Abstract

# Volume 2: Traffic Forecasting Methodologies

## Contents

Chapter 1. Introduction .................................................................................................................. 1  
1.1 Manual Structure ...................................................................................................................... 1  
1.2 Purpose of Volume 2 ............................................................................................................... 2  
1.3 NCHCRP 255 & NCHRP 765 Background ............................................................................... 2  
1.4 Resources ............................................................................................................................... 3  
1.5 StreetLight Data ...................................................................................................................... 3  

Chapter 2. Data and Parameters .................................................................................................. 4  
2.1 Data Collection Guidelines ..................................................................................................... 4  
2.2 Roadway Functional Classification .......................................................................................... 5  
2.3 Vehicle Classification ............................................................................................................. 5  
2.4 AADT Estimation .................................................................................................................... 6  
2.4.1 Traffic Count Expansion ...................................................................................................... 7  
2.4.2 Seasonal Adjustment .......................................................................................................... 7  
2.4.3 Partial Count Factor Form .................................................................................................. 8  
2.4.4 Queue Counts .................................................................................................................... 10  
2.5 Peak Hour Selection ............................................................................................................... 11  
2.5.1 Peak Hour Time Periods ...................................................................................................... 11  
2.5.2 System Peak Hour .............................................................................................................. 11  
2.6 Balancing and Smoothing ...................................................................................................... 12  
2.6.1 What is Balancing and Smoothing? .................................................................................. 12  
2.6.2 When is Balancing or Smoothing Required? .................................................................... 12  
2.6.3 How to Balance or Smooth Traffic Forecasts ................................................................. 13  
2.6.4 Factors to Consider When Balancing and Smoothing ..................................................... 14  
2.7 Factors (K, D) ....................................................................................................................... 15  
2.7.1 Design Hour Volume ......................................................................................................... 15  
2.7.2 K-Factor Determination Methods ..................................................................................... 17  
2.7.3 D-Factor Determination Methods .................................................................................... 20  
2.7.4 Impact of Land Use .......................................................................................................... 21  
2.8 Examples ............................................................................................................................... 21  
2.8.1 AADT Turning Movement Estimation ............................................................................. 21  
2.8.2 System Peak Hour Selection ............................................................................................. 25
5.4.2 Template ................................................................. 84
5.4.3 Transmittal Letter .................................................... 85

5.5 Technical Memorandums ............................................. 86
  5.5.1 Count Evaluation ................................................. 86
  5.5.2 Growth Rate Evaluation ........................................ 86

5.6 Technical Report ........................................................ 87
  5.6.1 Content Guidance ................................................. 87
  5.6.2 Appendices/Exhibits ............................................. 88

5.7 Filesharing Guidelines ............................................... 89

5.8 Certification ............................................................. 90
This page intentionally left blank.
Chapter 1. Introduction

The Ohio Traffic Forecasting Manual is intended to support and document the process managed by the Ohio Department of Transportation’s Office of Statewide Planning & Research, Modeling & Forecasting Section (ODOT M&F). The Manual documents the policies and procedures for Ohio traffic forecasts and serves as guidelines for other entities producing traffic forecasts.

Traffic forecasting dates back to the 1930s when the United States Bureau of Public Roads (later the Federal Highway Administration or FHWA) first started the federal financing of highway projects. From the very beginning, traffic counts were collected and growth rates were applied to produce a travel demand forecast used for planning and design purposes. Over 70 years later, the fundamental process is very similar although it has grown significantly more complex.

Throughout this document the following symbols are used to indicate:

- Items that are required or suggested for documentation
- Times that are required or suggested for coordination with ODOT M&F

1.1 Manual Structure

The purpose of this manual is to provide information and guidance on preparing traffic forecasts. The intended audience includes project managers, the end users of the traffic forecasts (traffic analysts and designers), developers of forecasts and travel demand forecasting modelers. The manual contents are developed based on both ODOT M&F’s policies and on other industry-wide methodologies and practices. The manual has been divided into three volumes:

1. Traffic Forecasting Background
2. Traffic Forecasting Methodologies
3. Travel Demand Forecast Modeling
1.2 Purpose of Volume 2

Volume 2 focuses on the forecast concepts and step-by-step instructions on how to develop and document traffic forecasts. Users of Volume 2 should already have an understanding of the information contained within Volume 1.

1.3 NCHCRP 255 & NCHRP 765 Background

NCHRP 765: Analytical Travel Forecasting Approaches for Project-Level Planning and Design (NCHRP 765), published in 2014, is the primary travel forecasting documentation available to industry professionals. It documents the “methods, data sources, and procedures for producing travel forecasts for highway project-level analyses.” The design traffic forecasting procedures detailed in Volume 2 are based on, and referenced in, these NCHRP documents.

A full understanding of NCHRP 765 requires an understanding of NCHRP 255: Highway Traffic Data for Urbanized Area Project Planning and Design (NCHRP 255). NCHRP 255, published in December 1982, documented the various techniques used by different state and local agencies to estimate future traffic volumes. NCHRP 255 was the first comprehensive traffic forecasting guide available to state and local agencies. NCHRP 765 is an update to NCHRP 255.

Exhibit 1-1, a table provided in NCHRP 765, identifies the procedures documented in NCHRP 255 and their applicability to NCHRP 765. The procedures have been categorized into four categories: (1) Obsolete, to be replaced with improved procedure, (2) Inadequate, limited applicability, improved procedure available, (3) Still valid, and (4) Not applicable. The primary procedures that have been maintained from NCHRP 255 to NCHRP 765 include Chapter 8 (Turning Movement Procedures) and Chapter 10 (Directional Distribution Procedures).
1.4 Resources

- **Traffic Monitoring Management System (TMMS)** is a web portal which stores and displays ODOT Continuous Count Data (AADT and Hourly), Short Term Count (AADT Estimates and Hourly), and Local Traffic Counts.
- **Transportation Information Mapping System (TIMS)** is a web-mapping portal for viewing the most current information on Ohio's transportation system, creating maps, and downloading GIS data.
- **Function Classification Maps** are provided at the county level for rural areas and in more detail for urban areas.
- The **Hourly Percent by Vehicle Type Report** shows the percentage of car and truck traffic for each hour of the day, by roadway functional classification.
- The **Seasonal Adjustment Factor Report** provides the average seasonal adjustment factor by month of year and day of week, summarized by functional classification of highway.
- The **K&D Factor Report** is a database of, among others, K-Factors and D-Factors derived from ODOT’s continuous count stations.
- The **Peak Hour to Design Hour Factor Report** contains factors relating the counted peak hour volume to the design hour volume, summarized by roadway functional classification, day of week, and month of year.
- **NCHRP Report 255** and **NCHRP Report 765** form the basis for all traffic forecasting procedures described in this Manual.
- [ODOT Division of Planning, Statewide Planning & Research, Modeling & Forecasting Section Homepage](#)
- [ODOT Division of Planning, Office of Technical Services Homepage](#)

1.5 StreetLight Data

StreetLight Data is an analytics company that organizes and interprets anonymous location data to provide meaningful travel metrics with high spatial accuracy. Using a series of proprietary algorithms, sample data obtained from cell phone towers and GPS satellites is converted into a comparative index that can be used to identify the relative proportion of vehicle trips beginning, ending, or passing between various origin and destination zones.

In 2017, ODOT completed the purchase of Statewide origin-destination data from StreetLight. The data is accessible to any public agency or University within Ohio. It can also be made temporarily available to any consultant working on a public agency’s projects; consultant access is limited to use on those public agency projects. All users of StreetLight Data must complete introductory training before access will be granted by the Office of Roadway Engineering. This data is being used to validate travel demand forecasting (TDF) model results and subsequently improve the accuracy of traffic forecasts. It can also be used to estimate weaving volumes when TDF model results are not available.
Chapter 2. Data and Parameters

2.1 Data Collection Guidelines

While Volume 1 provides information on the concepts and data collection guidelines, the information presented in this section offers additional detail and examples of how to use the data. Traffic monitoring data guidelines for design traffic forecasts are defined in ODOT’s compiled *Guidelines for Traffic Counts Used for Forecasts Certified for Roadway Design* and are summarized in Table 2-1.

Data collected by the Office of Technical Services, Traffic Monitoring Section is available through the Traffic Monitoring Management System (TMMS or MS2). Additional data on local roads and at intersections may be available through the MPO, if applicable. The remaining data required to fulfill these guidelines should be collected through the project’s count program.

