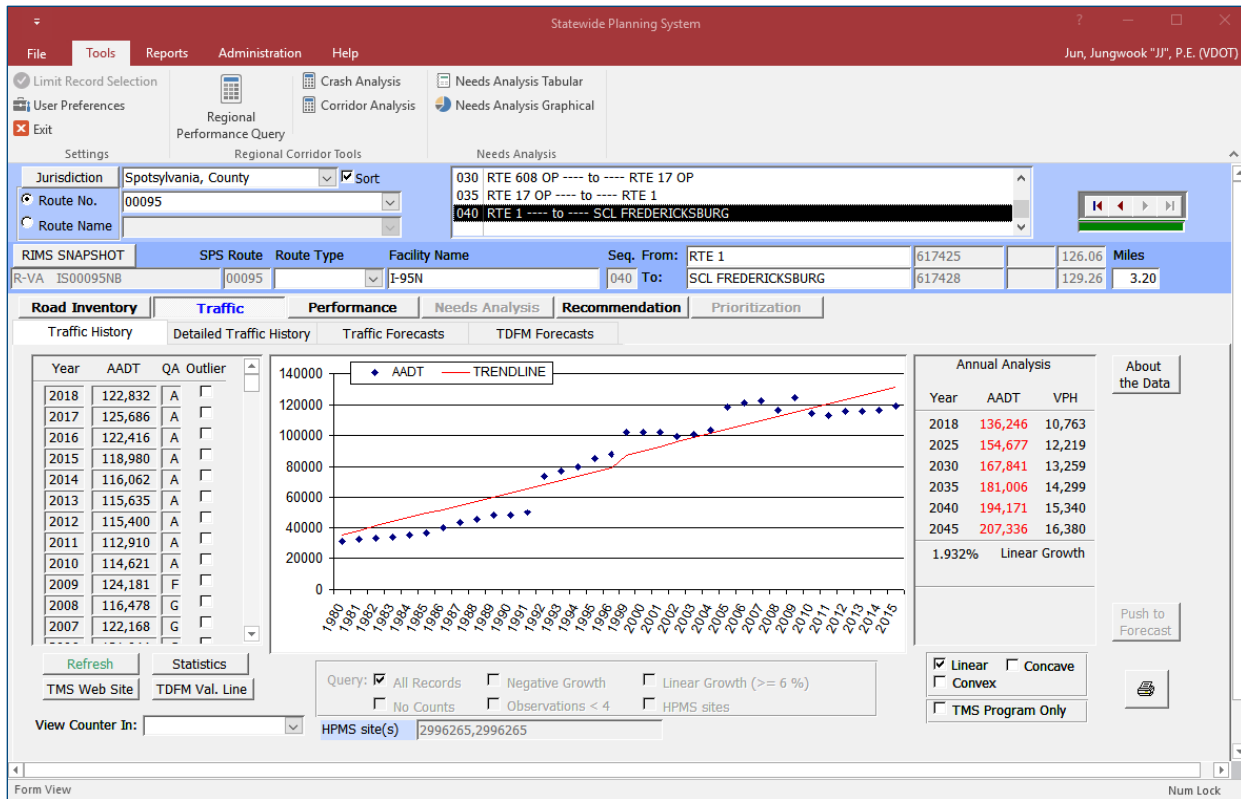


### VDOT Statewide Planning System (SPS)

The VDOT Statewide Planning System (SPS) is a VDOT internal database that contains an inventory of all roadways functionally classified as minor collector and above in the Commonwealth of Virginia. This inventory includes, but is not limited to, pavement widths, number of lanes, traffic volumes from the 1970s, traffic projections in five-year intervals derived from the VDOT Statewide Travel Demand Model, geometric characteristics, area type, and terrain type. The database analyzes the data, evaluates system deficiencies, provides highway improvement recommendations, and provides planning-level costs for proposed recommendations. Traffic volume history for a given segment is accompanied by a trendline graph. Forecasted traffic volumes are displayed on the SPS portal, derived from the linear regression growth rate. **Figure 9** shows the interface of SPS. SPS data may be requested from the VDOT project manager.

SPS can be used to develop traffic growth rates for study locations where a regional travel demand model is not available and to verify traffic growth projections from other data sources (e.g., Metropolitan Planning Organization [MPO] travel demand models, historical counts, socioeconomic, and land use data). Users should exercise caution when collecting data from SPS since the roadway inventory is not actively maintained and Statewide Travel Demand Model outputs are not intended for direct use of facility forecasts.

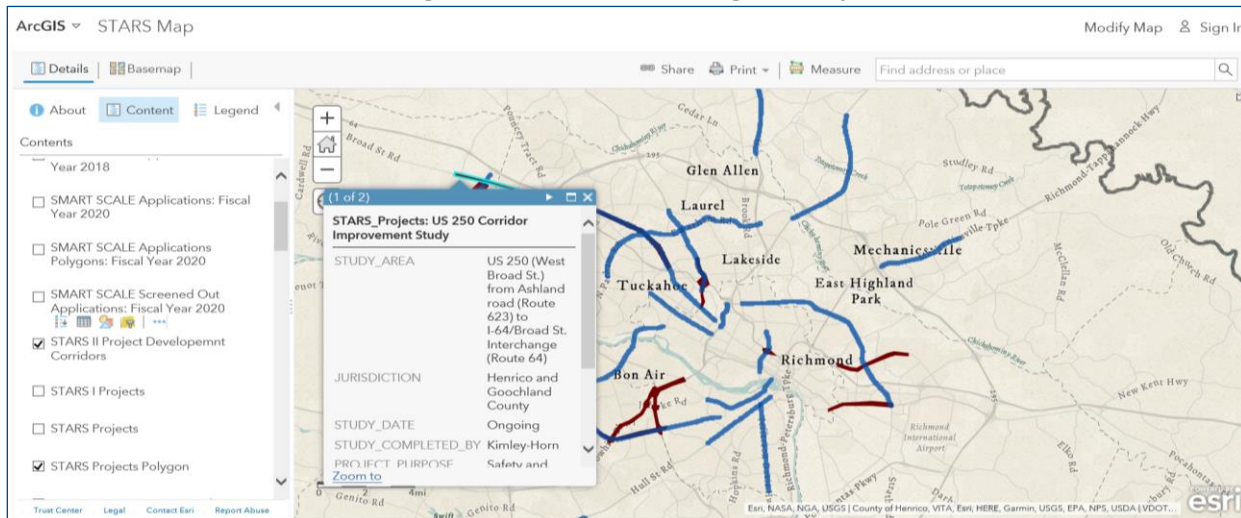
Figure 9: VDOT SPS



**STARS Program Map**

The STARS Program map (shown in Figure 10) contains safety and congestion information for roadways throughout Virginia, including the latest five years of crash data, potential for safety improvement (PSI) for intersections and segments, and volume to capacity (V/C) ratio are available for the current year. The V/C ratio also is available for future year analysis. The map includes an inventory of current and previous STARS projects and SMART SCALE applications and funded projects, too.

Figure 10: VDOT STARS Program Map

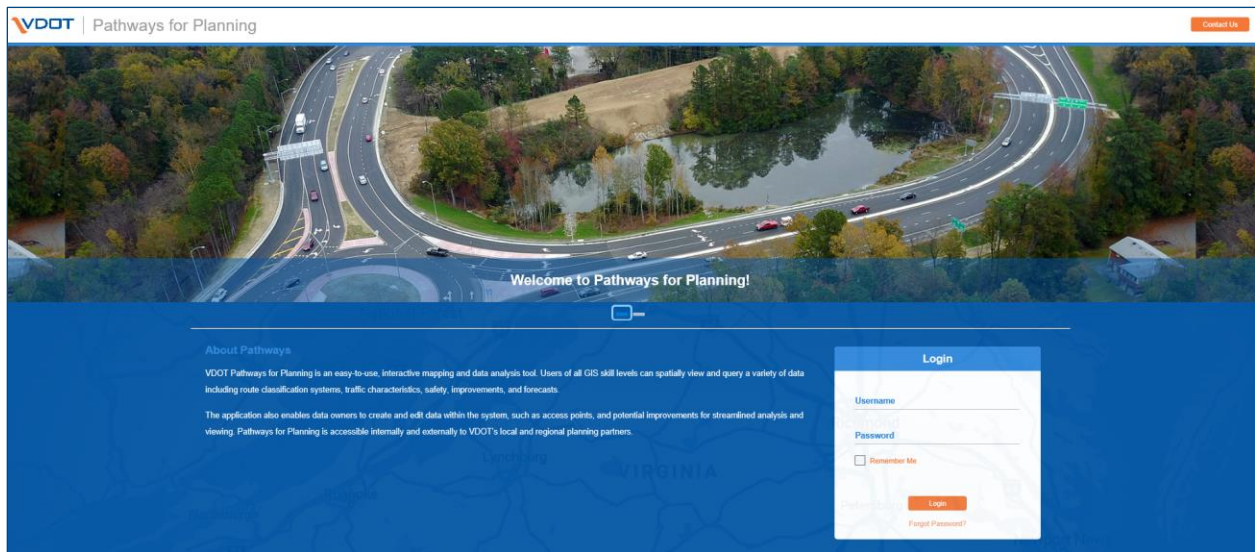




### Pathways for Planning (P4P)

Pathways for Planning (P4P) is a permissions-based, interactive mapping and data analysis tool, accessible internally and externally to VDOT's local and regional planning partners. The tool provides static data (e.g., traffic counts, future forecasts, growth rates, crash records, v/c ratio) and user-editable data (e.g., study locations, recommendations, access point inventory, bicycle pedestrian facilities). Users of all GIS skill levels can spatially view, query, edit, and export data. The tool eliminates the need for end user specialized GIS skills to apply the linear referencing system (LRS) for visualizing and analyzing planning data. P4P supports LRS and non-LRS data to allow users to reference features and streamline analysis and viewing.

Figure 11: VDOT P4P



### D-LITE

D-LITE (Design Level Intersection Traffic Estimation) is an integrated micro-level traffic forecasting tool designed to balance and forecast turning movements for a roadway having up to 10 crossings or intersections. This spreadsheet includes the following output modules: PIE (Preliminary Intersection Estimate), SILLQ (Signalized Intersection Left Lane Queuing), i-ENTRADA (Intersection Environmental Traffic Data), NCHRP 255 (National Cooperative Highway Research Program Report 255), Fratar, and P&A Gravity Model (productions and attractions using gravity model). The user can select the desired output module for future analysis in the following types of VDOT studies:

- LD-104 (Location and Design: For scoping and Design)
- LD-104B (Environmental Division: Noise Study)
- Design-Build (where a forecast of volumes is needed)
- Interchange modification or justification
- Bridge widening or replacement
- Material engineering, such as pavement design
- Traffic engineering, such as signal operations

## 4.2 Travel Demand Models

Travel demand models are technical tools used to forecast future regional travel behavior and growth, by mode of transportation, based on input data that consists of land use, demographics, and transportation network supply data (e.g., roadway and transit). These macroscopic models are fundamental to long-range transportation planning, as they are typically used to evaluate the impact of regionally significant projects such as major developments, new roadway connections, and modified or new interchanges.

Trip behavior is complex and is influenced by several factors such as land use, employment, household characteristics, activity centers, and transportation network characteristics. Travel demand models quantify the amount and purpose of travel in an aggregated way for each traffic analysis zone (TAZ) based on the relationship of TAZs (e.g., production and attraction of trips) and assign trips to the transportation network based on mode and route choices. Some models loop the procedures of trip assignment and trip distribution until volumes reach equilibrium, considering the effect of roadway congestion on traffic behavior.

Most travel demand models follow the conventional four-step transportation forecasting process shown in **Figure 12**; however, models also can be in other forms such as tour based, activity based, or a hybrid of the two. These models have more sophisticated methodologies to estimate trip making based on tours or activities of more disaggregated demographics. All the travel demand models that are currently adopted and used in the Commonwealth are four-step models.

**Figure 12: Conventional Four-Step Model Process**



Travel demand models can be referenced or actively used for projects. Model outputs, for example, may be used as a data source for trend analyses. On the other hand, models may be applied, modified, and/or calibrated and validated for a project as detailed in **Chapter 6**. Regardless of the selected methodology, travel demand models should be used as a data source when available.

### 4.2.1 Travel Demand Models in Virginia

When a travel demand model is needed for a study, the first step is to determine whether the project is located within or adjacent to an MPO coverage area. Often, an MPO will extend its modeling area outside its jurisdictional area to cover projects that might influence the MPO.

**Table 6** summarizes the available travel demand models in Virginia. At the time this guidebook was published, there are 18 travel demand models in Virginia spanning across 13 MPOs. **Figure 13** shows coverage areas of the 14 travel demand models supported by VDOT and the Kingsport Model and Bristol Model maintained by the Tennessee Department of Transportation (Tennessee DOT).

In addition to models adopted and maintained by the MPOs, several counties maintain their own travel demand models. In Northern Virginia, Fairfax County, Loudoun County, and Prince William County, each maintain their own travel demand model. Moreover, the Northern Virginia Transportation Authority

(NVTA) developed a regional travel demand model for the TransAction Plan.<sup>22</sup> This model was used to prioritize projects during the development of the plan. For more guidance regarding travel demand modeling, refer to the *VDOT Travel Demand Modeling Policies and Procedures Manual*.

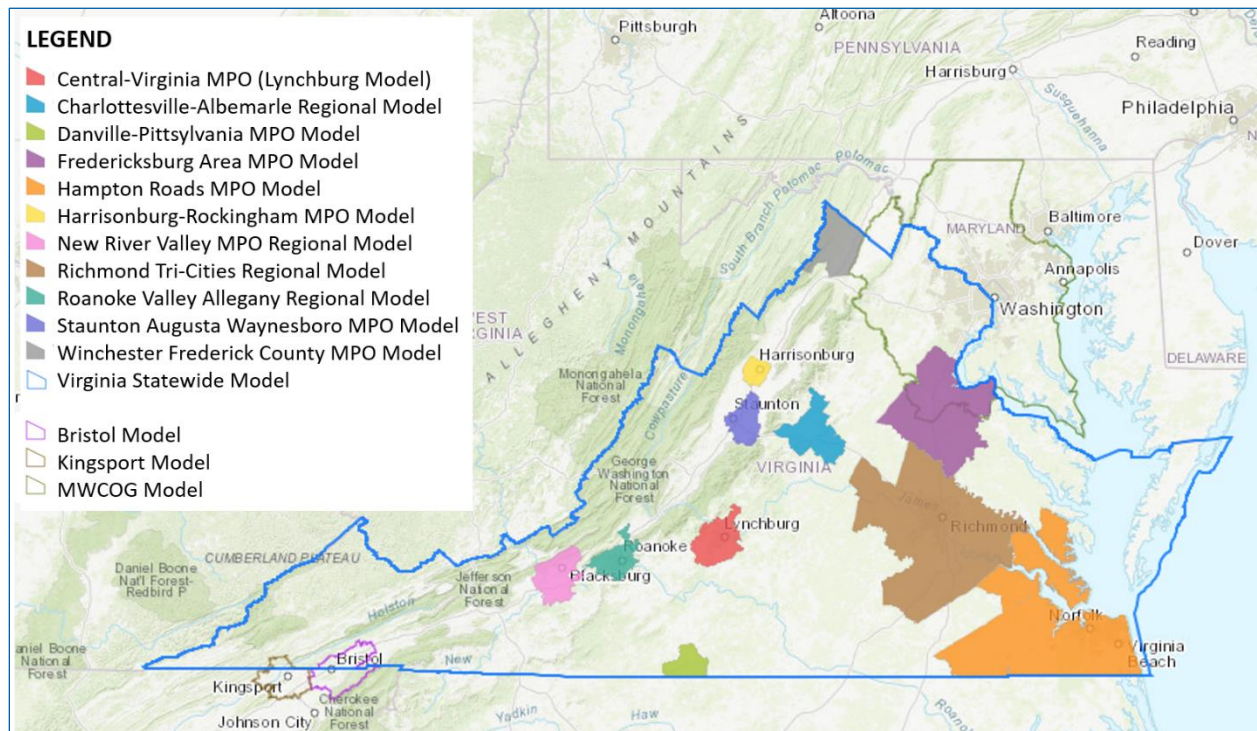
**Table 6: Travel Demand Models in Virginia**

Model	Software	Software Regional Characteristics	Supported By
Bristol Model*	TransCAD	Bristol MPO	Tennessee DOT
Central Virginia Area MPO (CVAMPO) Model	TransCAD	Central Virginia MPO	VDOT
Charlottesville-Albemarle Regional Model	TransCAD	Charlottesville MPO	VDOT
Danville-Pittsylvania MPO Regional Model	TransCAD	Danville MPO	VDOT
Fairfax County Model	CUBE	Fairfax County	Fairfax County
Fredericksburg-Area MPO Model	CUBE	Fredericksburg	VDOT
Hampton Roads Regional TPO Model	CUBE	Hampton Roads TPO	VDOT
Harrisonburg-Rockingham MPO Regional Model	CUBE	Harrisonburg MPO	VDOT
Kingsport Area Model*	TransCAD	Kingsport MPO	Tennessee DOT
Loudoun County Model	CUBE	Loudoun County	Loudoun County
Metropolitan Washington Council of Governments (MWCOG) Model (Northern Virginia)	CUBE	Washington D.C. Metropolitan Area	MWCOG
New River Valley MPO Regional Model	TransCAD	New River Valley MPO	VDOT
Prince William County Model	CUBE	Prince William County	Prince William County
Richmond/Tri-Cities Regional Model	CUBE	Richmond Regional TPO	VDOT
Roanoke Valley Alleghany Regional Model	CUBE	Roanoke Valley Area MPO and Roanoke Valley-Alleghany Regional Commission	VDOT
Staunton August Waynesboro MPO Model	TransCAD	Staunton-Augusta-Waynesboro MPO	VDOT
Virginia Statewide Model	CUBE	Virginia Statewide	VDOT
Winchester-Frederick County Regional MPO Model	CUBE	Winchester-Frederick County MPO	VDOT

\*Both Bristol and Kingsport MPO are based in Tennessee and include portions of Virginia that influence travel patterns in their regions.

<sup>22</sup> TransAction Plan is Northern Virginia’s long-rang multimodal transportation plan. It was adopted in October 2017 by the NVTA.

Figure 13: MPO Travel Demand Model Coverage Areas Within Virginia



#### 4.2.2 Travel Demand Model Applicability

As discussed in **Chapter 3**, the first question to examine when considering which travel demand model method to apply is whether a travel demand model can help address the goals of the project. The following assumptions and questions should be examined before applying a travel demand model.

- Is the travel demand model adequate for addressing goals presented by the project? Applying a travel demand model in its original form without modification may not be appropriate if the model is not adequate for the project needs. **Chapter 6** contains more details on how to determine when it is appropriate to modify a travel demand model.
- Raw model outputs should not be used as traffic forecast volumes. Depending on the project type and scope, rather than balancing each approach according to the process outlined in the *National Cooperative Highway Research Program Report 765* (see **Section 7.1**), a simplified traffic growth rate can be developed from model outputs using a trend analysis.
- What is the expected cost of preparing, modifying, or using a travel demand model compared to the estimated cost of using other methods? The project team should assess the cost from a budget and schedule standpoint. The availability of technical resources to modify the model and conduct quality control reviews may also affect the project schedule.

If multiple travel demand models are available for a given project and if the project location is within the coverage area of an MPO and locality model, the MPO model should be used to develop traffic forecasts. The application of an alternative travel demand model (e.g., locality model such as Fairfax County Model or project focused subarea model, which is introduced in **Chapter 6**) should be discussed with and agreed upon by VDOT and project stakeholders during the project scoping stage and be thoroughly documented in the subsequent forecasting document. The justification should include the

advantage of applying the alternative travel demand model and how it would benefit the traffic forecast. If the project location is not within the coverage area of an MPO travel demand model, the VDOT Statewide Travel Demand Model may be used upon consultation with VDOT. The model request form is available on VDOT's transportation modeling program website.<sup>23</sup>

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### 4.3 Planning Data

Planning data, such as economic and demographic data, can be used to identify current travel patterns and trends and forecast traffic. In some cases, definitions of data elements vary by source, so care must be taken when collecting, comparing, and combining data. For example, the total jobs in the U.S. during 2016 obtained from the Bureau of Economic Analysis (almost 150 million) is about 6 percent higher than jobs obtained from the Bureau of Labor Statistics (almost 142 million) since the latter does not include/fully include certain types of employment such as religious organizations, rail transportation, some nonprofits with fewer than four employees, and military employees.<sup>24</sup> More information about the data products below can be found on the VDOT Research Library website.

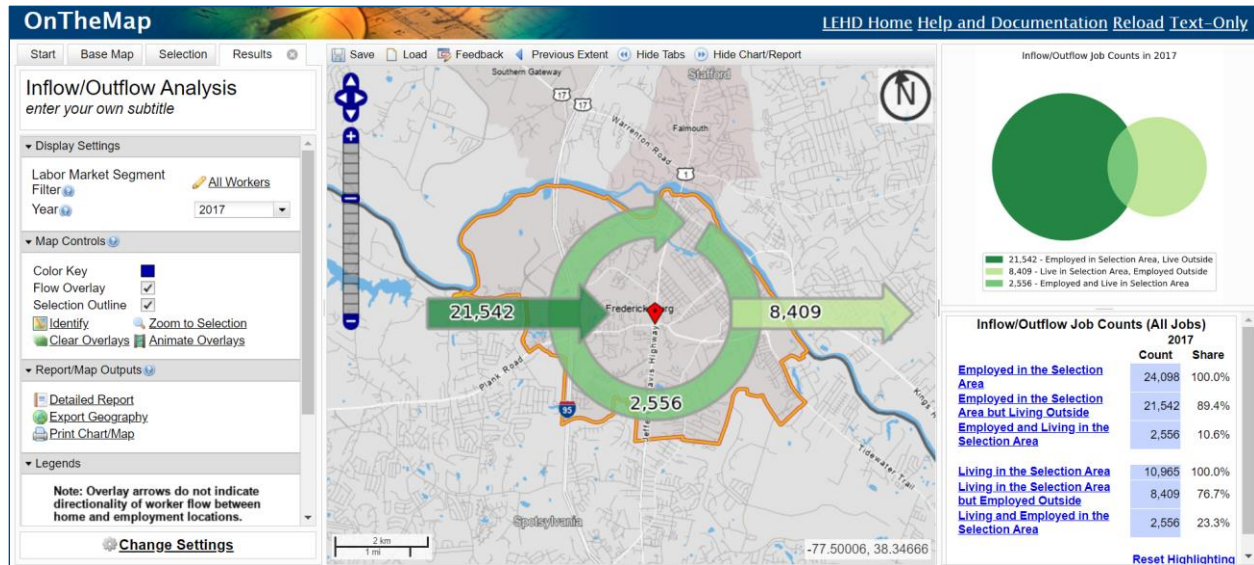
- **OnTheMap:** Web-based mapping and reporting application, shown in **Figure 14**, that displays where workers are employed and where they live.
- **2010 US Census:** Demographic, trip making, and social characteristics
- **Weldon Cooper State Demographics:** Population estimates and projections
- **American Community Survey:** Ongoing survey of more than 3.5 million addresses across the U.S. covering demographics, economics, housing, and social variables
- **Bureau of Labor Statistics Data:** A variety of data including employment, pay, benefits, productivity, workplace injuries, and regional resources
- **Bureau of Transportation Statistics Data:** A database of surveys, reports, and other statistical products related to national, multimodal transportation data
- **Bureau of Economic Analysis Data:** Gross Domestic Product (GDP) and personal income, fixed assets, international transactions, and more

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<sup>23</sup> <http://www.vdot.virginia.gov/projects/vtm/vtm.asp>

<sup>24</sup> Bureau of Economic Analysis. Local Area Personal Income and Employment Methodology, Washington, D.C., 2017. <https://apps.bea.gov/regional/pdf/lapi2016.pdf>

Figure 14: OnTheMap



### 4.3.1 Emerging Data Sources

Recent technological advances have provided engineers and planners the ability to rapidly retrieve and analyze large quantities of data, including information from large samples of mobile devices. A variety of big data products are now available and geared toward the transportation industry that can be used to support different steps of the conventional traffic forecasting process. Note that all of these sources should be considered “emerging,” and data from these sources should be validated against real-world data whenever possible.

#### Probe Data

Probe data, such as location-based service (LBS) data from mobile devices and GPS-navigation data, includes a large sample size at an economic scale. There are several vendors that currently provide O-D information from LBS and/or GPS-based data sources. These vendors provide tools that allow for customizable analyses where users can define zones representing O-D pairs in large geographic areas (e.g., TAZs and zip codes) or granular geographies (e.g., roadway links). Some providers offer information such as trip purpose and demographic information such as income, race, and education. The O-D information derived from the probe data sources can be used to develop trip distributions or anticipated travel patterns during traffic forecasting. Recently, additional applications have emerged including estimates of traffic flow data, such as estimates for AADT and VMT. These estimates have not been validated in Virginia as of 2019, although a few select other states have recently gone through a validation process. These tools can be used to supplement or validate travel demand model data.

## 5 TRAFFIC FORECASTING FUNDAMENTAL TECHNIQUES

### SECTION HIGHLIGHTS

#### **Section 5.1: Forecasting Link-Level Volumes Using a Trend Analysis**

Introduction to trend analyses, including methods using historical data and travel demand model outputs. Linear and exponential traffic growth trends are discussed.

#### **Section 5.2: Forecasting Intersection Turning Movements**

Overview of the techniques to forecast peak-hour traffic volumes.

#### **Section 5.3: Developing Site-Specific Trip Generation (ITE and non-ITE Methods)**

Overview of site-specific trip generation process using the Institute of Transportation (ITE) Trip Generation Method and the Virginia Department of Transportation (VDOT)-approved alternate method.

The traffic forecasting process outlined in **Chapter 2** should be used to select a forecasting method or combination of methods. It is recommended that multiple data sources (e.g., historical counts and land use data) be used or multiple techniques (e.g., applying travel demand model and trend analysis) be applied to solidify the traffic forecasts. Developing a traffic forecast using one technique or data source is typically not the preferred approach, unless it is determined that the resulting traffic forecasts from multiple data sources are similar. This chapter outlines fundamental forecasting techniques. Techniques related to applying a travel demand model are discussed in **Chapter 6**.

The desired outputs of traffic forecasting are largely dependent on the project type. For example, although daily traffic volume forecasts may be sufficient for regional transportation plans, capital projects usually require peak-hour roadway link or intersection turning movement volume forecasts to satisfy design year requirements. The techniques introduced in this chapter focus on both daily and peak hour traffic forecasts.

### 5.1 Forecasting Link-Level Volumes Using a Trend Analysis

A trend analysis (or trend forecast) is the process of developing traffic growth rates based on available traffic data, such as historical traffic counts or travel demand model outputs. Regardless of whether travel demand model outputs are used, computing a trend line using historical data is a fundamental step in the traffic forecasting process. Common considerations when performing a trend analysis include horizon year, traffic volume data, and growth method (linear versus exponential). The decision for selecting and using each forecast parameter should be discussed with stakeholders and clearly documented. It will likely be necessary to provide supporting data to justify the selected forecast year and growth rate.

### 5.1.1 Types of Traffic Growth Trends

There are several growth trends that can be applied when conducting a trend analysis:

- Exponential traffic growth** assumes traffic growth based on a percentage from the previous year. Exponential growth is indicative of a region with new growth, abundant undeveloped land, and available road capacity.

$$\text{Future Volume} = \text{Base Year Volume} (1 + \text{Traffic Growth Rate})^{\text{Number of Years}}$$

- Linear traffic growth** assumes a constant traffic growth each year without constraints due to available road capacity.

$$\text{Future Volume} = \text{Base Year Volume} (1 + \text{Traffic Growth Rate} * \text{Number of Years})$$

For interstate freeway facilities, VDOT has done extensive analysis comparing linear and non-linear traffic growth rates and has determined that linear growth best reflects the traffic growth patterns on the interstates in Virginia. For non-interstate facilities, non-linear traffic growth rates may be acceptable but should be reviewed with the project manager and checked against linear traffic growth rate forecasts.

- Declining traffic growth** assumes traffic growth tapers off due to land use approaching built-out conditions or traffic demand approaching or exceeding roadway capacity. A declining traffic growth trend can be replicated using logit or other fitting equation as a function of roadway capacity. A declining traffic growth trend should be considered to replace linear or exponential traffic growth when roadway capacity and land use constraints are observed to affect traffic demand and travel behavior.

$$\text{Future Volume} = \text{Base Year Volume} \sum_{\text{BY}}^{\text{FY}} \frac{X}{\text{FY} - \text{BY}} \sum_{\text{BY}}^{\text{FY}} \frac{X}{\text{FY} - \text{BY}}$$

Where X = Normal linear growth from trend data

The decision to use linear or exponential traffic growth methods also depends on the horizon year(s). **Chapter 3** describes the typical forecast horizon years by project type. Exponential traffic growth is typically used with horizon years of 10 years or less since an exponential curve tends to overestimate future traffic for longer horizon years. Since the potential to over-forecast traffic volumes increases with higher growth rates, shorter horizon years should be considered for projected annual growth rates greater than 3 percent. Prior to traffic forecasting, traffic growth rates should be checked for reasonableness against previously prepared traffic growth rates for the area and other data sources, such as socioeconomic data, if available.

In the case that the calculated traffic growth rate is unreasonably higher or lower than traffic growth rates from other sources, a base traffic growth rate should be established using engineering judgment and checked against one or more data sources. The expected population or economic growth of the area and the overall average traffic growth rate for all roadways in the area should be considered. When a trend analysis produces minimal or negative traffic growth rates, a minimum traffic growth rate of 0.2 percent annually should be applied. Traffic growth rate calculations should be documented to describe the selected trend.



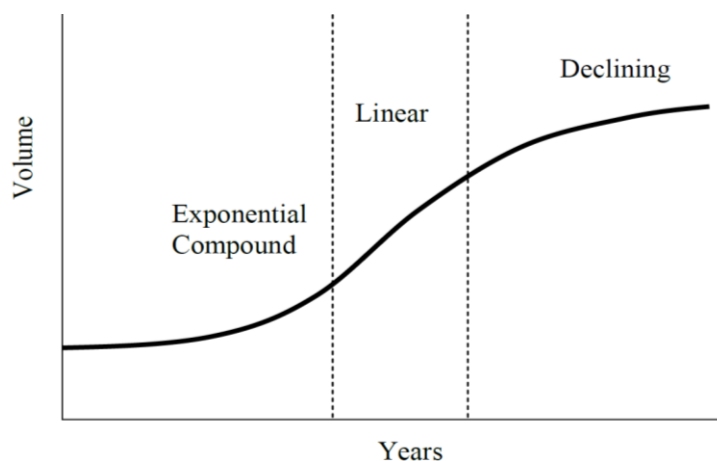
A project area is likely to experience varying traffic growth trends over time. **Figure 15** shows an example of varying growth in Fredericksburg, Virginia since 2003. The region grew exponentially from 2003–2006, slowed, and then remained consistent between 2006–2013. As the area nears its maximum development potential, it is experiencing declining growth. The growth trend over time is depicted in **Figure 16**.

**Figure 15: Example of Variable Growth in Fredericksburg, Virginia**



**Figure 16: Traffic Volume Growth Types**

Source: Oregon Department of Transportation (DOT) Analysis Procedures Manual, Version 2, Chapter 6



### 5.1.2 Traffic Forecasting with Historical Traffic Counts

A trend analysis using historical traffic counts should be performed when traffic is anticipated to follow past trends. Due to economic variances, it is recommended that forecasters obtain as much historical count data as possible from VDOT-maintained traffic count data in **Chapter 4**. A minimum of 10 years of data should be used as the benchmark for developing growth rates to diminish yearly traffic volume variations. Historical traffic counts during periods of recession (e.g., December 2007 to June 2009) should be assessed to validate irregular growth trends. If irregularities in traffic volumes and patterns exist, additional years of data should be evaluated. Also, more years should be evaluated to overcome irregularities in traffic volumes and patterns during these periods. The same applies to the period during which fast economic growth occurred. A trend analysis using historical traffic counts should include abundant data points (e.g., long period of time) to account for changes in socioeconomic data.

A historical trend analysis can be calculated and applied using the following steps.

**Step 1. Obtain historical traffic count data.** Annual historical traffic data is available on the VDOT Traffic Data website and Statewide Planning System (SPS). Data in previous years, in 5-year increments, also can be requested from VDOT.

**Step 2. Perform a trend analysis to obtain a traffic growth rate.** For projections over a few years or projections with low traffic growth rates, the difference in forecasts between the linear and exponential methods is often minimal; however, large differences can occur when using the exponential method with large growth rates. For this reason, a linear regression using multiple years of data is the preferred methodology. Different traffic growth patterns should still be considered if the data indicates a different past trend.

**Step 3. Apply the traffic growth rate to existing link volumes to forecast future link traffic volumes.**

Apply the calculated traffic growth rate to existing peak-hour link traffic volumes with consideration for capping forecast volumes at available road capacity and assigning the excessive demand volumes to shoulder period. If a future development(s) is planned in the area, estimated project trips should be computed using a site-specific trip generation methodology and added to the daily or peak-hour link volumes.

**Step 4. Convert daily link traffic volumes to peak-hour link traffic volumes (if necessary).** Calculate peak-hour link volumes and intersection turning movement traffic volumes (if necessary) using the techniques described in **Section 5.2**.

### Least Squares Regression Analysis Methodology

A Least Squares Regression Analysis is a methodology to develop a “best-fit” equation for a known dataset. The process produces a straight line that has the smallest sum of squared errors than any other straight-line model. The methodology is as follows:

- 1) Compute values of *sum of squares for error (SSE)*

$$SS_{xy} = \sum_{i=1}^n x_i y_i - \frac{(\sum_{i=1}^n x_i)(\sum_{i=1}^n y_i)}{n}$$

$$SS_{xx} = \sum_{i=1}^n (x_i^2) - \frac{(\sum_{i=1}^n x_i)^2}{n}$$

- 2) Compute slope of line

$$\hat{\beta}_1 = \frac{SS_{xy}}{SS_{xx}}$$

- 3) Compute y-intercept

$$\hat{\beta}_0 = \bar{y} - \hat{\beta}_1 \bar{x} = \frac{\sum_{i=1}^n y_i}{n} - \hat{\beta}_1 \frac{(\sum_{i=1}^n x_i)}{n}$$

- 4) Develop Least Squares Prediction Equation

$$\hat{y} = \hat{\beta}_0 + \hat{\beta}_1 x$$

In the case of traffic forecasts,  $x$  represents the year and  $y$  represents the traffic count (or forecast) for the corresponding year.

Microsoft Excel contains built-in functionality to develop an equation based on the Least Squares methodology. To analyze a dataset, enter data into two columns—year of known data ( $x$ ) and the corresponding traffic count ( $y$ ). The Microsoft Excel Regression Macro, located within the Data Analysis tool add-in, will compute the regression equation, which includes the estimated growth rate represented as the slope of the line.

**Example: Forecasting Mainline Volumes Using Historical Counts**

VDOT and Spotsylvania County identified the need to create a cost-effective set of improvements for the I-95 at US 1 interchange in 2018 due to the rapid growth in the Fredericksburg region, specifically within the Jackson Gateway area and southern portion of the Primary Settlement District of Spotsylvania County. Existing traffic volumes along I-95 are beginning to exceed the operational capacity of the Exit 126 interchange, resulting in lengthy delays and queueing that impacts operations along the mainline. In addition to the existing conditions constraint, several planned developments in the study area are expected to impact operations due to increased traffic volumes.

Assuming traffic along the interstate is not expected to grow exponentially, calculate the historical linear growth rate and future (2045) Average Annual Daily Traffic (AADT) along I-95 from US 1 to US 17 using historical count data from SPS, shown in **Figure 17** and **Table 7**.