### Table 2-1. Summary of Traffic Monitoring Data Guidelines

<table>
<thead>
<tr>
<th></th>
<th>Continuous</th>
<th>Short-Term</th>
<th>Intersection Turning Movement</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Definition</strong></td>
<td>Permanently installed or temporarily placed upon request; provide the annual traffic data at their location</td>
<td>Obtained using portable machine counters; typically installed for a continuous 24 to 48 hour period</td>
<td>Collected at intersections to determine turning movements; typically conducted on a single day surrounding the peak commute periods</td>
</tr>
<tr>
<td><strong>Location(s)</strong></td>
<td>Varies, as available in study area</td>
<td>All ramps, arterials, and collectors in the study area, unless AADT &lt; 1,000 vpd</td>
<td>All study intersections where turn movements forecasts are requested.</td>
</tr>
<tr>
<td><strong>Source(s)</strong></td>
<td>ODOT TMMS/MS2 (if available)</td>
<td>ODOT TMMS/MS2, MPO, Project count program</td>
<td>ODOT TMMS/MS2, MPO, Project count program</td>
</tr>
<tr>
<td><strong>Features</strong></td>
<td>N/A</td>
<td>Hourly intervals, directional, classified</td>
<td>15-min intervals, classified</td>
</tr>
<tr>
<td><strong>Duration</strong></td>
<td>N/A</td>
<td>Minimum 24 hours, preferred 48 hours</td>
<td>Minimum of eight (8) hours; twelve (12) hours if midday peak</td>
</tr>
</tbody>
</table>
2.2 Roadway Functional Classification

Highway functional classification is used to establish design criteria for various roadway features. Roadways are assigned to one of the seven (7) classifications within a hierarchy, as shown in Table 2-2, according to the character of travel service each roadway provides. Functional classifications are further defined by denoting whether the road is in a rural or urban area.

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Interstate</td>
</tr>
<tr>
<td>02</td>
<td>Freeway/Expressway</td>
</tr>
<tr>
<td>03</td>
<td>Other Principal Arterial</td>
</tr>
<tr>
<td>04</td>
<td>Minor Arterial</td>
</tr>
<tr>
<td>05</td>
<td>Major Collector</td>
</tr>
<tr>
<td>06</td>
<td>Minor Collector</td>
</tr>
<tr>
<td>07</td>
<td>Local</td>
</tr>
</tbody>
</table>

Table 2-2. Functional Classification of Roads

2.3 Vehicle Classification

As explained in Volume 1, all traffic count data should be classified into “cars” and “trucks”. The selected factors for AADT estimation, detailed in Section 2.4, are based on the classification type. For the purpose of selecting factors, “cars” includes motorcycles, passenger cars, panel (four-tire) trucks and pick-up trucks (i.e. Passenger & A Commercial, or P&A). “Trucks” then includes all other vehicles such as single-unit trucks, tractors with semi-trailers, trucks with trailers, recreational vehicles, and school and commercial buses (i.e. B & C Commercial, or B&C). These definitions are related to the FHWA Scheme F classification number as shown in Table 2-3. Depending on the source of the data, counts may be classified using a system that is different than, but related to, the FHWA Scheme F classification. Table 2-3 provides equivalencies for the Ohio Turnpike’s classification system as well as vehicle length.
### Table 2-3. Minimum Classification for Traffic Monitoring Data

<table>
<thead>
<tr>
<th>FHWA Scheme F Classification</th>
<th>Description</th>
<th>Minimum Classification</th>
<th>Equivalencies</th>
<th>Turnpike Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Motorcycles</td>
<td>Passenger Cars</td>
<td>0 - 22' (Short)</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Passenger Cars</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Other Two-Axle, Four-Tire, Single Unit Vehicles</td>
<td>A Commercial</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Buses</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Two-Axle, Six-Tire, Single Unit Trucks</td>
<td>C Commercial</td>
<td>22.1 - 40' (Medium)</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>Three-Axle Single Unit Trucks</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Four or More Axle Single Unit Trucks</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Four or Less Axle Single Trailer Trucks</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Five-Axle Single Trailer Trucks</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Six or More Axle Single Trailer Trucks</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Five or Less Axle Multi-Trailer Trucks</td>
<td>B Commercial</td>
<td>&gt;40.1' (Long)</td>
<td>6</td>
</tr>
<tr>
<td>12</td>
<td>Six-Axle Multi-Trailer Trucks</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Seven or More Axle Multi-Trailer Trucks</td>
<td></td>
<td></td>
<td>7</td>
</tr>
</tbody>
</table>

### 2.4 AADT Estimation

Model results, and thus traffic forecasts, are based on AADT volumes and then factored down to the design hour of the year (usually 30th highest hour) as necessary. For most segments, a full year of count data is typically not available for calculating the actual AADT; AADT estimation is therefore a vital portion of the traffic forecasting process as it stands today.

Growth rates may be different during peak periods compared to daily conditions due to congestion and network constraints. ODOT is therefore moving towards the use of period model results instead of AADT model results for forecast development. However, period model results are being validated on a case-by-case basis and are not always available for forecasting purposes. Thus, most traffic forecasts are based on AADT model results at this time. However, all procedures covered in this manual can be adapted to the use of period level model results if the hours covered by the model period are known. More precise guidance on these adaptations will be provided in the future as it becomes necessary.

Values for AADT are readily available along freeway ramps and mainline sections through TMMS. Short-term counts will cover a full 24-hour period at minimum, providing a value of ADT that can be seasonally adjusted to AADT using the procedures outlined in Section 2.4.2.
Intersection turning movement counts are nearly always partial day (less than 24 hour) counts. Partial day counts must first be extrapolated to estimate 24-hour turning movement volumes following the approach in Section 2.4.1; the volumes are then seasonally adjusted to AADT. The conversion of partial day counts to AADT can be done using the Partial Count Factor Form described in Section 2.4.3. As an example, Section 2.8.1 shows how to estimate AADT from partial day intersection turning movement counts.

2.4.1 Traffic Count Expansion

Traffic volumes are not evenly distributed throughout the day. Commuter traffic during a few short hours in the AM and PM usually accounts for a significant amount of the total daily traffic. It is therefore important to identify the daily distribution of traffic volumes to estimate the amount of total daily traffic if a 24-hour count is not available. These AADT turning movement volumes at intersections are used to calculate the 8th highest hour factor, necessary for signal warrants, and to verify K-factors. Additionally, AADT turning movement volumes are required inputs for the NCHRP factoring procedures discussed in Chapter 3.

ODOT recommends machine counts characterizing the hourly distribution of traffic on at least one approach of each intersecting road, in addition to turning movement counts, for the purposes of traffic count expansion and to verify the accuracy of the turning movement count. If short-term count data is not available on any particular leg of the intersection, statewide averages may be used based on the functional classification of the road. The Hourly Percent by Vehicle Type Report published by the ODOT Office of Technical Services provides the statewide average hourly distribution of traffic for each functional class of road as obtained from short-term and continuous count data collected throughout the state. Whether location-specific or statewide average data is used, the process to expand partial day counts is the same.

2.4.2 Seasonal Adjustment

Travel patterns and traffic volumes vary by season. Seasonal changes in traffic could be influenced by school schedule, inclement weather, recreational land uses, and other factors. Applying seasonal factors to existing traffic counts allows for the normalization of the data to assure that the base traffic volumes are representative of typical conditions, or AADT.

AADT can only truly be determined from data collected for an entire year. As this data is typically not available, the ODOT Office of Technical Services has compiled seasonal adjustment factors for the purpose of estimating AADT from counted daily traffic.

ODOT provides seasonal adjustment factors on the Division of Planning, Office of Technical Services website. The seasonal adjustment factors are calculated from the most recent years’ data obtained from over 200 continuous count stations across the state. The factors are categorized by functional classification and are summarized by month and day of week. The most current version of this data, contained in the Seasonal Adjustment Factor Report, should be used for newly conducted counts.

It is important to note that these seasonal adjustment factors are to be applied to both car and truck volumes. Previous practice was to seasonally adjust car volumes only as truck volumes were thought to remain relatively steady throughout the year. However, evaluation of continuous count station data has shown that there is merit to seasonally adjusting truck volumes as well; truck volumes are relatively stable throughout the year but typically vary by
day of week. At present, the same seasonal adjustment factor is applied to all classifications of vehicles, although future reports may be segregated into car and truck factors.

2.4.3 Partial Count Factor Form

ODOT has created a Partial Count Factor Form to estimate AADT turn movements from peak hour turning movement volumes. To utilize this tool, the user inputs classified turning movement counts along with the selected expansion factors and seasonal adjustment factors. The inputs for the Partial Count Factor Form are summarized in Table 2-4 and shown in Exhibit 2-1. If turning movement counts are not classified by car/truck, the user may input total volumes into the cells in Part 1 (rows 6 - 28) and choose expansion factors accordingly. Estimated AADT turn movements are plotted graphically (Exhibit 2-2) and can be used as a reference in the traffic forecasting documentation. The values are rounded to the nearest 10.

Table 2-4. Partial Count Factor Form Inputs and Outputs

<table>
<thead>
<tr>
<th>Cell Type</th>
<th>Column(s)</th>
<th>Row(s)</th>
<th>Title</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input</td>
<td>B</td>
<td>3</td>
<td>Date of Count</td>
<td>Date on which the count data was collected.</td>
</tr>
<tr>
<td>Input</td>
<td>B</td>
<td>6, 12, 18, 24, 32, 38, 44, 50</td>
<td>East/West/ North/South Leg</td>
<td>Road name by intersection leg.</td>
</tr>
<tr>
<td>Input</td>
<td>B - D</td>
<td>9, 15, 21, 27</td>
<td>P&amp;A Factor</td>
<td>Expansion factor applied to P&amp;A vehicles (cars) by leg, movement. Obtained from Hourly Percent by Vehicle Type Report.</td>
</tr>
<tr>
<td>Input</td>
<td>B - D</td>
<td>10, 16, 22, 28, 36, 42, 48, 54</td>
<td>Seasonal Factor</td>
<td>Seasonal adjustment factor applied to vehicles by leg, movement. Same factor is applied to car and truck volumes. Obtained from Seasonal Adjustment Factor Report.</td>
</tr>
<tr>
<td>Input</td>
<td>D</td>
<td>6, 12, 18, 24, 32, 38, 44, 50</td>
<td>FC</td>
<td>Roadway functional classification by intersection leg.</td>
</tr>
<tr>
<td>Input</td>
<td>E - G</td>
<td>8, 14, 20, 26</td>
<td>Left, Thru, Right</td>
<td>Total turning movement volume for P&amp;A vehicles (cars) summed over the duration of the count.</td>
</tr>
<tr>
<td>Input</td>
<td>E - G</td>
<td>34, 40, 46, 52</td>
<td>Left, Thru, Right</td>
<td>Total turning movement volume for B&amp;C vehicles (trucks) summed over the duration of the count.</td>
</tr>
<tr>
<td>Input</td>
<td>K - N</td>
<td>4, 30</td>
<td>Route</td>
<td>The major route for which the traffic forecast is being developed.</td>
</tr>
</tbody>
</table>
Exhibit 2-1. Partial Count Factor Form Inputs (P&A)

Exhibit 2-2. Partial Count Factor Form Outputs
2.4.4 Queue Counts

Traffic count data provides the number of vehicles that physically cross a point, or pass through an intersection, within a certain interval of time. In oversaturated conditions, it is likely that traffic count data does not reflect the true demand. In such cases, queue counts can be used to supplement traffic count data. Queue counts provide information regarding the number of vehicles within the queue at a specified location, which equates to the unmet demand after a certain time interval.

Queue counts are a special data request for Certified Design Traffic projects. The methodology for collecting queue count data will vary by project, although a typical approach is to measure the queue size at the end of every 15-minute interval at the beginning of the downstream traffic signal’s red phase. The need for queue count data, and the methodology used to obtain it, will be determined at the Early Coordination Meeting.

Table 2-5 illustrates an example set of queue count data. At the end of every 15-minute interval, the observer counts the number of vehicles in the queue that have not passed the count location the first time the signal turns red. The count location would be the approach stop bar at a signalized intersection. If a queue already exists prior to the start of the count, the starting queue should be captured as well. The queue size in vehicles could also be estimated by determining the length of the queue, in feet, and assuming approximately 20 feet per vehicle. It will sometimes be necessary to track the end of a queue through multiple upstream intersections. In such cases, the total queue size can be estimated by summing the available vehicle storage on links that are full, plus the queue size at the last upstream intersection.

<table>
<thead>
<tr>
<th>Time Interval End</th>
<th>Queue Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>4:15 PM</td>
<td>(7 veh)</td>
</tr>
<tr>
<td>4:30 PM</td>
<td>(15 veh)</td>
</tr>
<tr>
<td>4:45 PM</td>
<td>(10 veh)</td>
</tr>
<tr>
<td>5:00 PM</td>
<td>(3 veh)</td>
</tr>
</tbody>
</table>

Table 2-5. Example 15-minute Interval Queue Count Data
As shown in Table 2-6, the difference in queue counts between periods are added to the volume counts to obtain the true demand volume at the end of each 15-minute interval. The unmet demand for the full hour is equal to the queue size at the end of the hour. The ratio of the approach demand volume and counted approach volume can be used to factor individually counted turn movements to obtain demand turn movements for that period.

Table 2-6. Counted Volumes versus Demand Volumes

<table>
<thead>
<tr>
<th>Time Interval</th>
<th>(1) Counted Approach Volume (veh)</th>
<th>(2) Queue Size (veh) at End of Interval</th>
<th>(3) Queue Size (veh) at the End of Preceding Interval</th>
<th>(4) = (2) - (3) Unmet Demand (veh)</th>
<th>(5) = (1) + (4) Approach Demand Volume (veh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4:00 - 4:15 PM</td>
<td>221</td>
<td>7</td>
<td>0</td>
<td>7</td>
<td>228</td>
</tr>
<tr>
<td>4:15 - 4:30 PM</td>
<td>261</td>
<td>15</td>
<td>7</td>
<td>8</td>
<td>269</td>
</tr>
<tr>
<td>4:30 - 4:45 PM</td>
<td>238</td>
<td>10</td>
<td>15</td>
<td>(-5)</td>
<td>233</td>
</tr>
<tr>
<td>4:45 - 5:00 PM</td>
<td>190</td>
<td>3</td>
<td>10</td>
<td>(-7)</td>
<td>183</td>
</tr>
<tr>
<td>Total</td>
<td>910</td>
<td>35</td>
<td>32</td>
<td>3</td>
<td>913</td>
</tr>
</tbody>
</table>

2.5 Peak Hour Selection

2.5.1 Peak Hour Time Periods

Weekday AM and PM Peak Hour volumes are typically used for analysis purposes. In some cases, the Midday Peak Hour volumes may be higher than the AM Peak Hour volumes, however the AM Peak is still typically utilized unless extenuating circumstances exist. For areas where significant retail development exists, or in cases where the project is to conduct a Traffic Impact Study for a new commercial development, consideration may be given to choosing an alternative peak hour such as a Saturday Midday Peak or Saturday PM Peak. Alternative peak hours are typically utilized in addition to the Weekday AM and PM Peak Hours; substitution may be considered depending on the specific project and study area.

2.5.2 System Peak Hour

Peak hours are selected by reviewing data in 15-minute intervals. When there is more than one intersection within the study area, a consistent time period should be used for all intersections within a study area for developing an existing conditions traffic volume set, unless there is a reason that peak hours may vary. Larger projects are more likely to have variable peak hour start times at the intersections. For example, different peak hours may be warranted if a nearby school causes the peak hour of one corridor to vary from others or if a corridor is so long or heavily congested that it takes 15 minutes or more for a platoon to travel the corridor.
When choosing the peak hour volumes for a study area with multiple intersections, verify for reasonableness by asking the following:

- What are the individual intersection peaks or primary roadway peaks?
- Are they close to the same time?
- Are most of them the same time?
- For those intersections that are not the same time, do they have wider peaks, such that it wouldn’t be significantly fewer vehicles to use a different Peak Hour?
- What is the peak hour for the intersections with the highest overall volume?

An example of system peak hour selection is found in Section 2.8.2.

### 2.6 Balancing and Smoothing

Inconsistencies between locations in existing count data or design traffic forecasts often exist for multiple reasons including:

- Presence of other intersecting roadways
- Variations in growth rates
- Base count variations (collected on varying days, slight variations in count equipment clocks, counter error)

#### 2.6.1 What is Balancing and Smoothing?

Balancing and Smoothing are two processes by which differences between traffic volume data at two nearby locations (data points) are reduced or eliminated completely. These terms are defined as follows:

- **Balancing** refers to the process of eliminating the traffic volume difference between two points completely.
- **Smoothing** is used to reduce the traffic volume differences to reasonable levels as determined by the forecaster.

#### 2.6.2 When is Balancing or Smoothing Required?

Balancing or smoothing is **not required** on all design traffic forecasts. Balancing is typically required when a difference in volume is calculated between two data points and there are no intersecting roadways or driveways between the points to account for the discrepancy. The most common condition where balancing would be required is at an interchange.