**Figure 17: SPS Traffic History**

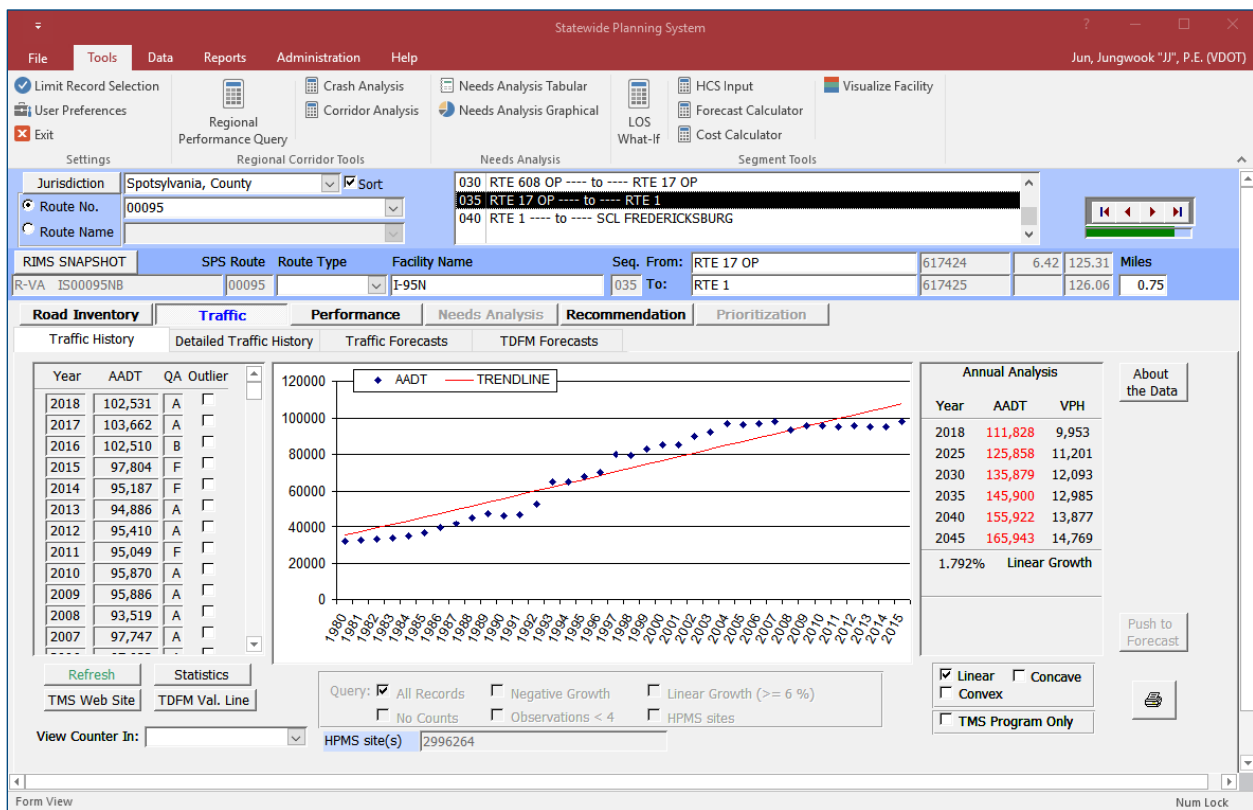


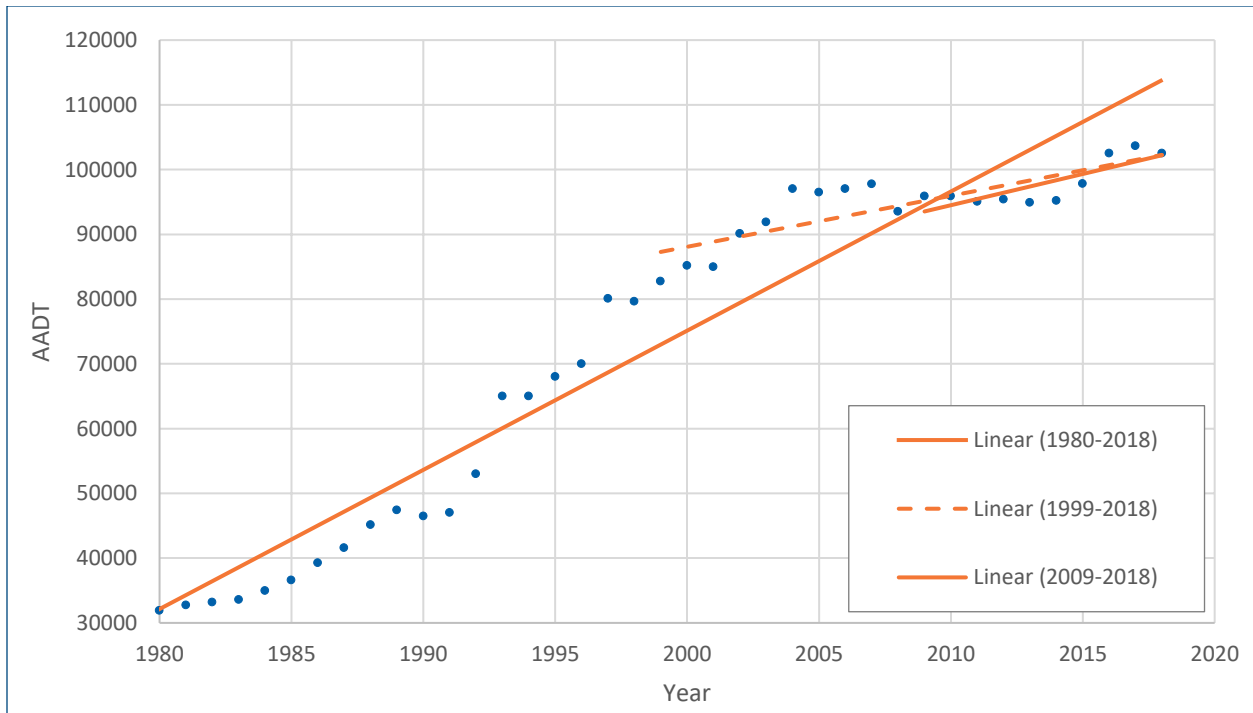
Table 7: I-95 AADT Between US 1 and US 17

Year	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
AADT	29,340	28,010	30,525	32,240	33,930	36,200	33,370	31,910	32,720	33,160
Year	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
AADT	33,590	34,980	36,590	39,270	41,590	45,130	47,400	46,450	47,000	53,000
Year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
AADT	65,000	65,000	68,000	70,000	80,055	79,618	82,766	85,180	84,980	90,126
Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
AADT	91,902	97,033	96,500	97,032	97,747	93,519	95,886	95,870	95,049	95,410
Year	2013	2014	2015	2016	2017	2018				
AADT	94,886	95,187	97,804	102,510	103,662	102,531				

Source: VDOT SPS

Figure 18 shows the resulting linear regression analysis of three periods from 1980-2018. As shown, each of the analyses resulted in varying growth rates. The annual growth rate for the 38-, 20-, and 10-year analyses were approximately 2,149, 788, and 965 vehicles per year, respectively. As stated in Section 5.1.2, as many years of data should be included in a linear regression analysis to overcome the irregularity in traffic volumes and patterns over time, specifically during periods of recession.

Figure 18: I-95 Linear Regression Analysis



### 5.1.3 Traffic Forecasting with Travel Demand Model Outputs

Travel demand model outputs can be used as an additional data source to develop traffic growth rates without modifying a model. This technique should be used with caution since a travel demand model may not be sufficiently validated for the project. The decision of whether to use this technique should be discussed with the VDOT project manager and study team. More details about when to modify and apply a travel demand model are provided in **Chapter 6**.

Traffic growth rates can be developed for individual links or at an aggregate level across all links in the study area. A simplistic calculation methodology, based on the *National Cooperative Highway Research Program Report 765 (NCHRP 765)*, calculates traffic growth using 1) the difference between future model traffic volume and existing model traffic volume, or 2) the average annual traffic growth rate between future model traffic volume and existing model traffic volume. This calculation can be done for an individual link or a group of links. Both the traffic growth rate and difference can be applied to the existing traffic counts and then averaged. Note that using this simplistic method could result in an unrealistic traffic growth rate if one or both data points from the model is an outlier.

A trend analysis using model outputs can be calculated and applied using the following procedure.

- **Step 1. Calculate the traffic growth rate for each link using daily link traffic volumes from the model.** Once the travel demand model is determined sufficient to meet the project purpose and need (e.g., either as-is or upon modification), extract the ratio of existing assigned traffic volumes to future assigned traffic volumes from the model and manually convert to an average annual growth rate. Note whether the computed rate is a linear or exponential trend.
- **Step 2. Apply the growth rate to existing traffic count volumes to compute future link volumes.** Multiply the growth rate by each existing traffic volume.
- **Step 3. Convert daily link volumes to peak-hour link volumes (if necessary).** Once link volumes are developed, convert daily link volumes to peak-hour link volumes (if necessary). Convert peak-hour link volumes to intersection turning movement volumes (if necessary) using the technique described in **Section 5.2**.

#### *Example: Trend Analysis Using the Simplistic Calculation Method and Travel Demand Outputs*

An existing 2010 daily traffic count on a sample link is 11,000 vehicles per day (vpd). The base year model estimated daily traffic volume is 10,500 vpd for the existing conditions and the forecasted daily traffic volume is 19,600 vpd for the 2040 model. It is required to forecast 2025 (interim year) and 2040 (design year) conditions.

- Compute annual traffic growth rate (linear)
  - Total growth is  $(19,600 - 10,500) \div 10,500 = 86.7\%$
  - Annual growth over 30 years is  $86.7\% \div 30 \text{ years} = 2.9\% \text{ per year}$
- Apply traffic growth rate to existing traffic volumes to compute forecasts
  - Interim year (2025):  $11,000 \times (1 + (0.029 \times 15)) = 15,766.7$ ; rounded 16,000
  - Design year (2040):  $11,000 \times (1 + (0.029 \times 30)) = 20,533$ ; rounded 21,000

In most cases, not all links can be validated to match the existing traffic counts. Travel demand model validation for project traffic forecasting typically focuses on screenlines or groups of roadways in the study area by functional classification (see **Chapter 6**).

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## 5.2 Forecasting Intersection Turning Movements

### 5.2.1 Traffic Growth Rate Computation

A simplistic method for developing intersection turning movement forecasts is to apply the traffic growth rate of each approach link to the turning movements on that approach, assuming that each turning movement volume will grow at the same rate. This methodology works well for intersections that are isolated from other study intersections.

A challenge with this method occurs when this process is applied to two closely-spaced intersections. The traffic forecast of departing volumes on a link at one intersection will likely not match the approach volumes at the downstream intersection; therefore, additional traffic volume adjustments may be required at these intersections to balance the traffic volumes between intersections. A second issue, even with isolated intersections, is that one intersection approach may have a much higher traffic growth rate than the other approaches. In that case, the turning movements to that approach (i.e. departing volumes from other approaches) would have a lower traffic growth rate than the movements from that approach (i.e. approaching volumes on the approach).

To address these issues in a simplified way, if deemed appropriate by the study team, one or multiple traffic growth rates may be developed to represent the predominant traffic growth in the study area. This simplified method is only if similar magnitude of traffic growth is expected throughout the study area or in different segments of the study area. An example of the simplified method is provided below. Alternatively, the Fratar technique (as described in the next section) can be used, as it considers growth on all approaching and departing links and adjusts growth on individual turning movements.

#### *Example*

A major commuting corridor is expected to experience large traffic growth generated outside the study area. Little to no traffic growth is expected from side streets in the study area.

In this case, a uniform traffic growth rate can be developed for all mainline movements. Traffic growth on the side streets can be kept a growth rate constant with expectations. Volume balancing is required to keep intersection traffic volume forecasts consistent.

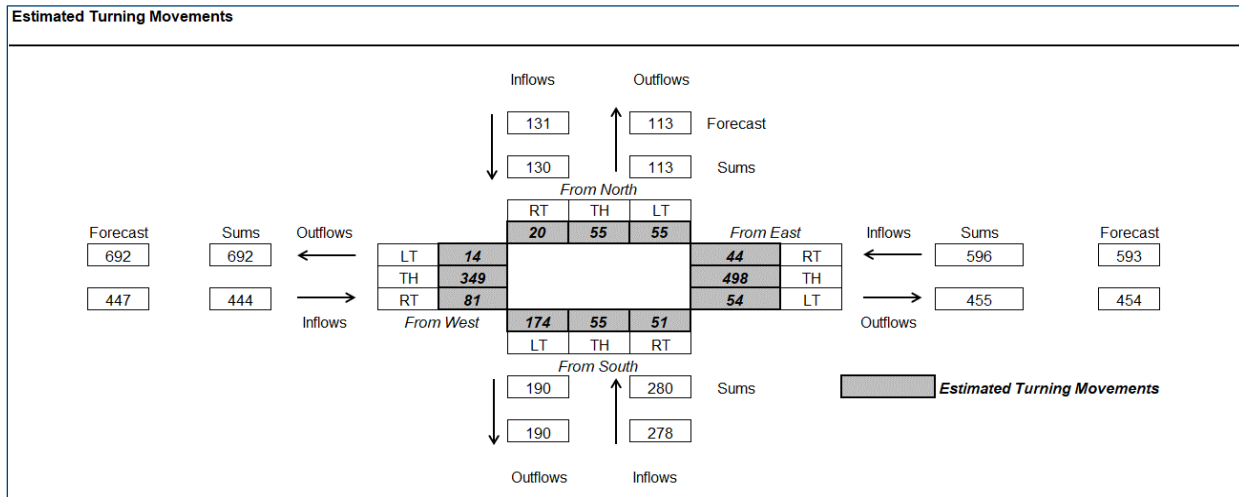
### 5.2.2 Fratar Methods

Most travel demand models can produce peak period intersection turning movement forecasts; however, manual calculations are required if the model is not validated at a local level or if the model does not include the study area. Since travel demand models are typically not calibrated for turning movements, Fratar methods, as discussed in the *National Cooperative Highway Research Program Report 255 (NCHRP 255)* and the *National Cooperative Highway Research Program Report 765 (NCHRP 765)*, can be used to develop turning movements by considering proportions of existing turning movements and the traffic growth on each link.

VDOT recommends the *NCHRP 765* “Iterative Procedure – Directional Method” for intersections having four legs or less. The method, outlined below, uses an iterative approach to balance entering and

departing volumes for each link until an acceptable level of convergence is reached. The method may be conducted using automated spreadsheets, such as that shown in **Figure 19**.

**Figure 19: NCHRP Intersection Forecasting Spreadsheet**



**Step 1. Obtain existing turning movements for intersection.** If the existing turning movements are not available, or if the intersection (or a specific leg of an intersection) does not yet exist, an initial turning movement seed is estimated. These turning movements are an input to the Fratar process and must be nonzero for any allowable future turning movement (even if there is no existing traffic volume for a specific movement). The Fratar process will adjust all nonzero movements to approximately sum to the input inbound and outbound traffic volumes on each link to the intersection.

**Step 2. Obtain approach and departure volumes on each link for both existing and future conditions.** The future conditions link volumes should follow steps previously described in **Section 5.1**. If the sum of the future inbound (approaching) and outbound (departing) traffic volumes do not equal each other, these traffic volumes should be adjusted proportionally so that the sum of all inbound traffic equals the sum of all outbound traffic. Otherwise, it will not be possible to achieve convergence, so the results will not be useable.

**Step 3. Compute row and column factors.**

Compute the ratio between forecasted traffic volumes and existing link traffic volumes for each row (representing inbound traffic) and column (representing outbound traffic) in the traffic volume matrix (examples tables are provided below in the sample calculation).

**Step 4. Conduct iterative process.** This step can be done in one of two ways:

- 1) Alternate between row iteration and column iteration. First, multiply each cell by its corresponding row factor to develop new column factors. Then, multiply each cell by its corresponding column factor and develop new row and column factors.
- 2) Using the average iteration, each cell in the volume matrix will be multiplied by the average of the row and column factor, specific to the row/column of that cell. After this step, develop new row and column factors. After each step, the ratio for both the rows and columns are recomputed. If the factors do not lie within the desired ratio range, the steps are repeated until all factors lie within the range determined by the study team. For example, if 1 percent is chosen as the margin, all values



would need to be in the range of 0.99 to 1.01. A minimum of five iterations should be completed, regardless of the value of the factors. More than five iterations may be needed. The process will gravitate towards all column and row factors converging to a value of 1.0. The objective is to have all factors within a desired percentage.

This methodology should be applied to each intersection under consideration. Travel demand model outputs for intersection turning movement counts should not be used directly; however, they can be used as the initial seed to prepare the final forecast, especially for new intersections where existing turning movements do not exist.

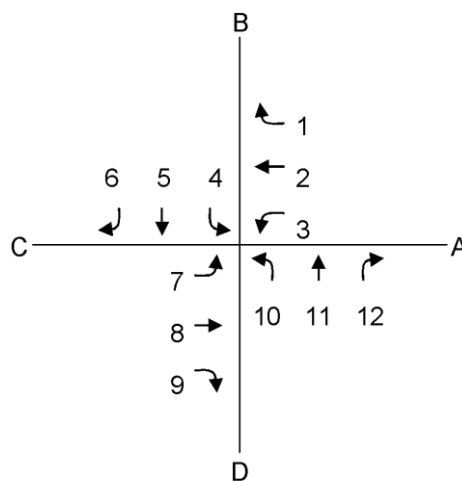
When forecasting interchange traffic, develop the existing traffic volumes matrix by converting the interchange and ramp traffic volumes into an origin-destination matrix, treating ramp movements as standard turning movements at an at-grade intersection. Existing and future link-level approaching and departing volumes and entering and exiting volumes must be known. Computations using these values would follow the same process as intersection computations.

**Sample Calculation: Fratar Technique for Intersection Turning Movement Forecasting**

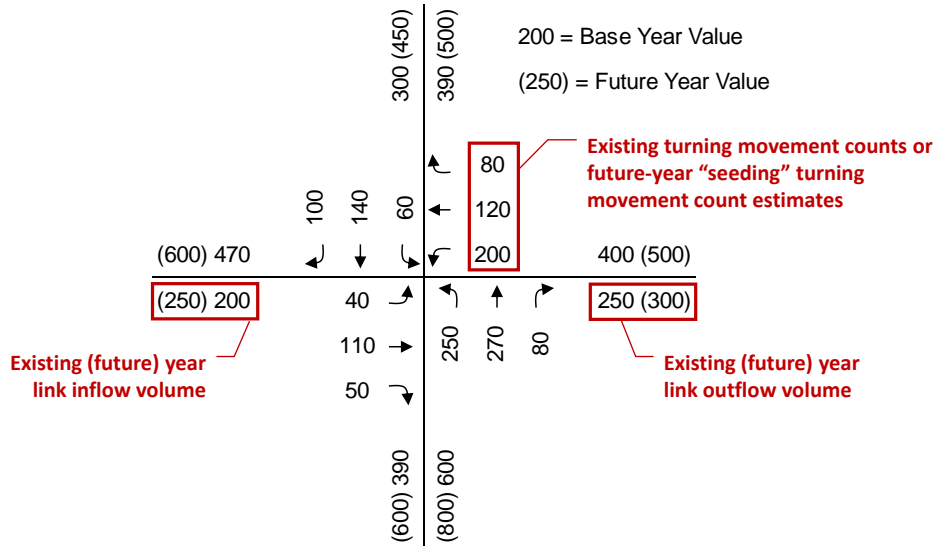
The below example outlines the Fratar methodology for forecasting intersection turning movements.

**Step 1: Create a matrix and diagram of turning movements by approach.** The rows and columns of the matrix represent each leg of the intersection. The rows represent the inflow volumes and the columns represent the outflow volumes.

Matrix		Outflow				Inflow Total	Inflow Future
		A <sub>out</sub>	B <sub>out</sub>	C <sub>out</sub>	D <sub>out</sub>		
Inflow	A <sub>in</sub>	-	1	2	3	A <sub>base</sub>	A <sub>future</sub>
	B <sub>in</sub>	4	-	6	5	B <sub>base</sub>	B <sub>future</sub>
	C <sub>in</sub>	8	7	-	9	C <sub>base</sub>	C <sub>future</sub>
	D <sub>in</sub>	12	11	10	-	D <sub>base</sub>	D <sub>future</sub>
Outflow Total		A <sub>base</sub>	B <sub>base</sub>	C <sub>base</sub>	D <sub>base</sub>		
Outflow Future		A <sub>future</sub>	B <sub>future</sub>	C <sub>future</sub>	D <sub>future</sub>		



**Steps 2: Obtain existing turning movements for intersection.** Obtain inbound and outbound traffic volumes on each link for both existing and future conditions.



**Step 3: Compute row and column factors.** Compute the ratio between forecast traffic volumes and existing link traffic volumes for each row (representing inflows) and column (representing outflows) in the traffic volume matrix.

Existing Conditions		Outflow				Inflow Total	Inflow Future	Inflow Ratio Factor
		A <sub>out</sub>	B <sub>out</sub>	C <sub>out</sub>	D <sub>out</sub>			
Inflow	A <sub>in</sub>	0	80	120	200	400	500	1.25
	B <sub>in</sub>	60	0	100	140	300	450	1.50
	C <sub>in</sub>	110	40	0	50	200	250	1.25
	D <sub>in</sub>	80	270	250	0	600	800	1.33
Outflow Total		250	390	470	390	Existing turning movement volumes		
Outflow Future		300	500	600	600			
Outflow Ratio Factor		1.20	1.28	1.28	1.54			

- The **inflow (and outflow) total** represents the sum of the base year inflow (and outflow) turning movement volume for each link.
- The **inflow future (and outflow future)** represents the forecast inflow (and outflow) turning movement volume for each link.
- The **inflow ratio factor (and outflow ratio factor)** represents the ratio between the forecast volume and the sum of the turning movement volumes.

**Step 4: Conduct iterative process.** Calculate updated turning movement volumes and row and column factors.

First Iteration		Outflow				Inflow Total	Inflow Future	Inflow Ratio Factor
		<i>A<sub>out</sub></i>	<i>B<sub>out</sub></i>	<i>C<sub>out</sub></i>	<i>D<sub>out</sub></i>			
Inflow	<i>A<sub>in</sub></i>	0	101	152	279	532	500	0.940
	<i>B<sub>in</sub></i>	81	0	139	213	433	450	10.40
	<i>C<sub>in</sub></i>	135	51	0	70	255	250	0.980
	<i>D<sub>in</sub></i>	101	353	326	0	781	800	1.025
Outflow Total		317	505	617	561	Calculated turning movement volume		
Outflow Future		300	500	600	600			
Outflow Ratio Factor		0.946	0.990	0.973	1.069			
<ul style="list-style-type: none"> <li>- Sample calculation:  <math display="block">(A_{in}, B_{out}) = \frac{1.25 + 1.28}{2} * 80 = 101</math> </li> <li>- The <b>inflow (and outflow) total</b> represents the sum of the calculated inflow (and outflow) turning movement volume for each link.</li> </ul>								

Second Iteration		Outflow				Inflow Total	Inflow Future	Inflow Ratio Factor
		<i>A<sub>out</sub></i>	<i>B<sub>out</sub></i>	<i>C<sub>out</sub></i>	<i>D<sub>out</sub></i>			
Inflow	<i>A<sub>in</sub></i>	0	98	145	280	523	500	0.956
	<i>B<sub>in</sub></i>	80	0	140	224	445	450	1.012
	<i>C<sub>in</sub></i>	130	50	0	71	251	250	0.996
	<i>D<sub>in</sub></i>	100	356	326	0	781	800	1.024
Outflow Total		310	503	611	576			
Outflow Future		300	500	600	600			
Outflow Ratio Factor		0.967	0.993	0.983	1.042			

Third Iteration		Outflow				Inflow Total	Inflow Future	Inflow Ratio Factor
		<i>A<sub>out</sub></i>	<i>B<sub>out</sub></i>	<i>C<sub>out</sub></i>	<i>D<sub>out</sub></i>			
Inflow	<i>A<sub>in</sub></i>	0	95	141	280	516	500	0.969
	<i>B<sub>in</sub></i>	80	0	139	230	449	450	1.001
	<i>C<sub>in</sub></i>	127	50	0	73	250	250	1.001
	<i>D<sub>in</sub></i>	99	359	327	0	785	800	1.019
Outflow Total		306	504	607	583			
Outflow Future		300	500	600	600			
Outflow Ratio Factor		0.979	0.993	0.989	1.029			

Fourth Iteration		Outflow				Inflow Total	Inflow Future	Inflow Ratio Factor
		<i>A<sub>out</sub></i>	<i>B<sub>out</sub></i>	<i>C<sub>out</sub></i>	<i>D<sub>out</sub></i>			
Inflow	<i>A<sub>in</sub></i>	0	93	138	280	511	500	0.979
	<i>B<sub>in</sub></i>	79	0	139	234	451	450	0.997
	<i>C<sub>in</sub></i>	126	49	0	74	249	250	1.002
	<i>D<sub>in</sub></i>	99	361	328	0	788	800	1.015
Outflow Total		304	503	605	588			
Outflow Future		300	500	600	600			
Outflow Ratio Factor		0.986	0.994	0.992	1.020			

Fifth Iteration		Outflow				Inflow Total	Inflow Future	Inflow Ratio Factor
		<i>A<sub>out</sub></i>	<i>B<sub>out</sub></i>	<i>C<sub>out</sub></i>	<i>D<sub>out</sub></i>			
Inflow	<i>A<sub>in</sub></i>	0	92	136	280	508	500	0.985
	<i>B<sub>in</sub></i>	78	0	138	236	452	450	0.995
	<i>C<sub>in</sub></i>	125	49	0	75	249	250	1.002
	<i>D<sub>in</sub></i>	99	362	329	0	791	800	1.012
Outflow Total		303	504	603	590			
Outflow Future		300	500	600	600			
Outflow Ratio Factor		0.990	0.993	0.995	1.016			

After five iterations, all ratios are within 0.02 (assuming 2 percent margin of error) of 1.0; therefore, the process could stop at this point. If the study team desires a higher precision, additional iterations can be performed until the desired threshold is reached. Once the final iteration is completed, the forecast traffic volumes may be rounded to the nearest five or ten when balancing traffic volumes in a network.

### *Example: Forecasting Using a Trend Analysis*

#### PROJECT BACKGROUND

US 220, which traverses between West Virginia and North Carolina in Virginia, is designated as a Corridor of Statewide Significance (CoSS). The corridor is operationally significant since it is the only principal arterial providing direct connection from the City of Roanoke to the North Carolina state border. US 220 serves as a primary route for local and regional traffic: local traffic uses US 220 to access commercial, residential, institutional, and recreational areas, and regional traffic uses US 220 for access to recreational areas and the mobility of goods and services. The corridor is a designated truck route as part of the Surface Transportation Assistance Act and carries approximately 12 percent to 15 percent heavy vehicles daily. The purpose of the study was to identify targeted safety and operational improvements.

#### TRAFFIC FORECASTING SCOPING

The US 220 Arterial Preservation Program (APP) study can be defined as a large, corridor planning project with stable growth along most of the corridor. Since a regional travel demand model was not available for US 220, VDOT provided SPS<sup>25</sup> data that included historical traffic counts for traffic forecasting. In addition, the project team reviewed VDOT historical traffic count data and information from approved traffic studies to consider in the development of future year volumes.

Corridor studies, such as those identified under the APP, typically have a forecast horizon of 15–20 years beyond the existing year. The project team identified the forecast horizon year as 2040 during the US 220 APP Framework Document development, approximately 20 years from the existing year (2018). The horizon year was used for the no-build and build analysis scenarios.

#### FORECASTING METHODOLOGY

VDOT TMPD provided the most recent SPS data along the US 220 study corridor. Traffic growth rates in SPS are generally derived through inspection of historical traffic data or interpretations from travel demand model output, if available. The provided SPS data in the study corridor was based on VDOT historical traffic data and consisted of varying traffic growth rates.

Since a regional travel demand model was not available for the study, the SPS traffic growth rates were compared to VDOT historical data, available traffic studies, approved site plans, and future zoning and land use plans along the study corridor. The project team agreed that based on the nature of the corridor and the historical traffic trends, the SPS traffic growth rate captured the expected growth along the study corridor. In addition, traffic growth rates were higher between the Roanoke County line and the Blue Ridge Parkway compared to the rest of the corridor which was confirmed during the review of available studies and plans. While three traffic growth rates were derived based on SPS data (0.5 percent, 0.8 percent, and 1.0 percent), the project team agreed that the 1.0 percent growth shown on the short segment between the Blue Ridge Parkway and Draper Road more closely aligns with the 0.8 percent growth to the south, rather than the majority of the corridor; therefore, the project team agreed to use the two growth rates (0.5 percent and 0.8 percent) derived from SPS along US 220 to develop the future 2040 traffic volumes, as displayed in **Figure 20**. Growth rates from SPS were based on

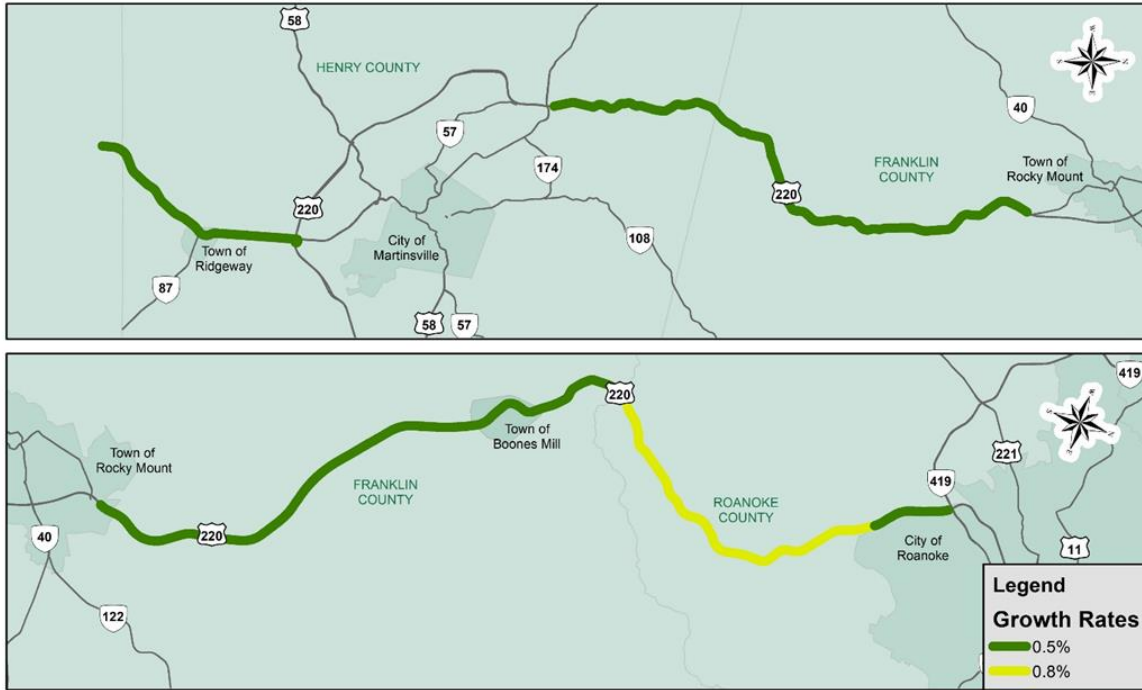
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<sup>25</sup> Refer to Section 4.1.2.

linear regression over 20 years of data. The resulting growth rate and forecasted volume were reasonable when considering inputs.

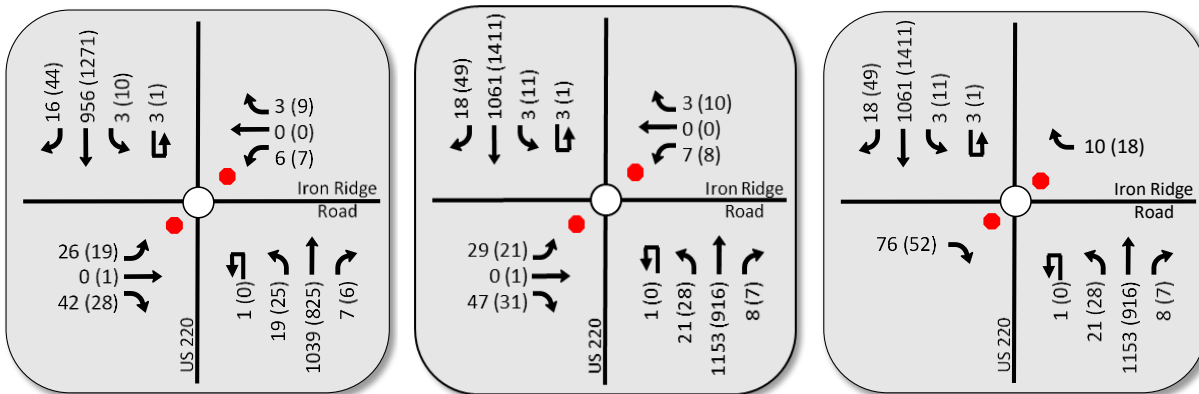
Roanoke County had a higher growth rate due to more anticipated economic growth in the area.

Figure 20: US 220 Selected Traffic Growth Rates



The project team applied the identified traffic growth rates linearly to the 2018 existing AM and PM peak-hour traffic volumes for all movements to obtain the 2040 no-build traffic forecast volumes. Based on the proposed intersection improvements, 2040 no-build traffic volumes were redistributed for restricted movements for a proposed restricted crossing U-turn intersection (RCUT) to obtain the 2040 forecasted build traffic volumes. These volumes were used in the 2040 no-build and build traffic analyses. **Figure 21** displays an example of the 2018 existing, 2040 no-build, and 2040 build (RCUT for side streets) traffic volumes for one intersection.

Figure 21: Intersection Traffic Volume Forecasted Example



### 5.3 Developing Site-Specific Trip Generation (ITE and non-ITE Methods)

The study area should consider sites where increased trip generation is anticipated. These sites may vary based on different uses and thus generate a different number of trips.

Site-specific traffic is estimated based on the proposed land use type and density using trip generation methodologies unique to traffic forecasting methods using trend analysis or travel demand models. The methodologies described in this section correspond to the trip generation process to determine traffic for a project, the additional vehicle trips generated by a project, or new land use.

Site-specific traffic is mostly independent of the forecasted traffic growth resulting from the other projects or improvements (e.g., background projects). Pass-by trips may be impacted by forecasted traffic growth, depending on how many trips are generated using the Institute of Transportation (ITE) methodology. When traffic volume forecasts are derived from a travel demand model, traffic forecasters should ensure that site-specific traffic is not double counted in the traffic forecast. For example, site-specific traffic should be added to traffic volumes derived from a trend analysis or traffic volumes from a travel demand model that excludes the proposed site development project. In addition, independently accounting for site-specific traffic improves the accuracy of estimating the traffic volumes to and from each site. Also, when determining the trip distribution for a site, traffic forecasters should be cautious to not directly use results from travel demand model because of the centroid and centroid connectors locations limitation. Instead, traffic from travel demand models should be post-processed according to *NCHRP 255*, which has been updated to *NCHRP 765*.

#### 5.3.1 ITE Trip Generation Methodology

The *ITE Trip Generation Manual* provides a trip rate or equation for various time periods for different land use categories. Users should use caution and pay attention to the standard deviation for each land use category as the number of data points vary for each use. The *ITE Trip Generation Manual* includes guidance on data limitations and procedures for use.

ITE trip generation methodology is typically used to determine site-specific traffic impacts onto adjacent roadways. The *Administrative Guidelines for the VDOT Traffic Impact Analysis Regulations (24VAC30-155)* outlines how to use and apply ITE trip generation methodology and includes requirements for submitting TIAs in Virginia. The following steps summarize the process.

- **Step 1. Background Information.** Determine background information and establish the study area based on the number of peak-hour trips generated by the site.
- **Step 2. Analysis of Existing Conditions.** Analyze existing conditions for intersections and roadways within the study area.
- **Step 3. Analysis of Future Conditions Without Development.** For most developments, a trend analysis can be used to determine future roadway traffic volumes for no-build conditions; however, large developments, including comprehensive plans, often require use of a regional travel demand model. The appropriate methodology and forecast years should be discussed during the traffic impact analysis scoping process outlined in the *Administrative Guidelines for the VDOT Traffic Impact Analysis Regulations (24VAC30-155)*. If a development is phased, no-build traffic volumes should be developed for the opening date of each phase.

The no-build analyses are then performed for each study year (e.g., opening, interim, and horizon) to be evaluated. A travel demand model can be used to obtain or validate assumptions regarding trip distribution and assignment onto the roadway network. For example, the relevant socioeconomic data for the proposed site could be added to the travel demand model and a select zone analysis could be run using the model. This analysis will show the breakdown of trips into and out of the zone on specific links.