Without any intersecting roadways between two interchange ramps, the traffic volumes between those two points, or intersections, should be completely balanced (i.e., difference = 0). Intersecting roadways or driveways can be any facility that would allow traffic to enter or exit the roadway between the two points, including alleys.
Smoothing is typically conducted when intersecting roadways or driveways exist between the data points, but the volume difference calculated is inconsistent with the amount of traffic carried by the intersecting roadway. For example, if the volume difference calculated between two points is 300 vehicles per hour and the only intersecting roadway between the two points is a driveway that provides access to a 20-space parking lot, it is unlikely that the parking lot would account for the volume difference calculated. Thus, smoothing would be required to create a more reasonable difference in link volumes.

2.6.3 How to Balance or Smooth Traffic Forecasts

The following methods are suggested for balancing/smoothing design traffic forecasts:

- **Split the Difference**: Add half of the total link imbalance to the lower volume intersection and subtract the remainder of the total link imbalance to the higher volume intersection.
- **Higher Volume Distributed**: Use the higher volume from one intersection to override the lower volume of the adjacent intersection and then distribute the volume difference based on the existing turning movement count distributions.
- **Higher Volume Through**: Use the highest volume and carry it through the other locations adding the excess traffic only to the through movements.
- **Spreadsheet Link Volume Forcing**: Use the link volume forcing option of the NCHRP 255 spreadsheet to automatically balance/smooth volumes. This method should be used with caution and does not always produce the desired outcome if convergence cannot be reached. More information on this option can be found in Section 3.6.4.
- **Combination**: A combination of all or some of the other methods. For example, the NCHRP Override process may be used first to get the volumes closer to being balanced, and then a combination of the Higher Volume Distributed method at the internal intersections and the Higher Volume Through at the network termini could be used.

A summary of the positive and negative aspects of each of these methods is provided in Table 2-7. Balancing and smoothing require a high level of professional judgement, and thus, the calculations should be well documented regardless of the method chosen. In most cases, a balancing and smoothing graphic should be developed to show the differences in volumes applied to each individual turning movement. These methods are examples of commonly applied balancing/smoothing techniques; it is acceptable to use other methods if justification is provided.

### Table 2-7. Balancing and Smoothing Methods

<table>
<thead>
<tr>
<th>Method</th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Split the Difference*</td>
<td>Realistic results</td>
<td>Time consuming, especially if multiple intersections are considered</td>
</tr>
<tr>
<td>Higher Volume Distributed*</td>
<td>Realistic results</td>
<td>Time consuming</td>
</tr>
<tr>
<td>Higher Volume Through</td>
<td>Ease of calculations</td>
<td>Unrealistic results</td>
</tr>
<tr>
<td>NCHRP Link Volume Forcing</td>
<td>Automated calculations</td>
<td>May not produce desired results</td>
</tr>
<tr>
<td>Combination</td>
<td>Realistic results</td>
<td>Time consuming</td>
</tr>
</tbody>
</table>

*Preferred Methods
While the final design traffic forecasts should be balanced/smoothed if warranted, existing volume sets do not necessarily need to be balanced prior to development of the design traffic forecast; this point will be decided at the Early Coordination Meeting. In any case, the existing volume set should be checked for significant discrepancies between counts. Section 2.8.3 includes an intersection balancing example using several of the techniques described above.

2.6.4 Factors to Consider When Balancing and Smoothing

The following factors should be considered when balancing traffic forecasts:

- Knowledge of the project area and professional judgement should be used when implementing balancing and smoothing. ODOT M&F may be consulted for further guidance.
- Existing volume sets do not require balancing/smoothing. However, using a balanced/smoothed existing volume set for input into the forecasting process may reduce the effort required to create a balanced/smoothed design traffic forecast. Balancing/smoothing existing traffic volumes may also be considered in order to avoid large and inconsistent discrepancies between the existing volumes and forecasted traffic volumes. The need for balancing/smoothing existing volumes will be determined at the Early Coordination Meeting. In any case, the existing volume set should be checked for large discrepancies between intersection counts.
- Balancing/smoothing must be conducted in a logical order as the adjustments will impact adjacent volumes. Typically, the balancing and smoothing operation starts at the edge of the study area and proceeds in order. Identification of breaks caused by long distances and/or major traffic generators between traffic forecast locations greatly aids this process, such breaks should be explicitly indicated on plates using a break line symbol.
- When balancing or smoothing, traffic volumes should not be reduced to a volume lower than the existing count unless justification exists.
- When increasing volumes during the process of balancing or smoothing, consider any unintended changes to the growth rate and the K-Factor. This situation may be unavoidable. It may be necessary to lessen the impact of such a change by reducing the raw forecast volume, while keeping it higher than the existing count, and then balancing.
- Balancing, instead of smoothing, should be considered even if an intersecting roadway or driveway exists between forecast intersections. For example, if the only intersecting roadway is a driveway to a single dwelling unit and the volume difference was calculated as 200 vehicles during the design hour, smoothing would be required given the unreasonableness of the volume difference relative to what would be generated by the driveway.
2.7 Factors (K, D)

2.7.1 Design Hour Volume

The K-factor (K) and D-factor (D) are primary design designations used in the traffic certification process. These factors both relate to the selected “design hour”. The AASHTO guide, A Policy on Geometric Design of Highways and Streets, also known as the Green Book, suggests that the 30th highest hour of the year be used for designing highways.

As explained in the Green Book, the traffic volume varies considerably during different hours of the day. Additionally, the traffic volume during any particular hour varies from day to day throughout the year. The design hour volume is a key criterion in roadway design, since using the highest hourly volume in the year might result in over-design. Similarly, using the average of all hourly volumes in a year as the design hour might result in an inadequate roadway design. The Green Book determined a best-suited hourly volume for design hour purposes by comparing the relationship between the highest hourly volumes against AADT from a wide range of traffic data collected under various geographic conditions. The charted curves from this data were reviewed and it was determined that the 30th Highest Hourly Volume of the year, abbreviated 30 HV, was best suited for use as the design hour volume in roadway design designations.

The 1965 Highway Capacity Manual was the source of most of the original research on selecting the optimal design period. The analysis is based on the graphical observation that traffic seems to change between the highest hour of the year and about the 200th highest hour of the year. Exhibit 2-3, taken from a continuous count station in Ohio, shows hourly traffic volumes for all the hours in the year 2006 at Station 153 (I-270 log point 16.030 in Franklin County) as well as volumes from the top 100 hours in the same year at the same location.
Exhibit 2-3. 2006 Data for Continuous Count Station 153 (I-270, Franklin County, Log Point 16.030)

As shown in the exhibit, there is a significant change in the traffic volumes between the first hour and the thirtieth hour. After the thirtieth hour, the change in volumes is roughly linear and follows a flatter slope. This point is sometimes referred to as the “knee” in the curve and is considered to separate “normal” operating conditions that should be considered in facility design from unusual operating conditions. As demonstrated in Exhibit 2-3, selection of alternative design hours (i.e. 30 HV, 50 HV, or 100 HV) will usually have little impact on the resulting traffic forecast. Design hours significantly greater than 100 HV could result in a dramatic change in the traffic forecasts; they are typically not used as the resulting design will not accommodate conditions that recur on most days.

Nonetheless, the 30 HV is not always selected as the design hour for a project. In some cases, a project-specific long-term count may be required to select the design hour. The design hour and the need for project-specific data will be chosen at the Early Coordination Meeting.
2.7.2 K-Factor Determination Methods

There are three main methods in which to determine the K-factor for a specific roadway. They are summarized as follows:

- **Continuous Count Station (or ATR) Data**: The only way to calculate the true K-factor of a facility is to obtain a full year’s worth of traffic count data. The K&D Factor Report is updated periodically by the ODOT Office of Technical Services and contains data, including K and D factors, for over 200 segments throughout the State of Ohio where Automatic Traffic Recorder (ATR) data is collected every day throughout the year. This report can be used to directly look up K-factors when a continuous count station is located on the facility near the study location. As an alternative, project-specific ATR data may be used to calculate the K-factor, if available.

The steps to calculate the K-factor from ATR data are as follows:

1. Determine the AADT:
   \[
   AADT = \frac{\text{Total Traffic, vehicles per year}}{365 \text{ days/year}}
   \]

2. Identify the design hour volume, DHV.

3. Calculate K:
   \[
   K = \frac{30 \ HV}{AADT}
   \]

- **Statewide Average DHV Factors**: ODOT’s Peak Hour to Design Hour Factor Report provides factors for converting peak hour volumes to design hour volumes based on the functional classification of the road, the day of week, and the month of year. Exhibit 2-4 shows an example of the data contained in this report for an Urban Principal Arterial road. All DHV factors in this report are based on the 30th highest hour volume, 30 HV.