- **Step 4. Trip Generation, Site Traffic Distribution, and Assignment.** Determine the land use types (and sub-category if applicable) listed in the *ITE Trip Generation Manual* for the site. From the manual, trip generation rates and distributions into and out of the site can be computed. The size of the development and the trip generation rate are used to compute the total development trips. The *ITE Trip Generation Handbook* also has factors for trip reductions based on various transportation demand management (TDM) strategies and the presence of transit. If the development is phased, site-specific trips need to be developed for each scenario.
- **Step 5. Analysis of Future Conditions with Development.** Calculate build conditions traffic volumes by summing site-specific traffic volumes and no-build (background) traffic volumes for each scenario. Analyze the build conditions for intersections and roadways within the study area.

### 5.3.2 Non-ITE Trip Generation Methodology for Mixed-Use Development

VDOT has selected an alternate non-ITE based trip generation methodology for mixed-used developments in the *Administrative Guidelines for the VDOT Traffic Impact Analysis Regulations (24VAC30-155)*. The methodology, developed by the San Diego Association of Governments and the Environmental Protection Agency, is approved for use when a local government conducts a single traffic impact analysis for all parcels within a small-area plan adopted as part of their comprehensive plan. This traffic impact analysis study can then be used for proposed rezoning for parcels located within the boundaries of the small-area plan. The methodology, *Mixed-Use Trip Generation Model V 4.0*, considers trip reduction for mixed-used development and is, ultimately, a replacement for the ITE trip generation process for mixed-use development projects. The remaining TIA analysis should follow the standard analytical procedure outlined in the *Administrative Guidelines for the VDOT Traffic Impact Analysis Regulations (24VAC30-155)*.



## 6 TRAFFIC FORECASTING WITH A TRAVEL DEMAND MODEL

### SECTION HIGHLIGHTS

#### **Section 6.1: Applying a Travel Demand Model**

Introduction of factors to be assessed when determining whether a travel demand model should be modified and what typically pertains to model modification for project traffic forecast application.

#### **Section 6.2: Applying a Subarea Model**

Overview of when a subarea modeling approach is effective in enhancing the accuracy of traffic forecasting.

#### **Section 6.3: Travel Demand Model Validation and Calibration**

Overview of travel demand model calibration and validation for project traffic forecasts.

#### **Section 6.4: Post-Processing Travel Demand Model Outputs**

Overview of post-processing travel demand model outputs.

This chapter describes the traffic forecasting process when applying a travel demand model. While **Section 5.1.3** focuses on the use of travel demand model outputs as a potential data source for a trend analysis, this chapter provides guidance on how to obtain those outputs by potentially modifying, calibrating, and/or validating a travel demand model if it is not adequate in its default form to address questions that arise from a project. This chapter also will provide guidance on techniques for post-processing model outputs for use in forecasting, rather than using the direct raw outputs.

*A travel demand model may be:*

- 1. Applied using default model inputs which should include post-processing model outputs to meet the needs of the analysis.*
- 2. Modified and applied which should include calibrating the model, validating and, and post-processing model outputs.*

This chapter will frequently reference the *VDOT Travel Demand Modeling Policies and Procedures Manual*, a policy and guidance document that provides a detailed overview of travel demand model usage including model data development and the development and validation of regional model processes themselves. The *VDOT Travel Demand Modeling Policies and Procedures Manual* aims to establish specific and uniform policies and procedures for use in model development and application by

Virginia Department of Transportation (VDOT), Metropolitan Planning Organizations (MPOs), Planning District Commissions (PDCs), and their consultants. It focuses on models for jurisdictions entirely in Virginia, which would not include the Metropolitan Washington Council of Governments (MWCOC),<sup>26</sup> whose model covers the Northern Virginia region, as well as the Bristol MPO and Kingsport MPO, whose models extend into Virginia. However, the *VDOT Travel Demand Modeling Policies and Procedures Manual's* guidance related to model application should be extended to any traffic forecasting effort in Virginia. Additionally, projects that require model calibration and validation with the forecasting efforts should reference the *VDOT Travel Demand Modeling Policies and Procedures Manual* for detailed

<sup>26</sup> The MWCOC is the Washington D.C. MPO.

guidance on how to conduct model modification, calibration, and/or validation and the associated requirements on calibration thresholds.

## 6.1 Applying a Travel Demand Model

Once a travel demand model is selected for the traffic forecasting process on a project, the project team should consider whether to modify the travel demand model inputs to align with the purpose and goals of the project, as opposed to using the model with the default inputs. The first step in making this decision is to address questions related to the validity and adequacy of a travel demand model for project-level traffic forecasting. The below factors should be considered and assessed by the project team: VDOT project manager, VDOT forecasting technical lead, local jurisdiction(s) representative(s), MPO/PDC representative(s), and consultants to determine whether a travel demand model should be modified and used.

### Model Horizon Year

- **Is the base year for the project the same as the year of the model that is used as a starting point for traffic forecasting (e.g., base year or interim year)?**

If the model and project base year differ, the model network and inputs should be modified to be consistent with the base year for the project. For example, programmed projects (e.g., Constrained Long-Range Plan [CLRP] projects) that will be open to traffic between the model interim year of 2022 (e.g., MWCOG model Ver2.3.70 for 2016 Air Quality Conformity) and project base year of 2018 should be added to the 2018 model network if these programmed projects influence the travel behavior in the project study area. Any projects that will not be open to traffic prior to the project base year should be removed.

- **Are there improvements in the future year model that are not anticipated to be implemented prior to the project forecast horizon year?**

If yes, remove those projects from the model prior to running the future year model upon agreement from the project team.

### Model Network

- **Does the model roadway network represent the study area street connectivity and access so it can be used for traffic forecasting?**

If not, model roadway network and centroid connectors should be modified to closely represent the study area street network that will result in enhanced traffic assignment. If so, post-processing may be all that is needed. Fundamental model network attributes (e.g., number of lanes, speed, capacity, functional classification, etc.) should be accurately coded for the base and future years.

- **Are the transit network and/or park-and-ride facilities adequately represented?**

If a model contains a transit network or park-and-ride facilities that are anticipated to influence travel patterns in the project study area, these inputs should be checked. For example, the transit route input file should be checked to ensure that transit service—especially high-capacity transit service, such as rail service—is represented in the model in terms of appropriate headways/frequency and locations of stops. For transit service that is anticipated to draw park-and-ride traffic that also influences the roadway network capacity, the location of park-and-ride

nodes should be confirmed. It is important to note that most travel demand models do not assign the access and egress trips to park-and-ride to the highway network. If this is a critical aspect of the analysis, then it should be added to the model or applied in a post processing application.

- **Does the model use reasonable toll values and toll set-ups in the model network?**

If a travel demand model contains tolling on certain links segments, the forecaster should check the reasonableness of toll values, time period, and locations. If the forecaster plans on modifying toll values or tolling parameter inputs or algorithms, a discussion should be held with the VDOT project manager to review the appropriate steps to incorporate such modifications.

#### *Traffic Analysis Zone and Socioeconomic Data*

- **Does the socioeconomic and land use data in model traffic analysis zones (TAZs) sufficiently represent base year and future year conditions reflected in regional and local transportation plans?**

If not, the project team should obtain and apply updated socioeconomic data and land use data from MPOs, local governments, and/or a third-party socioeconomic data provider.

- **Does the default level of granularity of model TAZs sufficiently represent the level of granularity of the trip generation, trip distribution, and traffic loading needed for the project?**

If not, consider splitting the TAZs to improve traffic loading in the model network to satisfy the accuracy required for the traffic forecasting process. In addition, project-specific traffic data could be used to supplement output from the model.

#### *Data Sources*

- **Is sufficient traffic data available (e.g., counts, speeds, etc.) to assist with model validation? This data collection could include traffic data beyond the project study area if model validation includes a comparison of traffic volumes across subarea or regional screenlines.**

If not, the project team should discuss whether to look for additional data with the VDOT project manager.

#### *Other Considerations*

Should it be deemed necessary, modifications to a travel demand model could include, but are not limited to:

- Changes to underlying socioeconomic data, including splitting or refinement of zones or updating of zonal population and employment data
- Modifications to centroid connectors between model TAZs and the roadway network to achieve a more appropriate loading of traffic volume during the traffic assignment process
- Modifications to the link/node structure of a network to provide more granularity in the traffic assignment, such as the number of lanes on a short segment of a facility or showing individual ramp movements at an interchange
- Modifications to link attributes in the network that affect capacity, including changes to facility type and/or free-flow speed

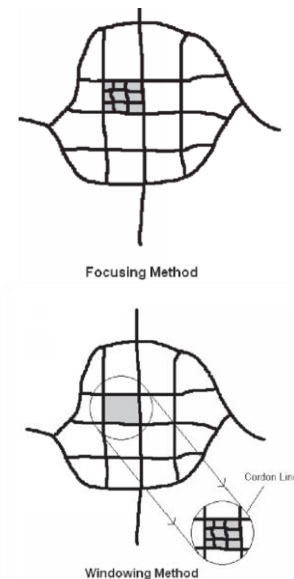
- Modifications to model structure or scripts, such as incorporation of turn penalties, additional vehicle classes, tolling, etc.
- Trip distribution might need to be adjusted based on survey or other big data sources
- Tolling algorithm or value might need attention for projects involving express toll lanes
- In areas with transit service, transit coding and access to transit might need to be adjusted according to the highway network

Any of these modifications may be needed to support the level of detail required for a traffic forecast. These modifications may also be utilized as part of the calibration and validation process, which may be required for the project and is described in the next section. All modifications made to the default inputs of a travel demand model should be discussed with the VDOT project manager and documented as part of the traffic forecasting documentation. More detailed modifications, such as refinements to model scripts or other input parameters, should also be discussed and approved by the VDOT project manager.

## 6.2 Applying a Subarea Model

If a travel demand model is applied for a project and the default level of granularity of the model network and TAZs is not sufficient for answering questions desired for the project, the project team should consider using a subarea modeling approach which may involve modifications to the model, such as adding or modifying roadway links, adding or modifying centroid connectors, or splitting TAZs to provide sufficient detail to support the project needs.

A subarea (also referred to as an influence area) represents an area that generally is geographically larger than the study area such that the project team can understand the travel patterns beyond the immediate project boundaries while still within a subset of the region that is of interest to the project. As discussed in previous sections, increasing the spatial resolution of a travel demand model (e.g., network, TAZs, etc.) is an effective technique to refine the model details and achieving enhanced accuracy in model procedures and outputs. Furthermore, applying actual recent traffic count data (e.g., origin and destinations [O-Ds] or traffic counts) to enhance the model outputs is another technique to post-process model outputs. The approach to enhance spatial details for a specific small area in a travel demand model is referred to as a subarea modeling approach. *The National Cooperative Highway Research Program Report 765 (NCHRP 765)* details the pros and cons of three subarea modeling methods: 1) focusing; 2) windowing; and 3) custom applications. The focusing and windowing methods are shown in **Figure 22**.



Source: NCHRP 765

### 6.2.1 Focusing Method

In the focusing method, substantial details are added to TAZs and the road network within a given subarea of the original travel demand model while the rest of the model network outside the subarea remains unmodified. These exercises are sometimes part of process for the model modification and

calibration. The system-wide effects of the proposed project beyond the subarea can be observed in the focusing method.

Consider the following when using the focusing method:

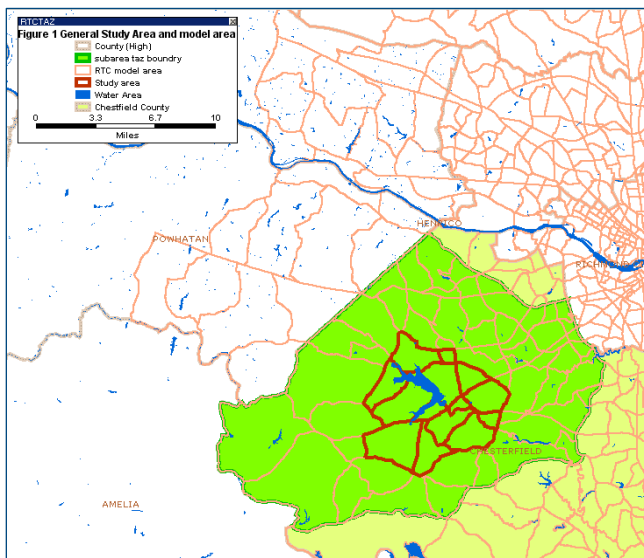
- If the proposed project potentially has a system-wide (regional) impact to travel behavior, the focusing method should be used to observe such system-wide effects of the proposed project in the traffic forecasting process
- The focusing method can be efficiently performed within the original model environment without introducing a new (windowed) model or new software. The focusing method should be applied to ensure that the modifications made to the model do not alter the basic functionality and calibration of the base model.

**Example: Subarea Model Focusing Method**

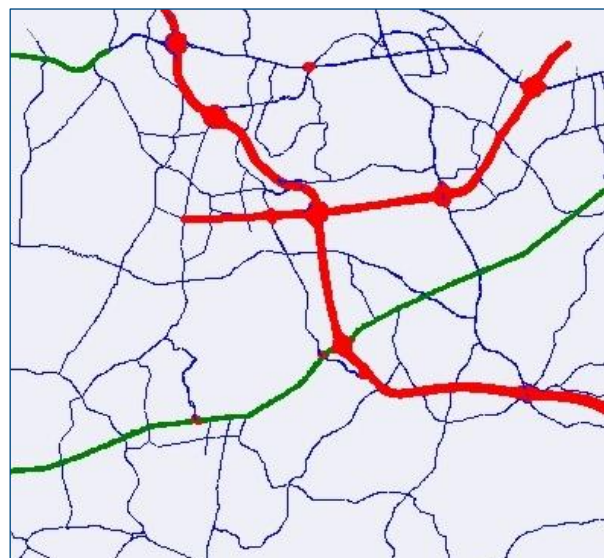
The US 360/Route 288 Interchange Study encompassed a large area of the planned alternative transportation network. As such, the study team decided to apply a travel demand model to capture the traffic impact of future improvements outside of the interchange area as well as understand how the high growth within and surrounding the study area impacts travel patterns on different facilities.

The Richmond Tri-Cities (RTC) model was available; however, as shown in **Figure 23**, the model did not contain enough details regarding TAZ structure and roadway network to analyze the traffic diversion impact from the two roadway alternatives. In addition, the impact from planned development within the study area could only be accurately captured with more granular TAZ boundaries that better align with the development data. As a result, the project team used a subarea model to support the traffic forecasting needs. The model was designed using CUBE Voyager as a refinement to the RTC model, following the focusing approach methodology. As shown in **Figure 24**, the level of detail for the street network and zone definition within the study area were refined, whereas the surrounding highway network and TAZ system were retained (i.e., The subarea model split 70 zones, original to the RTC model, into 106 subarea zones. Land use data was revised and split to accommodate the additional 36 zones).

**Figure 23: RTC Model Network**



**Figure 24: Subarea Model Network**



## 6.2.2 Windowing Method

In the windowing method, a subarea network is extracted from the original travel demand model and coded with additional details. The subarea model is executed independently without observing the system-wide effect of the entire model network. The subarea model may be applied in a different software platform to enhance model functionality and performance (run time); it can be applied in its original platform as well.

Consider the windowing method:

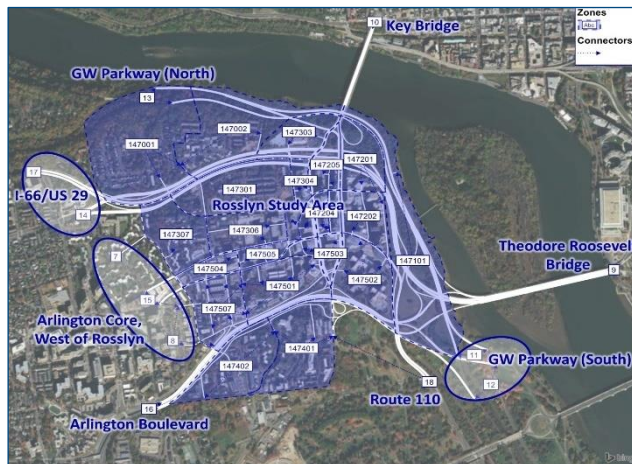
- When splitting TAZs is not easy to implement or the run time is prohibitive for the number of improvement alternatives that need to be evaluated in a regional travel demand model
- When the ratio of the number of TAZs in the selected study area to the number of TAZs in the whole regional model is very low (e.g., 1/30), or the location of the study area is adjacent to the regional model boundary

The selection of a subarea approach is also dependent upon the availability of traffic data (e.g., counts, speeds, etc.) to assist with the development of a subarea model. Using the windowing method usually requires more traffic count data, such as intersection turning movement counts and provides the ability to develop or update the O-D patterns and other information which may not be well represented in the regional model.

### *Example: Subarea Model Windowing Method*

A subarea modeling approach was used for the Core of Rosslyn Transportation Study to develop traffic assignment and future traffic volume forecasts in the study influence area. Although the MWCOC travel demand model was available and calibrated to reflect regional travel conditions, it did not accurately

**Figure 25: Rosslyn Subarea Model Area**



reflect traffic patterns within the study area due to coarse TAZs and model network structures. As a result, the project team used a subarea model to capture local impacts of the proposed street network and land changes at a more granular level than what was available in the MWCOC model.

The subarea model, shown in **Figure 25**, was developed using the windowing method: the project team extracted a portion of the MWCOC model that encompassed the major roadway network surrounding the study area. The subarea model was imported into Visum, at which point the network, TAZ structure, and

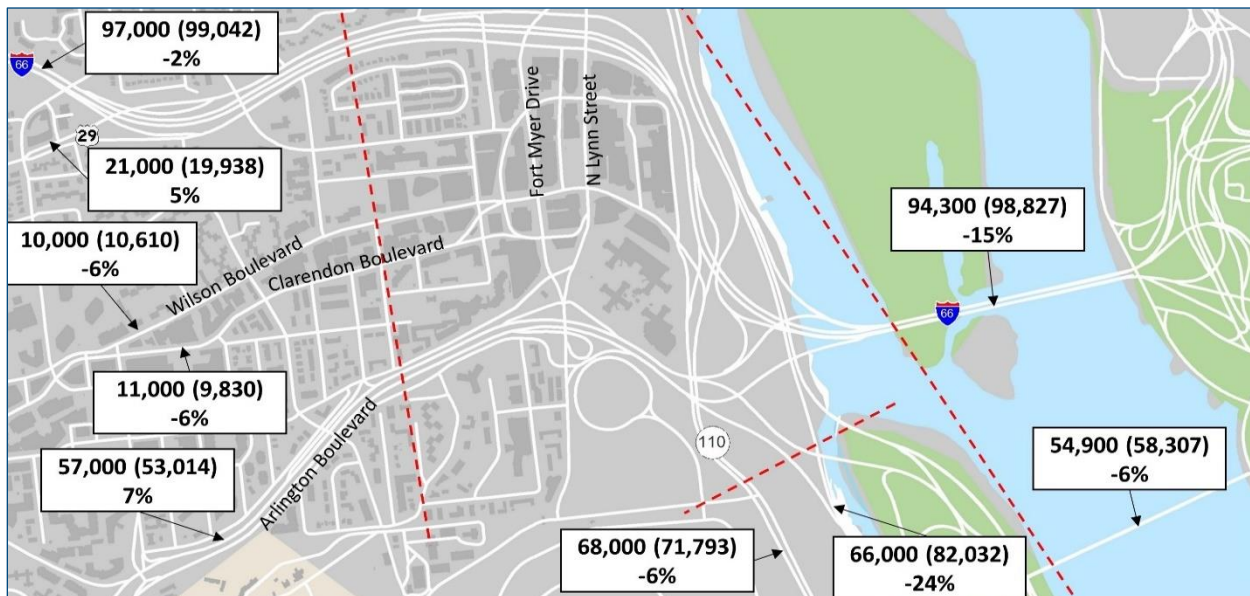
peak period trip tables were refined. The TAZs and associated trips were split to provide a greater level of detail and more accurate trip loading and assignment to the network. Data such as population, employment, and parking supply were used as the basis for proportioning trips into subdivided TAZs. The TAZ inputs were also modified to reflect the county comprehensive plan and recently approved development projects for the future year scenarios for more accurate trip loading and traffic assignment.

### 6.3 Travel Demand Model Validation and Calibration

Model calibration is the process of adjusting parameters to better replicate observed data for a base (calibration) year or otherwise produce more reasonable results. Model validation is the application of a calibrated model and comparison of the results against observed data. Ideally the model calibration and model validation data are separate datasets, but this is not always practical or feasible. Proper model validation also should include sensitivity testing to ensure that the model responds reasonably. The guidance on model calibration and validation discussed in this guidebook is limited to project level as opposed to regional level. Refer to the *VDOT Travel Demand Modeling Policies and Procedures Manual* for guidance on model validation procedures.

Typically, each component of an MPO model is calibrated and validated at the regional level, including regional trip generation and distribution, transit trips, average occupancy, and total traffic volumes across regional screenlines as shown in **Figure 26**.

Figure 26: Example of Regional Screenlines



Often a calibration and validation process are needed as part of the model modification process described earlier to further refine a model to reflect field conditions at the project study area level. VDOT recommends that if a project team is modifying the inputs to a regional model (whether this includes modifications to the socioeconomic data, network, or model algorithms), a calibration process should be conducted. Alternatively, the reverse process also may happen: if VDOT requires a model calibration process, modifications may need to be made to the model socioeconomic data, network, or algorithms. For example, for high-impact projects—such as large corridor studies or Interchange Justification Report (IJR)/ Interchange Modification Report (IMR) projects in Northern Virginia and Hampton Roads—VDOT may require a model calibration process for the project study area or subarea. As such, proper model modification is needed to achieve the calibration goals set forth by VDOT.

The *VDOT Travel Demand Modeling Policies and Procedures Manual* provides guidance on model validation for all four steps of a traditional four-step travel demand model.<sup>27</sup> The most common validation checks for traffic forecasting efforts typically involve checks on the Highway Assignment step of the four-step process. Generally, these checks consist of comparisons of base-year model output link volumes against observed data from traffic counts. The manual includes guidance on reasonableness checks or problems that may be observed with model results that would suggest further calibration efforts may be needed (perhaps only in a localized area):

- Low, high, or unrealistic base-year modeled link volumes compared to traffic counts
- Uneven facility loading on parallel competing routes
- Links with zero assigned traffic volume
- Links with very high assigned volume/capacity ratios
- Modeled travel times/speeds not consistent with observed data

For each of these issues, the *VDOT Travel Demand Modeling Policies and Procedures Manual* provides guidance on specific network or input elements that should be checked to potentially mitigate these issues. VDOT recommends that, at the very least, the first three checks listed above be performed on model outputs in a project study area if a model is being used in traffic forecasting efforts.

Based on guidance provided in **Section 3.3**, the following guidelines explain when a model calibration and/or validation process is required.

- If a travel demand model is warranted for the purpose and need of a project (e.g., high-impact transportation projects) and needs to be modified to adequately address questions for a project, a model calibration/validation process is required
- If a travel demand model is warranted and deemed sufficient for project-level traffic forecasting application (e.g., previously calibrated/validated for an adjacent project), a calibration/validation process might not be required depending on the new project location model performance. A comparison table of estimated volumes and traffic counts needs to be prepared and studied.
- Using regional model outputs as an additional data source for trend analysis to help develop traffic growth should not be confused with modifying and applying travel demand model, and such intended purpose should be documented and approved by the VDOT project manager. Calibration/validation would not be required but post-processing is recommended.

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<sup>27</sup> Note that at the time this document was published, all travel demand models being used in the Commonwealth are four-step models; however, for outputs of an activity-based or tour-based model, validation checks on traffic assignment results would still be applicable.



**Example: Core of Rosslyn Transportation Study Model Validation**

The Core of Rosslyn Transportation Study was completed in 2017 to evaluate and recommend actionable street reconfiguration concepts to provide a refined multimodal transportation system for residents, workers, and visitors in Rosslyn. The project team decided to apply and validate the MWCOG travel demand model for the forecasting effort. Mode split, trip patterns, and traffic volumes were selected as the validation criteria. A validation of mode split and trip patterns was conducted qualitatively, whereas the screenline volume validation<sup>28</sup> was conducted quantitatively following the guidance and thresholds provided in the Federal Highway Administration (FHWA) *Travel Model Validation and Reasonableness Checking Manual (2nd edition)* and VDOT *Travel Demand Modeling Policies and Procedures (Version 2.0)*.

**VALIDATING THE MWCOG TRAVEL DEMAND MODEL USING A SCREENLINE ANALYSIS**

The subarea model volume validation included comparisons between the following:

- Percent difference in total volume
- R-squared between modeled volume and counts on links
- Percent different in total freeway volumes (subarea model)
- Percent difference in total volume for arterials
- Percent difference of individual freeway and arterial links

Screenlines were defined across major commuting corridors surrounding the study area as well as major arterials internal to the study area. The screenline validation for the MWCOG model was focused on comparing daily volumes from the MWCOG model to VDOT and the District Department of Transportation's (DDOT) annual average daily traffic and annual average weekday traffic (AAWT) count databases. AAWT counts were used wherever possible, and DDOT 2015 counts were grown to 2016 based on historical AADTs.

The screenline volumes were within the FHWA model validation thresholds but not the VDOT model validation threshold for screenline analyses. As a result, the project team decided to conduct a more detailed calibration effort for the subarea model to achieve the required level of confidence for the traffic forecast.

**VALIDATING THE MWCOG TRAVEL DEMAND MODEL TRIP PATTERNS**

The proportions of subarea trips traveling through, into, out of, or within the Rosslyn study area were compared between StreetLight Data and the MWCOG model to validate travel patterns. The results showed that the MWCOG model produced a magnitude of vehicular trips relative to the Rosslyn study area that closely match traffic counts and StreetLight Data (e.g., within 7%). As a result, the project team determined it was appropriate to use the MWCOG model for future traffic growth projection.

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<sup>28</sup> Screenline traffic volumes are the cumulative amount of traffic that passes through a defined imaginary line across several parallel links near the study area.

## 6.4 Post-Processing Travel Demand Model Outputs

*According to NCHRP 765, raw output data supplied by a travel demand model is rarely suitable for direct use.*

Regardless of whether a model has been modified or validated as part of the project, model outputs should be post-processed to develop link-level forecasts. There are multiple procedures to post-process the model outputs on a daily volume basis, as described in *NCHRP 765*.

Frequently, spreadsheet-based post-processing tools are used to refine or smooth model output data to develop

results throughout the study area that better match observed data.

A travel demand model is calibrated for regional trip generation, distribution, and assignment. However, at a local level, travel demand models can have inconsistencies and limitations on a link-by-link basis, as these models are not calibrated to the link level. Therefore, further adjustments or post-processing of the model's daily or peak-period outputs should be applied prior to use in an analysis. VDOT can provide model outputs from the Virginia Statewide Travel Demand Model and contact information for an MPO, who can provide model outputs for a region of the state (see **Section 4.2**). This section discusses various techniques for post-processing model outputs and considerations that must be made during post-processing, such as treatment of new or unbuilt facilities.

### 6.4.1 Factoring Procedures: Ratio, Difference, and Average Methods

Factoring procedures are simplistic procedures used to predict future-year volumes based on the relationships between existing conditions volumes, base-year model volumes, and future-year model volumes. There are three methods which are recommended to be assessed together in developing traffic forecasts:

- The **Ratio Method** is used to predict future-year traffic volume based on the relationship between base year traffic counts and base year model assignments. The assumption is that future facilities will be similar in nature to existing. Based on this assumption, future year volumes can be estimated by applying the ratio of the base year traffic count to the base year model assignment and multiplying by the future year model assignment. The calculation is as follows:

$$FF = \frac{FA}{BA} \times BC$$

Where:

FF = future-year forecast volume  
 BC = base year count  
 FA = future year model assignment  
 BA = base year model assignment

- The **Difference (or Delta) Method** is used to predict future year traffic volume based on the difference between base year traffic counts and base year model assignments. The calculation is as follows:

$$FF = (FA - BA) + BC$$

Where:

FF = future year forecast volume  
 BC = base year count  
 FA = future year model assignment  
 BA = base year model assignment

- The **Average Method** simply averages the results from the ratio and difference methods. A fundamental assumption of both the ratio and difference methods, as stated previously, is that future conditions will be similar in nature to existing conditions, including but not limited to land use, general development patterns, and the resulting traffic patterns within the area. Note that while *NCHRP 765* discusses averaging the results from the ratio and difference methods to reduce the extremes that may be reached using one of those methods, *NCHRP 765* does not recommend this hybrid adjustment. For a large-scale project, however, using only one preferred method may produce unreasonable results; therefore, VDOT recommends at the very least checking the outputs of all three methods.

When applying these methods, the model base year assignments should be checked for reasonableness before these actual methods are used. If the existing model volume is significantly higher than the actual count, then the future model forecasts would likely be over-forecasted. If the existing model volume is significantly lower than the actual count, then the future model forecasts would likely be under-forecasted.

#### **Sample Calculation: Factoring Procedures (Over-Forecast)**

A roadway link has an existing AADT of 10,000 vehicles per day (vpd), and the travel demand model shows an existing output of 11,000 vpd. There is a difference between the actual count and model forecast, meaning that there is a local-level error that would propagate into the future model run(s). In this case, the model forecast is higher than the existing count volume, so the model would likely over-forecast future volumes. The future year model shows a forecast of 18,000. The following steps in the adjustment process are described in more detail.

- Compute factors
  - Difference Factor:  $11,000 - 10,000 = +1,000$  (sign retention is critical in subsequent steps)
  - Ratio Factor:  $11,000 \div 10,000 = 1.1$
- Apply factors to model forecasted traffic volume
  - Difference Factor Method:  $18,000 - (+1,000) = 17,000$
  - Ratio Factor Method:  $18,000 \div (1.1) = 16,364$
  - Average Factors:  $(17,000 + 16,364) \div 2 = 16,682$
  - Final Forecast Volume: Rounded to 16,500

#### **Sample Calculation: Factoring Procedures (Under-Forecast)**

A roadway link has an existing AADT of 12,000 vpd, and the model shows an existing output of 11,000 vpd. In this case, the model forecast is lower than the count volume, so the model would likely under-forecast future volumes. The future year model shows a forecast of 16,000. The adjustment is required, as follows:

- Compute factors
  - Difference Factor:  $11,000 - 12,000 = -1,000$  (sign retention is critical in subsequent steps)
  - Ratio Factor:  $11,000 \div 12,000 = 0.917$
- Apply factors to model forecasted traffic volume
  - Difference Factor Method:  $16,000 - (-1,000) = 17,000$
  - Ratio Factor Method:  $16,000 \div (0.9) = 17,455$
  - Average Factors:  $(17,000 + 17,455) \div 2 = 17,227$
  - Final Forecast Volume: Rounded to 17,000

#### 6.4.2 Screenline Refinement with Base Volumes

This process improves upon link-by-link forecasts produced by a travel demand model by adjusting volumes across a screenline or a series of parallel links. Future volumes are adjusted across a screenline based on relationships among base year traffic counts, base year assignments, and future year link capacities. It should be noted that this procedure should be limited to situations in which reasonable screenline(s) can be constructed across parallel facilities. Further, more detailed examples of this process can be found within Chapter 6 of *NCHRP 765*.

- **Step 1. Define the screenline.** First, a screenline(s) must be defined, which should include, at a minimum, the next parallel facility to either side of the project facility. Multiple screenlines may need to be developed for longer corridors.
- **Step 2. Compile and compare traffic volumes.** The base-year traffic counts (e.g., existing counts or historical counts if base year is prior to the current year) and base year/future year model assignment volumes for all screenline links should be compiled. The analyst should check the deviation in total screenline traffic count volumes and model volumes; if this deviation is too large, the model may need to be modified and re-calibrated to better suit the study area or additional facilities may need to be added to the screenline.
- **Step 3. Adjust traffic volumes, if needed.** Volumes can be adjusted based on the ratio of the total count volume to the total model screenline volume as well as the ratios/differences between the individual counts and individual model volumes. Computations should be performed in a spreadsheet. Example spreadsheet setups are provided in *NCHRP 765*.

#### 6.4.3 Project Build Scenario Forecasting

Build scenario traffic forecasts can be developed starting from the no-build forecast or the base-year forecast. VDOT recommends that the no-build forecast be the basis upon which the forecast for all other build scenarios are ultimately based. Using the no-build forecast as a starting point allows the analyst and users of the forecast to maintain consistency with the forecasting assumptions used in developing the no-build forecast and directly compare the impacts of the project irrespective of other changes (land use or network) which also may have happened.

The following provides guidance on how to develop build traffic forecast based on three different scenarios.

- If the build project is determined to have little impact on traffic patterns by the project team, the no-build forecast can be used directly as the build forecast for traffic analysis
- If the build scenario is deemed to have regional impact on traffic flows, a build travel demand model scenario needs to be developed in addition to the no-build model scenario. Build project forecasts should be based on the relationship between model link volumes in the no-build and build scenarios.
- If the build scenario is deemed to only impact the travel patterns in the study area, the no-build forecast may be post-processed to develop build forecast. If a subarea modeling approach (**Section 6.4**) is used, no-build subarea volumes can be reassigned in the build subarea model to establish the relationship between the model volumes in the two subarea models.

**Example**

A two-lane express lane system is proposed adjacent to existing general-purpose lanes. Travel demand model output volumes and existing (2018) field counts are:

Facility	Travel Demand Model Outputs (Daily Volumes)			Existing (2018) Counts
	Existing (2018)	2045 No-Build	2045 Build	
Northbound General-Purpose Lanes	100,000	130,000	110,000	95,000
Northbound Express Lanes	-	-	30,000	-

Calculate the future forecast volumes for 2045 no-build and build conditions.

**SOLUTION**

1) Develop no-build volumes (general-purpose lanes)

- a. Calculate growth rate from transportation demand management (TDM) outputs

$$\left(\frac{130,000}{100,000} - 1\right) \div (2045 - 2018) = 1.1\%$$

- b. Apply growth rate to existing counts

$$95,000 * [1 + 1.1\% * (2045 - 2018)] = 123,500$$

2) Develop build volumes (general-purpose lanes)

- a. Difference Method

$$123,500 + (110,000 - 130,000) = 103,500$$

- b. Ratio Method

$$123,500 * \left(\frac{110,000}{130,000}\right) = 104,500$$

c. Average Method

$$\frac{(103,500 + 104,500)}{2} = 104,000$$

3) Develop build volumes (express lanes) using the relationship between express and general purpose TDM outputs and apply to the final general-purpose forecast volumes

a. Difference Method

$$104,000 + (30,000 - 110,000) = 24,000$$

b. Ratio Method

$$104,000 * \left(\frac{30,000}{110,000}\right) = 28,364$$

c. Average Method

$$\frac{(24,000 + 28,364)}{2} = 26,182$$

Round final daily volume to nearest 100 = 26,200

#### 6.4.4 Forecasting for New Facilities (Unbuilt in Existing Conditions)

New routes or bypass projects present more complex challenges for traffic forecasting than a traditional project such as a widening or interchange reconfiguration. Forecasts for traffic volumes along new facilities, represented in the build scenario, should not simply utilize the raw travel demand model output volumes for the build scenario. Rather, steps should be taken to review the proportional changes in model volumes along existing facilities between the no-build and build scenarios and use those proportions to refine the raw model volumes from the build scenario for the new facility. For example, see the following potential approaches from the North Carolina Department of Transportation (NCDOT).

- Develop screenline volumes (including additional parallel routes, if necessary) from the no-build and build models. Use these screenlines to develop a build/no-build ratio. Apply this ratio to the existing facility. The initial volume on the new facility will be the difference between the initial screenline and calculated volume for the existing facility.
- Calculate model build/no-build ratios to develop initial build estimates on all existing links along a screenline. Next, compare the initial build estimates on the screenline to the no-build estimates and use the total change as a starting point to estimate the volumes using a new bypass.

For estimating turning movements for new facilities, the Fratar method is recommended after estimating the corresponding link-level approach and departure volumes. An initial seeding estimate of turning movement percentages into and out of the new facility should be provided in the Fratar method. At the very least, all allowable movements may be set to the same proportion as a starting point.