Factors are statewide average peak hour to design hour ratios. This is the preferred method for determining design hour volumes unless (1) site-specific count data is available, or (2) an ATR exists that is a good match for the project location. If the latter is true, the Proxy K-factor method should be used over the Statewide Average DHV method. For very high-risk projects, both methods should be considered when selecting a K-factor.
EXAMPLE - Check website for most current version

PEAK HOUR to DESIGN HOUR FACTORS
FUNCTIONAL CLASSIFICATION = 03upa
(Urban Principal Arterial)

<table>
<thead>
<tr>
<th>Month</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
<th>Saturday</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>1.40</td>
<td>1.39</td>
<td>1.38</td>
<td>1.37</td>
</tr>
<tr>
<td>February</td>
<td>1.37</td>
<td>1.36</td>
<td>1.35</td>
<td>1.34</td>
</tr>
<tr>
<td>March</td>
<td>1.37</td>
<td>1.36</td>
<td>1.35</td>
<td>1.34</td>
</tr>
<tr>
<td>April</td>
<td>1.37</td>
<td>1.36</td>
<td>1.35</td>
<td>1.34</td>
</tr>
<tr>
<td>May</td>
<td>1.37</td>
<td>1.36</td>
<td>1.35</td>
<td>1.34</td>
</tr>
<tr>
<td>June</td>
<td>1.37</td>
<td>1.36</td>
<td>1.35</td>
<td>1.34</td>
</tr>
<tr>
<td>July</td>
<td>1.37</td>
<td>1.36</td>
<td>1.35</td>
<td>1.34</td>
</tr>
<tr>
<td>August</td>
<td>1.37</td>
<td>1.36</td>
<td>1.35</td>
<td>1.34</td>
</tr>
<tr>
<td>September</td>
<td>1.37</td>
<td>1.36</td>
<td>1.35</td>
<td>1.34</td>
</tr>
<tr>
<td>October</td>
<td>1.37</td>
<td>1.36</td>
<td>1.35</td>
<td>1.34</td>
</tr>
<tr>
<td>November</td>
<td>1.37</td>
<td>1.36</td>
<td>1.35</td>
<td>1.34</td>
</tr>
<tr>
<td>December</td>
<td>1.37</td>
<td>1.36</td>
<td>1.35</td>
<td>1.34</td>
</tr>
</tbody>
</table>

peak hour volume * factor = design hour volume

source: year 2013 & 2014 Automatic Traffic Recorders (ATR) Data
ATR STATIONS:
2014: 021, 028, 123, 202, 523, 538, 543, 544, 550, 585, 594, 605, 622, 725, 750, 764, 785, 768, 780
2013: 021, 028, 123, 202, 523, 538, 543, 544, 550, 585, 594, 605, 622, 725, 750, 764, 785, 768, 780

Ohio Department of Transportation
Modeling & Forecasting Section
November 2017

Exhibit 2-4. Example Statewide Average DHV Factors, Urban Principal Arterial

The DHV is calculated to the peak hour volume as follows:

\[ DHV = \text{Counted Peak Hour Volume}_{\text{site}} \times \text{DHV Factor} \]

In addition to the DHV, K-factors are required as a design designation and as input for post-processing methods. The resulting K-factor can be directly calculated as:

\[ K = K_{\text{count}} \times \text{DHV Factor} = \frac{\text{Counted Peak Hour Volume}_{\text{site}}}{\text{AADT}_{\text{site}}} \times \text{DHV Factor} \]
▪ **Proxy K-Factor:** If there is not a continuous count station located nearby, data contained in the K&D Factor Report can be paired with project site-specific data to estimate design designations. The K&D Factor Report lists all ATR stations by functional class and includes the location, AADT, DHV, and K-factor for each site. To select a Proxy K-factor, the forecaster should identify a facility or facilities that have the same functional classification, are in the same area type (urban vs. rural), and have similar magnitudes of AADT. Professional judgement should be used when assuming design designations from other facilities and other conditions bides those listed should be used if possible to select a location that is as similar as possible.

Proxy K-factors selected from this report must then be compared against the site-specific volume count by considering the resulting DHV factor:

\[
DHV \text{ Factor} = \frac{Design \text{ Hour Volume}}{Counted \text{ Peak Hour Volume}} = \frac{K \times AADT}{Counted \text{ Peak Hour Volume}}
\]

It is ODOT practice to assume that the counted peak hour volume is not higher than the design hour volume. If the Proxy K-factor yields a DHV Factor that is greater than one, then it is acceptable to use for estimating the design hour volume. If the Proxy K-factor yields a DHV Factor that is less than one, then the counted peak hour volume is taken as the design hour volume or the Statewide DHV Factor method is used.

The steps to select a K-factor using a Proxy K from ATR data contained within the K&D Factor Report include:

1. Identify one or multiple facilities with similar characteristics using the following criteria:
   a. Has the same functional classification
   b. Is in the same area type (urban or rural)
   c. Has similar magnitude of AADT
   d. Ideally is located in the same area of the state and/or in an area serving similar types of traffic

   The Proxy K-factor may be estimated from one single ATR location that best represents the site, or as an average of multiple facilities with similar characteristics.

2. Calculate the DHV Factor using the highest counted peak hour volume, the AADT estimated from the count, and the Proxy K-factor.

   \[
   DHV \text{ Factor} = \frac{Proxy \ K \times AADT_{site}}{Counted \text{ Peak Hour Volume}_{site}}
   \]

3. Check the Proxy K against site-specific data:

   If DHV Factor $\geq 1$, use Proxy K.

   If DHV Factor $< 1$, assume $K = K_{count} = \frac{Counted \text{ Peak Hour Volume}_{site}}{AADT_{site}}$ or use Statewide Average DHV Method
It should be noted that the Proxy K-Factor Method and Statewide Average DHV Method are fundamentally different. The latter method factors up a counted peak hour volume based upon statewide average DHVs, thus preserving counted peaking characteristics. The Proxy K-Factor, on the other hand, assumes the peaking characteristic on the design day through the selected Proxy K without regard to actual count day peaking. The Statewide Average DHV Factors method is preferred because these factors are given by functional classification, by day of week and by month of year which is assumed to account for typical differences between count day peaking and design day peaking. However, if the analyst has reason to believe that count day peaking was atypical, one of the other methods should be used (or new counts collected).

- **Project-Specific Long-Term Count Data:** If the available K-factor sources are not sufficient for estimating design hour traffic volumes, a long-term count must be collected within the project limits. In such cases, the Office of Technical Services may be contacted to install a project-specific ATR. If the project timeline permits, it is preferable to collect an entire year’s worth of count data for calculating the K-factor. When this is not possible, the K-factor can be estimated from a count duration that is shorter than one year. Existing ATR data suggests that the highest hourly volume of traffic occurring on a Friday in July may be a good indicator of the 30 HV. Nonetheless, the ODOT M&F does not recommend any one procedure for estimating the K-factor from a count of less than one year. Instead, the traffic forecaster should consider the available data and characteristics of the study area to recommend a procedure. The procedure used must be thoroughly documented and approved by the ODOT M&F.

### 2.7.3 D-Factor Determination Methods

The D-factor may be estimated with similar methods as the K-factor:

- **ATR Data:** The true D-factor of a facility may be obtained from a full year’s worth of data. The steps to calculate the D-factor from ATR data are as follows:
  1. Identify the 30th Highest Hour Volume of the entire year, 30 HV.
  2. Identify the directional 30th Highest Hour Volume, 30 HVD.

\[
D = \frac{30 \text{ HVD}}{30 \text{ HV}}
\]

- **Peak Hour Data:** Typically the D-factor observed during the peak hour ranges from 0.55 to 0.60. This means that during a typical peak hour, between 55% and 60% of the traffic flows in one direction (i.e., the peak direction). The D-factor may be greater for corridors that experience extreme peak flow conditions. The directional distribution of a roadway remains fairly consistent even though peak hour volumes may fluctuate daily or yearly. Thus, a D-factor calculated using existing data is a suitable estimate for use in the Design Year when there are no projected changes in travel patterns. In cases where planned projects include new facilities, new access points, or changes to the area land use, a different D-factor estimate may be required during the Design Year.

- **K&D Factor Report:** The K&D Factor Report can also be used to determine D-factors based on historic data.
2.7.4 Impact of Land Use

The forecaster must take into consideration the type of land uses that are being served by the facility when selecting design designations. Schools and factories frequently produce atypical K-factors and D-factors. It is not unusual for D-factors to exceed 0.70 on facilities that primarily serve those land use types. Mixed land use areas often have lower K-factors and evenly split directional distributions (50%/50%).

2.8 Examples

2.8.1 AADT Turning Movement Estimation

Location

- Columbus, OH (Urban)
- Intersection of W. Broad Street and Roys Avenue

Data Available

- Classified Turning Movement Count from 6:00 - 10:00 AM and 3:00 - 7:00 PM on Wednesday, September 7, 2016
- Classified 24-hour count on West Broad Street on Thursday, September 8, 2016
- W. Broad Street - Principal Arterial
- Roys Avenue - Local Road

The turning movement volumes collected at this intersection, summed from 6:00 - 10:00 AM and 3:00 - 7:00 PM, are illustrated in Exhibit 2-5.

In this example, machine counts have been obtained on the major intersecting road (W. Broad Street) but not on the minor intersecting road (Roys Avenue). The 24-hour count data obtained on W. Broad Street is summarized in Table 2-8. The charted profiles shown in Exhibit 2-6 illustrate the importance of obtaining classified traffic volumes for traffic forecasting.

The highlighted rows in Table 2-8 indicate the hours that are captured by the intersection turning movement count from 6:00 - 10:00 AM and 3:00 - 7:00 PM. The turning movement count therefore represents 48.3% of the daily car traffic and 54.3% of the daily truck traffic on W. Broad Street at this location. The turning movement count should then be extrapolated by the inverse of these percentages. The expansion factor applied to car volumes is 1/48.3% = 2.070 while the factor applied to truck volumes is 1/54.3% = 1.842.
### Table 2-8. Sample Counted Hourly Percent by Vehicle Type, W. Broad St

<table>
<thead>
<tr>
<th>Hour Start</th>
<th>Cars (P&amp;A)</th>
<th></th>
<th>Trucks (B&amp;C)</th>
<th></th>
<th>Total</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Volume</td>
<td>Percent of Total</td>
<td>Volume</td>
<td>Percent of Total</td>
<td>Volume</td>
<td>Percent of Total</td>
</tr>
<tr>
<td>12:00 AM</td>
<td>242</td>
<td>1.2%</td>
<td>4</td>
<td>0.7%</td>
<td>246</td>
<td>1.2%</td>
</tr>
<tr>
<td>1:00 AM</td>
<td>145</td>
<td>0.7%</td>
<td>4</td>
<td>0.7%</td>
<td>149</td>
<td>0.7%</td>
</tr>
<tr>
<td>2:00 AM</td>
<td>130</td>
<td>0.7%</td>
<td>1</td>
<td>0.2%</td>
<td>131</td>
<td>0.6%</td>
</tr>
<tr>
<td>3:00 AM</td>
<td>109</td>
<td>0.5%</td>
<td>2</td>
<td>0.4%</td>
<td>111</td>
<td>0.5%</td>
</tr>
<tr>
<td>4:00 AM</td>
<td>125</td>
<td>0.6%</td>
<td>5</td>
<td>0.9%</td>
<td>130</td>
<td>0.6%</td>
</tr>
<tr>
<td>5:00 AM</td>
<td>238</td>
<td>1.2%</td>
<td>9</td>
<td>1.7%</td>
<td>247</td>
<td>1.2%</td>
</tr>
<tr>
<td>6:00 AM</td>
<td>547</td>
<td>2.7%</td>
<td>31</td>
<td>5.7%</td>
<td>578</td>
<td>2.8%</td>
</tr>
<tr>
<td>7:00 AM</td>
<td>1,126</td>
<td>5.6%</td>
<td>37</td>
<td>6.9%</td>
<td>1,163</td>
<td>5.7%</td>
</tr>
<tr>
<td>8:00 AM</td>
<td>1,081</td>
<td>5.4%</td>
<td>50</td>
<td>9.3%</td>
<td>1,131</td>
<td>5.5%</td>
</tr>
<tr>
<td>9:00 AM</td>
<td>988</td>
<td>4.9%</td>
<td>38</td>
<td>7.0%</td>
<td>1,026</td>
<td>5.0%</td>
</tr>
<tr>
<td>10:00 AM</td>
<td>998</td>
<td>5.0%</td>
<td>28</td>
<td>5.2%</td>
<td>1,026</td>
<td>5.0%</td>
</tr>
<tr>
<td>11:00 AM</td>
<td>1,088</td>
<td>5.4%</td>
<td>34</td>
<td>6.3%</td>
<td>1,122</td>
<td>5.5%</td>
</tr>
<tr>
<td>12:00 PM</td>
<td>1,190</td>
<td>6.0%</td>
<td>35</td>
<td>6.5%</td>
<td>1,225</td>
<td>6.0%</td>
</tr>
<tr>
<td>1:00 PM</td>
<td>1,208</td>
<td>6.0%</td>
<td>32</td>
<td>5.9%</td>
<td>1,240</td>
<td>6.0%</td>
</tr>
<tr>
<td>2:00 PM</td>
<td>1,274</td>
<td>6.4%</td>
<td>37</td>
<td>6.9%</td>
<td>1,311</td>
<td>6.4%</td>
</tr>
<tr>
<td>3:00 PM</td>
<td>1,404</td>
<td>7.0%</td>
<td>44</td>
<td>8.1%</td>
<td>1,448</td>
<td>7.1%</td>
</tr>
<tr>
<td>4:00 PM</td>
<td>1,520</td>
<td>7.6%</td>
<td>38</td>
<td>7.0%</td>
<td>1,558</td>
<td>7.6%</td>
</tr>
<tr>
<td>5:00 PM</td>
<td>1,749</td>
<td>8.8%</td>
<td>35</td>
<td>6.5%</td>
<td>1,784</td>
<td>8.7%</td>
</tr>
<tr>
<td>6:00 PM</td>
<td>1,233</td>
<td>6.2%</td>
<td>20</td>
<td>3.7%</td>
<td>1,253</td>
<td>6.1%</td>
</tr>
<tr>
<td>7:00 PM</td>
<td>1,121</td>
<td>5.6%</td>
<td>17</td>
<td>3.1%</td>
<td>1,138</td>
<td>5.5%</td>
</tr>
<tr>
<td>8:00 PM</td>
<td>930</td>
<td>4.7%</td>
<td>14</td>
<td>2.6%</td>
<td>944</td>
<td>4.6%</td>
</tr>
<tr>
<td>9:00 PM</td>
<td>683</td>
<td>3.4%</td>
<td>11</td>
<td>2.0%</td>
<td>694</td>
<td>3.4%</td>
</tr>
<tr>
<td>10:00 PM</td>
<td>478</td>
<td>2.4%</td>
<td>9</td>
<td>1.7%</td>
<td>487</td>
<td>2.4%</td>
</tr>
<tr>
<td>11:00 PM</td>
<td>364</td>
<td>1.8%</td>
<td>5</td>
<td>0.9%</td>
<td>369</td>
<td>1.8%</td>
</tr>
<tr>
<td><strong>Daily Total</strong></td>
<td><strong>19,971</strong></td>
<td><strong>100.0%</strong></td>
<td><strong>540</strong></td>
<td><strong>100.0%</strong></td>
<td><strong>20,511</strong></td>
<td><strong>100.0%</strong></td>
</tr>
<tr>
<td><strong>Counted Total</strong></td>
<td><strong>9,648</strong></td>
<td><strong>48.3%</strong></td>
<td><strong>293</strong></td>
<td><strong>54.3%</strong></td>
<td><strong>9,941</strong></td>
<td><strong>48.5%</strong></td>
</tr>
</tbody>
</table>

*Note: Hours counted during turning movement count period highlighted in yellow.*
For Roys Avenue either the factors calculated for Broad Street or the statewide averages for hourly percent by vehicle type could be used in the absence of site-specific machine counts on Roys Avenue. A screenshot of the report summary for urban local roads is seen in Exhibit 2-7. From this report, it can be assumed that the turning movement count represents 51.5% of the daily car traffic and 49.6% of the daily truck traffic on Roys Avenue. The expansion factor applied to car volumes is $1/51.5\% = 1.942$ while the factor applied to truck volumes is $1/49.6\% = 2.016$. Applying these expansion factors to the counted volumes yields an estimated ADT for each movement (Table 2-9).

![Hourly Percent by Vehicle Type Report, Statewide Average, Urban Local Road](image)

The applicable seasonal adjustment factor tables for urban principal arterial (W. Broad Street) and urban local road (Roys Avenue) are shown in Exhibit 2-8. Based on 2015 continuous count station data, the seasonal adjustment factor is assumed to be 0.922 for volumes on the W. Broad Street approaches and 0.912 for volumes on Roys Avenue approaches. Since these values are below 1, the ADT on both intersecting roads is expected to be slightly higher than the annual average. The applied expansion factors, seasonal adjustment factors, and resulting AADT estimates are summarized in Table 2-9.
In this example, the short-term count data on W. Broad Street was collected on a different day (Thursday, September 8, 2016) than the intersection turning movement count data. It is preferable to collect all data on the same day if possible, but limited resources may prevent this. The 24-hour volumes on W. Broad Street would be seasonally adjusted by a factor of 0.897. The estimated AADTs can be compared to identify large discrepancies in the data sets.
2.8.2 System Peak Hour Selection

Location
  - Columbus, OH (Urban)
  - Eight (8) Intersections on W. Broad Street

Data Available
  - New Turning Movement Counts from 6:00 - 10:00 AM and 3:00 - 7:00 PM in September of 2016
  - Previous Turning Movement Counts from 7:00 - 9:00 AM and 4:00 - 6:00 PM in April and September of 2016

This example is a continuation of the project referenced in Section 2.8.1. For this project, design traffic was developed for a total of eight intersections on W. Broad Street in Columbus, OH. The study intersections are illustrated in Exhibit 2-9.

![Exhibit 2-9. Study Area, W. Broad Street, Columbus, OH](image)

The existing traffic count data used to prepare this forecast was obtained from a combination of sources. Previously collected traffic count data was available at three of the eight intersections and covered the timeframes of 7:00 - 9:00 AM and 4:00 - 6:00 PM. New eight-hour counts were conducted at the remaining five intersections from 6:00 - 10:00 AM and 3:00 - 7:00 PM. A system peak hour was selected from 7:00 - 9:00 AM and 4:00 - 6:00 PM due to the varying count durations.

The first step in determining a system peak hour is to identify the peaks for each individual intersection. The hourly total entering intersection volumes for the AM count window are summarized in Table 2-10. A majority of the intersections experience a morning peak in vehicular traffic volumes from 7:15 - 8:15 AM. This time frame also serves the largest aggregate volume across all intersections.
### Table 2-10. Sample Total Entering Intersection Volume, W. Broad Street, Columbus, OH

<table>
<thead>
<tr>
<th>Intersection No.</th>
<th>Count Month</th>
<th>7:00 – 8:00 AM</th>
<th>7:15 – 8:15 AM</th>
<th>7:30 – 8:30 AM</th>
<th>7:45 – 8:45 AM</th>
<th>8:00 – 9:00 AM</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4/14/16</td>
<td>1,156</td>
<td>1,223</td>
<td>1,196</td>
<td>1,154</td>
<td>1,119</td>
</tr>
<tr>
<td>2</td>
<td>9/26/16</td>
<td>1,258</td>
<td>1,326</td>
<td>1,287</td>
<td>1,248</td>
<td>1,201</td>
</tr>
<tr>
<td>3</td>
<td>9/26/16</td>
<td>1,163</td>
<td>1,217</td>
<td>1,205</td>
<td>1,150</td>
<td>1,133</td>
</tr>
<tr>
<td>4</td>
<td>9/07/16</td>
<td>1,283</td>
<td>1,345</td>
<td>1,321</td>
<td>1,265</td>
<td>1,234</td>
</tr>
<tr>
<td>5</td>
<td>4/20/16</td>
<td>1,521</td>
<td>1,532</td>
<td>1,535</td>
<td>1,593</td>
<td>1,664</td>
</tr>
<tr>
<td>6</td>
<td>9/26/16</td>
<td>1,323</td>
<td>1,332</td>
<td>1,312</td>
<td>1,335</td>
<td>1,280</td>
</tr>
<tr>
<td>7</td>
<td>9/26/16</td>
<td>1,289</td>
<td>1,295</td>
<td>1,279</td>
<td>1,302</td>
<td>1,290</td>
</tr>
<tr>
<td>8</td>
<td>9/26/16</td>
<td>1,328</td>
<td>1,350</td>
<td>1,334</td>
<td>1,331</td>
<td>1,310</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>10,321</strong></td>
<td><strong>10,620</strong></td>
<td><strong>10,469</strong></td>
<td><strong>10,378</strong></td>
<td><strong>10,231</strong></td>
</tr>
</tbody>
</table>

As an additional check, the difference in “system peak hour” volume and “actual peak hour volume” was determined. There is less than a 1% difference between the system peak hour volume and actual peak hour volumes for intersections #6 and #7. However, the actual peak hour volume at intersection #5 is 8% greater than the system peak which is partially accounted for by the different count day. The system peak hour is chosen as 7:15 – 8:15 AM.

In this example, the individual intersection peaks clearly pointed to a system peak hour. If this were not the case, other suggestions for selecting a system peak hour include:

- Identify the peak hour of the major street (W. Broad Street) at each intersection
- Consider the peak hour of the highest volume intersection(s)
2.8.3 Intersection Volume Balancing

Location

- Liberty Township, OH (Urban)
- Intersection of Cincinnati Dayton Road and SR 129 Westbound Ramps
- Intersection of Cincinnati Dayton Road and Yankee Road

Data Available

- Forecasted Design Hour Traffic Volumes

Design traffic was developed for two intersections on Cincinnati Dayton Road in Liberty Township, OH. There are no intersecting roads between these two points, and traffic volumes on the link of Cincinnati Dayton Road in between the two intersections must be balanced. The raw (unbalanced) design hour traffic volumes are illustrated in Exhibit 2-10. The volume imbalance is 210 vph in the northbound direction and 150 vph in the southbound direction.

Exhibit 2-10. Raw (Unbalanced) Design Hour Traffic Volumes, Cincinnati Dayton Road in Liberty Township, OH
Split the Difference Method

Using the Split the Difference Method, the traffic volumes at intersections #1 and #2 must both be altered.

The total imbalance in the southbound direction is 150 vph. Dividing this imbalance equally between intersections would result in an alteration of 75 vph; for rounding purposes, the southbound volume entering intersection #1 is decreased by 70 vph while the southbound volume exiting intersection #2 is increased by 80 vph.

The southbound volume entering intersection #1 is split into two movements:

\[
\text{#1 Southbound through: } \frac{2,210 \text{ vph}}{(2,210 \text{ vph } + 550 \text{ vph})} \times 70 \text{ vph} = 56 \text{ vph} \rightarrow 60 \text{ vph} \\
\text{#1 Southbound right: } \frac{550 \text{ vph}}{(2,210 \text{ vph } + 550 \text{ vph})} \times 70 \text{ vph} = 14 \text{ vph} \rightarrow 10 \text{ vph}
\]

Check: 60 vph + 10 vph = 70 vph  

The southbound volume exiting intersection #2 is contributed to by three movements: the westbound left turn, southbound through, and eastbound right turn movements. The amount that each of these movements is increased by is calculated as a proportion of their sum:

\[
\text{#2 Westbound left: } \frac{1,030 \text{ vph}}{(1,030 \text{ vph } + 1,070 \text{ vph } + 510 \text{ vph})} \times 80 \text{ vph} = 32 \text{ vph} \rightarrow 30 \text{ vph} \\
\text{#2 Southbound through: } \frac{1,070 \text{ vph}}{(1,030 \text{ vph } + 1,070 \text{ vph } + 510 \text{ vph})} \times 80 \text{ vph} = 33 \text{ vph} \rightarrow 30 \text{ vph} \\
\text{#2 Eastbound right: } \frac{510 \text{ vph}}{(1,030 \text{ vph } + 1,070 \text{ vph } + 510 \text{ vph})} \times 80 \text{ vph} = 16 \text{ vph} \rightarrow 20 \text{ vph} \\
\]

Check: 30 vph + 30 vph + 20 vph = 80 vph  

Similarly, the northbound imbalance of 210 vph may be corrected by subtracting 100 vph from the northbound volumes exiting intersection #1 and adding 110 vph to the northbound approach of intersection #2:

\[
\text{#1 Northbound through: } \frac{2,450 \text{ vph}}{(2,450 \text{ vph } + 1,270 \text{ vph})} \times 100 \text{ vph} = 66 \text{ vph} \rightarrow 70 \text{ vph} \\
\text{#1 Westbound right: } \frac{1,270 \text{ vph}}{(2,450 \text{ vph } + 1,270 \text{ vph})} \times 100 \text{ vph} = 34 \text{ vph} \rightarrow 30 \text{ vph} \\
\]

Check: 70 vph + 30 vph = 100 vph  

\[
\text{#2 Northbound left: } \frac{790 \text{ vph}}{(790 \text{ vph } + 1,590 \text{ vph } + 1,130 \text{ vph})} \times 110 \text{ vph} = 25 \text{ vph} \rightarrow 20 \text{ vph} \\
\text{#2 Northbound through: } \frac{1,590 \text{ vph}}{(790 \text{ vph } + 1,590 \text{ vph } + 1,130 \text{ vph})} \times 110 \text{ vph} = 50 \text{ vph} \\
\text{#2 Northbound right: } \frac{1,130 \text{ vph}}{(790 \text{ vph } + 1,590 \text{ vph } + 1,130 \text{ vph})} \times 110 \text{ vph} = 35 \text{ vph} \rightarrow 40 \text{ vph} \\
\]

Check: 20 vph + 50 vph + 40 vph = 110 vph
The final design hour traffic volumes, balanced using the Split the Difference Method, are illustrated in Exhibit 2-11.