#### 6.4.5 NCHRP 765 Volume Post-Processing (Fratat method)

The growth factoring methods discussed earlier in this section can be applied with Fratatar method to generate forecast intersection turning volumes. The steps for conducting Fratatar method are provided in **Section 5.2.2**.

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## 7 OTHER TECHNIQUES AND APPLICATIONS

### SECTION HIGHLIGHTS

#### **Section 7.1: Traffic Volume Balancing**

Overview of volume balancing techniques.

#### **Section 7.2: Origin-Destination (O-D) Matrix Estimation**

Overview of how to develop and apply O-D matrices that represent travel patterns within a study area.

#### **Section 7.3: Peak Spreading**

Overview of how to analyze and model peak spreading conditions.

#### **Section 7.4: Addressing Uncertainty in Project Traffic Forecasts**

Overview of how to address traffic forecast uncertainty, including guidance on performing a sensitivity analysis.

This chapter outlines other techniques and applications that can be used alongside the primary traffic forecasting methods discussed in **Chapter 5** and **Chapter 6**. These techniques and applications aim to supplement the primary methods by addressing the following subjects relating to traffic forecasting:

- Volume balancing
- O-D matrix estimation
- Peak spreading
- Uncertainty in traffic forecasting

### 7.1 Traffic Volume Balancing

Although traffic volume balancing is not directly related to traffic forecasting techniques, networks should be balanced to enhance the accuracy of traffic analyses. Small imbalances in existing traffic volumes when projected to the future can grow to have significant impacts on traffic analysis results. In addition, minor fluctuations in volumes can have significant impacts on microsimulation results.

It is not uncommon to find inconsistencies in traffic volumes between intersections when conducting a traffic analysis. The *National Cooperative Highway Research Program Report 765 (NCHRP 765)* notes that not only may variances between field counts and model volumes occur, there may also be inconsistencies between the traffic counts themselves. The *Traffic Operations and Safety Analysis Manual (TOSAM)* outlines several factors that may cause imbalances in the traffic volumes departing and arriving at each intersection. In all cases, an explanation for the volume balancing process should be provided in the traffic forecasting documentation. The Virginia Department of Transportation (VDOT) strongly recommends the overall end-to-end network imbalance be checked prior to volume balancing. Any inconsistencies in unbalanced field data should be documented, including any efforts made to resolve the inconsistencies (e.g., assume the imbalance between two intersections represents trips into/out of a midblock shopping center).

#### 7.1.1 Volume Balancing Tools

Manually balancing networks can be time and labor intensive and presents challenge with review and quality control, especially with large project areas. For this reason, VDOT recommends count data be

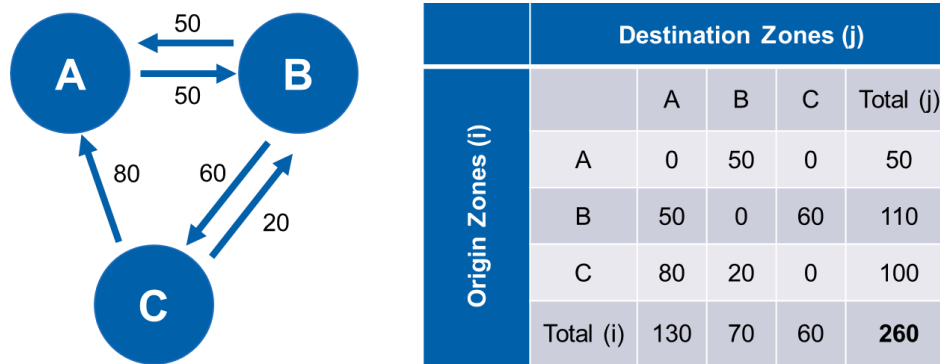
adjusted and balanced between upstream and downstream locations using Excel spreadsheets or other tools that can help with review and quality control.

In addition, Synchro can be used as a tool for traffic volume balancing, especially along arterial corridors where signal timing and other traffic analyses are being conducted. Synchro can display the traffic volume imbalance along a link, which can help expedite the balancing process. It is important to save a version of the Synchro network with the raw, unbalanced volumes for a comparison against the adjusted, balanced volumes.

## 7.2 Origin-Destination (O-D) Matrix Estimation

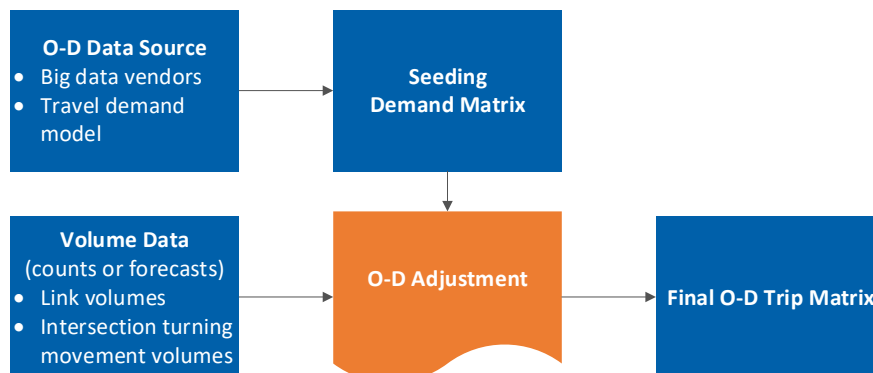
Planners and engineers use O-D matrices to represent travel patterns within a study area. An O-D matrix, shown in **Figure 27**, is comprised of rows and columns which represent origin or destination zones, and cells representing O-D pairs. The traffic volume moves between a specific origin and destination.

Figure 27: Example O-D Matrix



Observing O-D patterns in the field is the most accurate way of developing an O-D matrix; however, direct observation of every O-D pair is very labor intensive. For this reason, O-D Matrix Estimation (ODME) techniques are used to develop O-D matrices, to enhance the accuracy of travel demand model outputs and performance measures. The ODME process can be applied to both existing and future year scenarios. The existing conditions ODME process requires a significant amount of traffic count data as well as an initial O-D matrix which is the starting point for further adjustment. **Figure 28** illustrates the ODME process.

Figure 28: ODME Process



### 7.2.1 Developing O-D Trip Matrices for Existing Conditions

Developing O-D matrices for existing conditions is not directly related to traffic forecasting, but it provides baseline O-D matrices that can be used to develop trip matrices for future scenarios. Detailed ODME steps and techniques are outlined in VDOT’s Visum training material.<sup>29</sup>

### 7.2.2 Developing O-D Trip Matrices for Future Scenarios

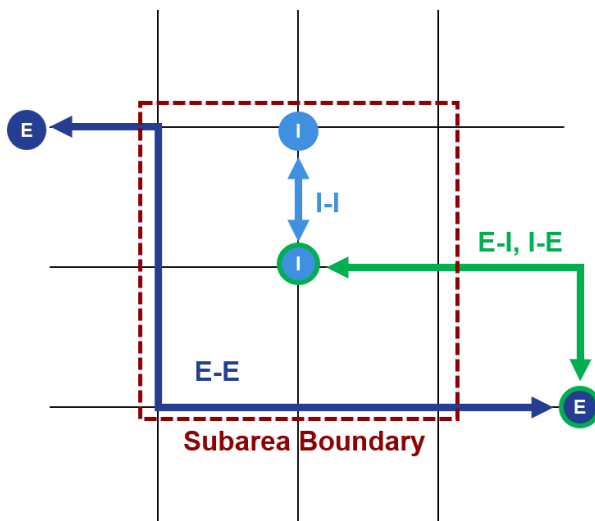
This section outlines two different approaches to develop O-D trip matrices for future scenarios. The first approach is illustrated in **Figure 28**. Like existing conditions, the ODME process requires a seeding matrix as a starting point for further adjustment. The seeding matrix comes from a travel demand model, and it is validated and refined using traffic forecast volumes.

The second approach involves dissecting trip matrices into three different types of vehicular trips, as listed in **Table 8** and depicted in **Figure 29**: 1) Internal-External, External-Internal (I-E or E-I); 2) External-External (E-E); and 3) Internal-Internal (I-I) which are relative to the study or project site.

**Table 8: Origin-Destination Trip Matrix**

Zones		Destination	
		Internal	External
Origin	Internal	I-I	I-E
	External	E-I	E-E

**Figure 29: External and Internal Trip Pairs**



I-E trips and E-I trips have either trip end inside the study area and are dependent upon the proposed land use and transportation facilities within the vicinity of the study area. E-E trips, on the other hand, are dependent upon factors outside the study area and are more influenced by regional travel behavior and patterns. It is essential to distinguish I-E and E-I trips from E-E trips when developing traffic forecasts if the trip characteristics are different. For example, an urban/suburban activity center with multimodal opportunities (e.g., pedestrian and bicycle facilities) that is located near congested regional highways may have drastically different trip making patterns for I-E and E-I, E-E, and I-I vehicular trips. In such cases, E-E trips may be expected to

grow at a milder pace than I-E and E-I trips due to capacity constraints, while I-I vehicular trips could have minimal growth due to multimodal opportunities. The goal for this approach is to identify growth patterns for each type separately. The process is described as follows.

<sup>29</sup> <http://www.virginiadot.org/business/manuals-default.asp>

**Step 1. Develop subarea model and trip matrices.** A subarea modeling approach described in **Chapter 6** can be applied to develop trip matrices that consist of three types of trips relative to the project site. The subarea should encompass the study area or project influence area. The subarea model is usually extracted from a regional travel demand model.

**Step 2. Develop a growth rate for each O-D pair in the trip matrices.** In this step, a growth rate matrix (the same size as the trip O-D matrix) is developed and applied to the existing trip matrix to develop a future scenario trip matrix. Growth rates should be refined and validated using an iterative process. Some guidance for considerations includes:

- Assessing trip growth for the three types of trips separately (E-E, I-E/E-I, and I-I, respectively) should be considered for large and complex roadway network improvement projects (e.g., small area plan, downtown street reconfiguration) when travel behavior change relative to the subarea may not be fully captured by regional travel demand model;
- Regional travel demand, due to the inherent ability to capture regional travel patterns, may be more an appropriate source of data for E-E trip growth;
- Analysts need to take land use and multimodal transportation facilities into consideration when developing I-E/E-I or I-I trip growth;
- I-E/E-I and I-I trip-growth can be reviewed and verified against socioeconomic and land use data and observed trip patterns. If land use patterns and transportation facilities shift to include more multimodal opportunities, I-E/E-I and I-I vehicular trip growth may need to be reduced according to alternative methods such as ITE trip generation and travel surveys. **Table 9** provides an example breakdown of effective growth rates for E-E, I-E/E-I, and I-I trips for a project.

**Table 9: Example Breakdown of Effective Growth Rates for O-D Pairs**

Trip Type	2017		2030		Effective Annual Growth
	Trips	% of Trips	Trips	% of Trips	
E-E	79,205	78.2%	81,353	72.0%	0.21%
E-I	7,775	7.7%	10,999	9.7%	3.19%
I-E	13,135	13.0%	19,165	17.0%	3.53%
I-I	1,178	1.2%	1,399	1.2%	1.45%
<b>Total Trips</b>	<b>101,294</b>	<b>100.0%</b>	<b>112,916</b>	<b>100.0%</b>	<b>0.88%</b>

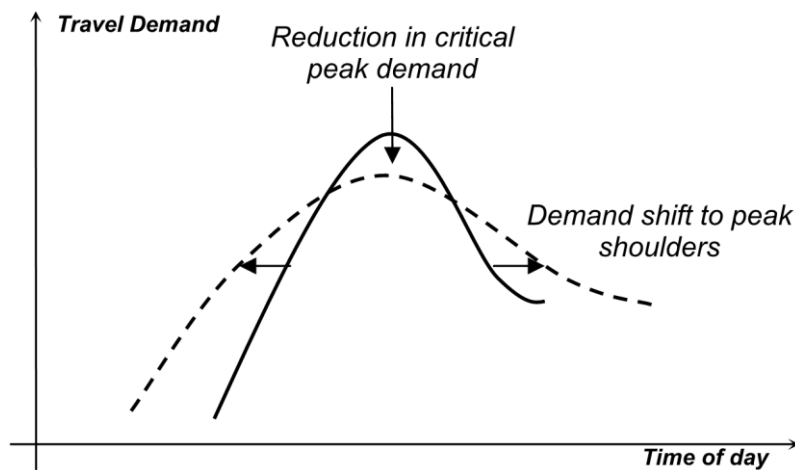
**Step 3. Develop trip matrices based on growth rates, assign trips to model network, and develop/post-process traffic forecast volumes.** A future trip matrix can be developed by applying the corresponding growth rates for E-E, I-E/E-I, and I-I trips developed in Step 2 to the existing trip matrix. The process to assign the future trip matrix to the transportation network consists of running the traffic assignment procedure in the subarea model. After that, link level traffic growth can be developed and traffic volumes post-processed following the steps outlined in **Section 6.4**.

## 7.3 Peak Spreading

Traffic analyses generally consider peak-hour traffic conditions to assess the roadway network. Although existing conditions may operate acceptably, once future traffic volumes are computed, traffic demand may be near or exceed the roadway capacity. To analyze and model realistic traffic conditions, peak spreading should be considered on a case-by-case basis to appropriately develop future traffic demand for the facilities under evaluation.

Peak spreading describes conditions where a large traffic demand is spread across multiple hours due to capacity constraints—such as a bottleneck—and subsequent driver behavior changes, as shown in **Figure 30**. Peak spreading due to capacity constraints occurs when increased traffic causes delays, extending travel time and the peak period. In addition, peak spreading due to driver behavior occurs when drivers adjust travel plans to avoid unacceptable travel conditions or travel times. This could mean changing departure time (e.g., leaving earlier or later than typical commuting period) or mode of travel.

**Figure 30: Peak Spreading Representation**



Source: Australasian Transport Research Forum

Peak spreading usually occurs in heavily congested urban/suburban study areas and corridors where high demand and congestion sustains over multiple hours in the peak period. In rural areas, traffic demand and congestion usually concentrate in a shorter period time, and therefore, peak spreading is less likely to occur. Peak spreading could occur under existing conditions and projected future conditions. Under existing conditions, hourly traffic counts collected represents throughput traffic volumes when demand exceeds capacity, and the excessive demand is processed over a multi-hour period when congestion dissipates; however, there is a lack of industry standard to accurately estimate existing peak hour demand traffic volume under peak spreading conditions which creates challenge for project level traffic forecasting under such conditions.

### 7.3.1 Identifying Peak Spreading Conditions

A peak hour factor (PHF) approaching 1.0 is a good indicator of peak spreading conditions; as traffic conditions become more consistent across each 15-minute interval, the PHF increases. In addition, sharp peaks in the diurnal curve, which shows the distribution of daily hourly traffic, may indicate peak spreading conditions. The diurnal curve can be developed using data collected from short-term

classification counts or permanent count stations. Data collected in 5-minute or 15-minute increments should be summarized in hourly increments. Hourly data can be requested from VDOT.

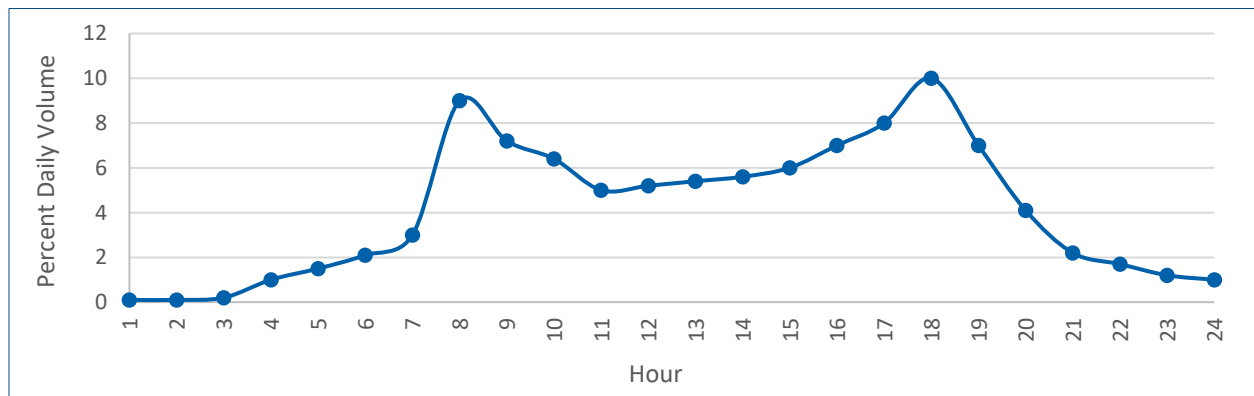
A sample diurnal calculation is provided in **Table 10**. The corresponding curve is shown in **Figure 31**. Each hourly volume in the table is divided by the daily total volume to obtain the percentage of daily traffic. The maximum percentage represents the k-factor, with the respective time representing the peak hour.

Diurnal curves may be used to convert daily link-level forecasts to hourly volumes. If the forecast includes two travel directions, daily-to-hourly volume ratios should be applied to the two-way daily link volume to produce two-way hourly volumes. A directionality factor can be applied to the two-way peak-hour volumes to produce directional peak-hour volumes. The calculation assumes that the diurnal (hourly percentage of the daily total) obtained from classification counts remains constant in future years. In areas of congestion, it is likely that peak spreading will occur, and some adjustments to the factors will need to be made, such as assuming a lower hourly-to-daily ratio, also known as the k-factor, in future conditions.

**Table 10: Sample Diurnal Calculation**

AM			PM		
Start Time	Volume	Percentage of Daily	Start Time	Volume	Percentage of Daily
12:00 AM	4	0.1%	12:00 PM	190	5.4%
1:00 AM	4	0.1%	1:00 PM	197	5.6%
2:00 AM	7	0.2%	2:00 PM	211	6.0%
3:00 AM	35	1.0%	3:00 PM	246	7.0%
4:00 AM	53	1.5%	4:00 PM	281	8.0%
5:00 AM	74	2.1%	5:00 PM	352	10.0%
6:00 AM	105	3.0%	6:00 PM	246	7.0%
7:00 AM	316	9.0%	7:00 PM	144	4.1%
8:00 AM	253	7.2%	8:00 PM	77	2.2%
9:00 AM	225	6.4%	9:00 PM	60	1.7%
10:00 AM	176	5.0%	10:00 PM	42	1.2%
11:00 AM	183	5.2%	11:00 PM	35	1.0%

**Figure 31: Sample Diurnal Curve**



### 7.3.2 Peak Spreading Techniques

Forecasting without a travel demand model often faces a lack of capacity constraint as analysts apply traffic growth rates to existing traffic volumes. As such, post-processing techniques are applied to address the phenomenon associated with peak spreading. *NCHRP 765* explains that peak spreading techniques allow analysts to: 1) Develop more realistic hourly forecast volumes based on a capacity constraint and 2) Demonstrate the prolonged congestion effects temporally.