![Exhibit 2-11. Balanced Design Hour Traffic Volumes Using Split the Difference Method, Cincinnati Dayton Road in Liberty Township, OH](image)

**Higher Volume Distributed Method**

Using the Higher Volume Distributed Method, the traffic volumes at intersection #2 must be increased to match #1.

The southbound volume exiting intersection #2 is increased by a total of 150 vph, proportioned between the contributing movements:

- **Westbound left:**
  \[
  \frac{1,030 \text{ vph}}{1,030 \text{ vph} + 1,070 \text{ vph} + 510 \text{ vph}} \times 150 \text{ vph} = 59 \text{ vph} \rightarrow 60 \text{ vph}
  \]

- **Southbound through:**
  \[
  \frac{1,070 \text{ vph}}{1,030 \text{ vph} + 1,070 \text{ vph} + 510 \text{ vph}} \times 150 \text{ vph} = 61 \text{ vph} \rightarrow 60 \text{ vph}
  \]

- **Eastbound right:**
  \[
  \frac{510 \text{ vph}}{1,030 \text{ vph} + 1,070 \text{ vph} + 510 \text{ vph}} \times 150 \text{ vph} = 29 \text{ vph} \rightarrow 30 \text{ vph}
  \]

**Check:**
\[
60 \text{ vph} + 60 \text{ vph} + 30 \text{ vph} = 150 \text{ vph} \quad \text{OK}
\]
The volumes on the northbound approach are then increased in a similar manner:

**Northbound left turn:**
\[
\frac{790 \text{ vph}}{(790 \text{ vph} + 1,590 \text{ vph} + 1,130 \text{ vph})} \times 210 \text{ vph} = 47 \text{ vph} \rightarrow 50 \text{ vph}
\]

**Northbound through:**
\[
\frac{1,590 \text{ vph}}{(790 \text{ vph} + 1,590 \text{ vph} + 1,130 \text{ vph})} \times 210 \text{ vph} = 95 \text{ vph} \rightarrow 90 \text{ vph}
\]

**Northbound right turn:**
\[
\frac{1,130 \text{ vph}}{(790 \text{ vph} + 1,590 \text{ vph} + 1,130 \text{ vph})} \times 210 \text{ vph} = 67 \text{ vph} \rightarrow 70 \text{ vph}
\]

**Check:**
\[
50 \text{ vph} + 90 \text{ vph} + 70 \text{ vph} = 210 \text{ vph} \quad \text{OK}
\]

The final design hour traffic volumes, balanced using the Higher Volume Distributed Method, are illustrated in **Exhibit 2-12**.

**Exhibit 2-12. Balanced Design Hour Traffic Volumes Using Higher Volume Distributed Method, Cincinnati Dayton Road in Liberty Township, OH**
Higher Volume Through Method

Using the Higher Volume Through Method, the northbound and southbound through volumes at intersection #2 would be increased by 210 vph and 150 vph, respectively. The final design hour traffic volumes, balanced using the Higher Volume Through Method, are illustrated in Exhibit 2-13.

2.8.4 Selecting a K-Factor

Location

- Liberty Township, OH (Urban)
- Intersection of Cincinnati Dayton Road and SR 129 Westbound Ramps

Data Available

- Classified Turning Movement Count from 6:30 - 9:00 AM and 4:00 - 7:00 PM on Monday, November 16, 2015
- Cincinnati Dayton Road - Minor Arterial
- SR 129 Westbound Ramps - Freeway

This example focuses on selecting and checking Proxy K-factors for the intersection of Cincinnati Dayton Road at the SR 129 Westbound Ramps. The counted AM and PM Peak Hour traffic volumes are illustrated in Exhibit 2-14. Based on these volumes, the PM Peak Hour services a larger volume of traffic and will be used to compute the K-factor. First, the AADT is estimated from the intersection turning movement counts using the Partial Count Factor form and the appropriate expansion and seasonal adjustment factors. The resulting AADT estimate is shown in Exhibit 2-15.

Exhibit 2-14. Counted Peak Hour Traffic Volumes, Cincinnati Dayton Road and SR 129 WB Ramps
The counted K-factor are computed as:

**North Leg:**

\[ K_{\text{Count,N}} = \frac{1,425 + 2,128}{22,170 + 22,580} \times 100\% = 8.1\% \]

**South Leg:**

\[ K_{\text{Count,S}} = \frac{1,201 + 1,275}{18,380 + 14,920} \times 100\% = 7.4\% \]

**East Leg:**

\[ K_{\text{Count,E}} = \frac{1,083}{9,080} \times 100\% = 11.9\% \]

**West Leg:**

\[ K_{\text{Count,W}} = \frac{454}{6,210} \times 100\% = 7.3\% \]

---

**Using Statewide Average DHV Factors**

The [Peak Hour to Design Hour Factor Report](#) is used to find a DHV factor for each intersecting road with count data collected on a Monday in November. Cincinnati-Dayton Road is classified as an urban minor arterial, and the selected DHV factor is 1.12 (Exhibit 2-16). SR 129 is an urban freeway with a DHV factor of 1.13 (Exhibit 2-17).

The K-factors can be calculated by applying these factors to the counted K-factor:

**North Leg:** \( K_N = 8.1\% \times 1.12 = 9.1\% \)

**South Leg:** \( K_S = 7.4\% \times 1.12 = 8.3\% \)

**East Leg:** \( K_E = 11.9\% \times 1.13 = 13.4\% \)

**West Leg:** \( K_W = 7.3\% \times 1.13 = 8.2\% \)
### Exhibit 2-16. Statewide Average DHV Factor, Urban Minor Arterial, Monday in November

<table>
<thead>
<tr>
<th>Month</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
<th>Saturday</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>1.22</td>
<td>2.01</td>
<td>1.20</td>
<td>1.23</td>
</tr>
<tr>
<td>February</td>
<td>1.17</td>
<td>1.91</td>
<td>1.25</td>
<td>1.17</td>
</tr>
<tr>
<td>March</td>
<td>1.31</td>
<td>1.92</td>
<td>1.26</td>
<td>1.27</td>
</tr>
<tr>
<td>April</td>
<td>1.13</td>
<td>1.56</td>
<td>1.15</td>
<td>1.13</td>
</tr>
<tr>
<td>May</td>
<td>1.15</td>
<td>1.56</td>
<td>1.10</td>
<td>1.19</td>
</tr>
<tr>
<td>June</td>
<td>1.27</td>
<td>1.62</td>
<td>1.25</td>
<td>1.26</td>
</tr>
<tr>
<td>July</td>
<td>1.27</td>
<td>1.64</td>
<td>1.29</td>
<td>1.27</td>
</tr>
<tr>
<td>August</td>
<td>1.21</td>
<td>1.64</td>
<td>1.25</td>
<td>1.21</td>
</tr>
<tr>
<td>September</td>
<td>1.10</td>
<td>1.57</td>
<td>1.12</td>
<td>1.10</td>
</tr>
<tr>
<td>October</td>
<td>1.10</td>
<td>1.51</td>
<td>1.10</td>
<td>1.10</td>
</tr>
<tr>
<td>November</td>
<td>1.14</td>
<td>1.61</td>
<td>1.12</td>
<td>1.20</td>
</tr>
<tr>
<td>December</td>
<td>1.12</td>
<td>1.67</td>
<td>1.15</td>
<td>1.11</td>
</tr>
</tbody>
</table>

### Exhibit 2-17. Statewide Average DHV Factor, Urban Freeway/Expressway, Monday in November

<table>
<thead>
<tr>
<th>Month</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
<th>Saturday</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>1.25</td>
<td>2.44</td>
<td>1.27</td>
<td>1.24</td>
</tr>
<tr>
<td>February</td>
<td>1.20</td>
<td>2.33</td>
<td>1.23</td>
<td>1.21</td>
</tr>
<tr>
<td>March</td>
<td>1.20</td>
<td>2.21</td>
<td>1.24</td>
<td>1.18</td>
</tr>
<tr>
<td>April</td>
<td>1.13</td>
<td>1.93</td>
<td>1.16</td>
<td>1.14</td>
</tr>
<tr