It is important to capture the effects of residual demand when demand exceeds capacity, but this condition alone does not necessitate applying peak spreading. By contrary, the decision to apply peak spreading techniques is dependent upon study area traffic flow characteristics, such as sustained congestion with demand exceeding capacity over an extended period as well as regional travel behavior. Travel demand models are often insensitive to peak spreading since they focus on daily and peak period traffic forecasts; however, it is possible for a model to assign additional traffic to a roadway segment over the hourly operational capacity constraint.

A basic approach to peak spreading, as documented in *NCHRP 765*, is as follows:

**Step 1. Establish existing daily trip distribution.** Gather continuous hourly traffic counts to generate a curve, similar to **Figure 32-A**. Ensure that count data collected extends beyond the peak hour or covers a large enough time band to establish a peak period. *Note: This count-based diurnal distribution does not represent a true demand distribution of congestions and high traffic volumes persist over extended period.*

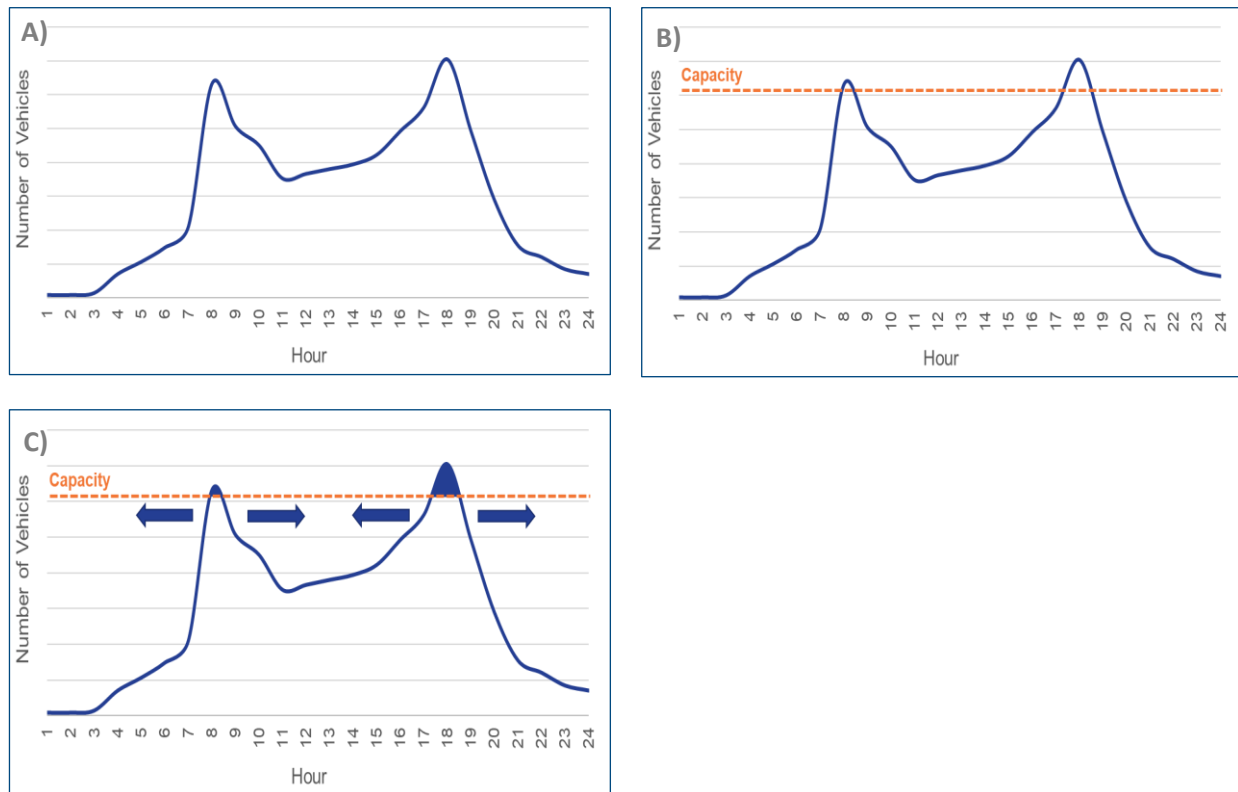
**Step 2. Determine the future year hourly traffic volume profile.** Factor the base year traffic volume profile using growth rates calculated by methods described in **Chapter 5**. *Note: Depending upon study area traffic flow patterns and regional travel behavior, peak period or peak hour traffic volumes may be forecasted using existing traffic counts during peak spreading. The forecasted peak period or peak hour volumes can then be used to estimate hourly volumes for shoulder hours based on capacity constraints.*

**Step 3. Identify hourly capacity.** Calculate the roadway capacity per the *Highway Capacity Manual*.

**Step 4. Determine which hours of future traffic volumes surpass capacity.** **Figure 32-B** illustrates an example comparison of hourly traffic volumes to the roadway capacity. The roadway exceeds capacity at 6:00 PM.

**Step 5. Shift excess demand to shoulder hours.** Trips affected by bottlenecks leave at their original times but take longer to complete due to congestion. As such, some demand may be shifted to the period prior to the peak hour to replicate the peaking of demand volumes and the resulting flattening and descending of throughput volumes due to congestion (e.g., traffic counts collected only represent the constrained throughput volumes). The unserved demand should be shifted to period after the peak hour. For trips resulting from driver behavior change, demand shifts earlier or later based on driver preference. For these trips, identify the portion of trips that will be shifted based on the project area characteristics (e.g., availability of travel demand management program and incentives). **Figure 32-C** illustrates the shift in excess demand.

Figure 32: Peak Spreading Technique



## 7.4 Addressing Uncertainty in Project Traffic Forecasts

The accuracy of a traffic forecast is affected by the uncertainty that exists from factors such as:

- Character and size of future land use
- Traveler decision-making characteristics including mode choice
- Influence of the surrounding transportation network
- Evolving technologies

In addition, evolving technology, such as connected and autonomous vehicle impacts and shared mobility, are likely to have a large impact on travel behavior as well as other factors mentioned above. As such, no traffic forecast is perfect. Analysts should recognize and acknowledge the uncertainty inherent in project traffic forecasts that have a longer horizon year (e.g., more than 20 years), appropriately document the factors, and explore hypothetically or retrospectively the sensitivity of traffic forecasts in terms of how changes to the forecast would impact consequent project design, implementation, and return on investment.

It is important to realize how forecast uncertainty impacts investment decisions. The Virginia Transportation Research Council (VTRC) conducted a study which examined previous studies to determine the accuracy of forecasts and assumptions inherent in applying various techniques. The study included 39 projects where the current year (of the VTRC study) had exceeded the forecast year from the project. For each segment, a percent error was calculated based on the percent difference between the forecast volume and the observed volume. The average median absolute percent error was



40 percent, ranging from one percent to 134 percent amongst the 39 projects. The research team concluded the following factors affected the magnitude of the forecast:

- Forecast type (e.g., peak hour volume versus a 24-hour volume)
- Forecast method
- Forecast horizon
- Economic variations between the base year and forecast year

**Figure 33** illustrates how traffic forecast uncertainty can affect project development, noting the ranges in traffic volume forecasts based on different recommended improvements. To mitigate these uncertainties, each stage of the forecasting process should be well documented. In addition, a sensitivity analysis can be conducted as a way of checking the analysis for reasonability; however, a sensitivity analysis should not be used to replace the process and steps described in the earlier chapters to develop a robust traffic forecast. The following sections describe potential approaches to explore the sensitivity of traffic forecast.

**Figure 33: Traffic Forecast Uncertainty Impacts on Project Development**



### 7.4.1 Sensitivity Analysis

Conducting a traffic sensitivity analysis is a way of asking what-if questions to help understand the impact of forecast uncertainty. Sensitivity analyses depend on how far the forecasts reach to the future and the impact of various factors on forecasts. There is not a one-size-fits-all way of conducting a sensitivity analysis to achieve a reasonable traffic forecast and applying engineering judgement also is key to understanding and addressing the inherent uncertainty in traffic forecast and the risk associated with the project planning and development process. A key part of the traffic forecasting analysis is also documenting assumptions so it is clear what has and hasn't been considered as well as how it was considered.

#### *Land Use and Trip Generation*

Changes in future land use patterns can have a major impact on traffic forecasts, especially for a distant horizon year. For example, uncertainty in development trends (e.g., likelihood or scale of an activity center) and population growth near a project site during a 20– to 25–year period may warrant some degree of assessment of potential scenarios of development patterns if land use is deemed a critical factor that drives the traffic growth in the study area. The same may be said for the uncertainty in vehicular trip rates 25 years from now, especially considering emerging mobility options such as shared mobility and connected and autonomous vehicles. As such, the trip making characteristics that are associated with the intensity and type of land use should be closely reviewed based on the best information available.

### ***Transportation Network***

The future transportation network, including alternative modes to vehicle travel, is another factor that can influence forecasts. When alternative modes of transportation are available and popular in the study area, the traffic forecast should take that into account. For example, vehicular trip rates for a proposed development next to high-capacity transit facilities should be reviewed closely. In such a case, a regional travel demand model may not produce trip generation characteristics that match the transit-oriented land use, and additional analysis may need to be conducted. This could include applying retrospective data, including surveys or field observed counts, from other areas with similar land use to replace the rate from the regional model. Not addressing such situations would lead to over-forecasted traffic volumes.

### ***Project Phasing and Return on Investment***

Traffic forecasters sometimes develop not only long-term forecasts but near-term or mid-range forecasts to understand the near-term benefit in comparison to cost. This is important because projects that can be implemented in a near- to mid-term range to address transportation congestion and safety needs on a cost-effective basis are more likely to be funded. As such, near-term improvements or phased improvements are recommended to be submitted for funding applications as part of the project planning and development process, such as in Strategically Targeted Affordable Roadway Solutions (STARS). The questions about the longevity of such improvements remain, but sometimes it is not in the best interest of a project from a return on investment and from a funding constraint point of view to look 20 or 25 years into the future to determine an ultimate solution for an issue that needs immediate attention. In this case, it is important not to exclude a project even if a long-term forecast may yield undesirable operations for the proposed project; rather, the forecast should examine how much longer or at what level of demand a proposed project can still perform at an acceptable level. A sensitivity analysis or interpolation of growth trends lacking in better information about the future beyond the near- and mid-term may be necessary to understand the impact on traffic operations and change in benefit/cost relationship when compared to a long-term ultimate improvement.

### ***Technology***

Perhaps the biggest unknown factor to traffic forecasters and entire transportation industry is disruptive technologies and their resulting impact on traveler behavior and transportation infrastructure/land use. The rise of new urban shared mobility options—such as transportation network companies (e.g. Uber, Lyft, etc.), bikeshare, and E-Scooters— is already changing the way people travel. The advancement of connected and autonomous vehicles (CV/AVs) and shared mobility technology will further alter how people travel and nearly everything else relating to traffic forecast like trip rates, flow mix, etc. It is important that traffic forecasters acknowledge such an impact and take that into consideration when developing plans and designing for a transportation solution. In the near-term before more empirical data relating to shared mobility and CV/AVs becomes available to practitioners, it is important to conduct sensitivity analysis assuming a potential impact from these technologies.

## APPENDIX A: REFERENCE LIST

*Updated Administrative Guidelines for the Traffic Impact Analysis Regulations.* Virginia Department of Transportation, December 2018. Web.

<[http://www.virginiadot.org/projects/resources/TIA\\_Administrative\\_Guidelines.pdf](http://www.virginiadot.org/projects/resources/TIA_Administrative_Guidelines.pdf)>

*Interstate System Access Informational Guide.* Federal Highway Administration, August 2010. Web.

<<https://www.fhwa.dot.gov/design/interstate/pubs/access/access.pdf>>

*Local Area Personal Income and Employment Methodology.* Bureau of Economic Analysis, 2017. Web.

<<https://apps.bea.gov/regional/pdf/lapi2016.pdf>>

*National Cooperative Highway Research Program Report 765: Analytical Travel Forecasting Approaches for Project-Level Planning and Design.* Transportation Research Board of the National Academies, 2014.

Web. <[http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp\\_rpt\\_765.pdf](http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_765.pdf)>

*Traffic Analyses to Support NEPA Studies.* Virginia Department of Transportation, November 2016. Web.

<[http://www.virginiadot.org/projects/resources/Chapter\\_1\\_NEPA\\_Tiering\\_Process.pdf](http://www.virginiadot.org/projects/resources/Chapter_1_NEPA_Tiering_Process.pdf)>

*Traffic Operations and Safety Analysis Manual (TOSAM) — Version 2.0.* Virginia Department of

Transportation, February 2020. Web. <<http://www.virginiadot.org/business/resources/TOSAM.pdf>>

*Travel Demand Modeling Policies and Procedures.* Virginia Department of Transportation, 2014. Web.

<[https://www.virginiadot.org/projects/resources/vtm/VTM\\_Policy\\_Manual.pdf](https://www.virginiadot.org/projects/resources/vtm/VTM_Policy_Manual.pdf)>

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## APPENDIX B: TRAFFIC FORECASTING PROMPT LIST

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## VDOT Traffic Forecasting Prompt List

This prompt list is intended to be used during the traffic forecasting process. While this list covers common elements of a traffic forecast, it should not be used as the sole guidance for traffic forecasting. Refer to the Virginia Department of Transportation (VDOT) *Traffic Forecasting Guidebook* for guidance on the traffic forecasting process, including scoping, data collection, forecasting methodologies, and other techniques.

TRAFFIC FORECASTING SCOPING <sup>1</sup>	
<u>Project type:</u> <input type="checkbox"/> Statewide and Regional Planning <input type="checkbox"/> Corridor and Project Planning <input type="checkbox"/> Traffic Impact Analysis (TIA) <input type="checkbox"/> Design and Implementation Project <input type="checkbox"/> Other, specify _____	
<input type="checkbox"/> Determine the project objective, purpose, and need. <input type="checkbox"/> Review guidance and policies that affect the scoping of traffic forecasting.	
<input type="checkbox"/> Determine forecast analysis scenarios.	<u>Year:</u> _____
<input type="checkbox"/> Determine if a regional travel demand model is available.	<input type="checkbox"/> Yes, model: _____ <input type="checkbox"/> No
<input type="checkbox"/> Select forecasting method based on project impact and characteristics.	
Project Characteristics and Proposed Methodology	
<u>Project size:</u> <input type="checkbox"/> Small, Non-Development Project <input type="checkbox"/> Small, Development Project <input type="checkbox"/> Large, Non-Development Project <input type="checkbox"/> Large, Development Project	
<u>Project area type:</u> <input type="checkbox"/> Stable Growth Area <input type="checkbox"/> High Growth Area <u>Project Impact:</u> <input type="checkbox"/> Low <input type="checkbox"/> Medium <input type="checkbox"/> High	
<u>Proposed method:</u> <input type="checkbox"/> Establish project schedule, including model validation and calibration strategy, if applicable. <input type="checkbox"/> Review previously developed traffic forecasts within the project study area, if available. <input type="checkbox"/> Submit scope to VDOT project manager for approval.	
Project Scoping Meeting	
<u>Meeting Date:</u> _____	
Contact Information	
Project Manager (Administering Agency) <sup>2</sup>	<u>Name:</u> _____ <u>Organization:</u> _____ <u>Email:</u> _____
Project Manager (Delivering Agency) <sup>3</sup>	<u>Name:</u> _____ <u>Organization:</u> _____ <u>Email:</u> _____
Traffic Forecasting Stakeholders	<u>Name, Role:</u> _____ <u>Name, Role:</u> _____ <u>Name, Role:</u> _____

<sup>1</sup> Refer to Chapter 3 of the VDOT *Traffic Forecasting Guidebook* for guidance on project scoping, including definitions of project type, project size, project area type, and project impact.

<sup>2</sup> The project manager at the Administering Agency initiates the project. Typically, the administering project manager is within VDOT, a locality, or other agency. Refer to the VDOT *Traffic Operations and Safety Analysis Manual (TOSAM)* Chapter 9 for additional information.

<sup>3</sup> The project manager at the Delivering Agency is responsible for delivering the project. The delivery project manager may be a consultant. Refer to the TOSAM Chapter 9 for additional information.



## TRAFFIC FORECASTING DATA SOURCES

Review the available data sources listed in **Chapter 4** of the VDOT *Traffic Forecasting Guidebook*.

Data used for traffic forecast:

- VDOT Traffic Count Data    VDOT Statewide Planning System (SPS)    Pathways for Planning (P4P)  
 Strategically Targeted Affordable Roadway Solutions (STARS) Map    Economics and Demographic Data  
 OnTheMap    Other:

## TRAFFIC FORECASTING TECHNIQUE

**Development Project Traffic Forecasts (if applicable)**

Select appropriate trip generation methodology for analysis.

Trip Generation Methodology:

- Institute of Transportation Engineers (ITE) Trip Generation  
 Non-ITE Trip Generation for Mixed-Use Development  
 Other:

**Trend Analysis (if applicable)**

- Gather historical traffic count data  
 Gather travel demand model outputs, if applicable.  
 Balance existing traffic volumes prior to traffic forecasting.  
 Select a trend analysis method and perform the analysis.  
 Apply the approved growth rate(s) to existing volumes.

**Apply Travel Demand Model (if applicable)**

- Determine how the travel demand model will be used. Refer to **Chapter 6** of the Traffic Forecasting Guidebook.  
 Convert daily link volumes to peak-hour link and turning movement volumes, if necessary.

## DOCUMENTATION

- Document forecasting assumptions, methods, and analysis results.  
 Obtain VDOT approval on forecast volumes and documentation.  
 Upload traffic forecasts to the VDOT SPS and/or P4P

Designee responsible for uploading documentation:

Designee organization:

Designee email: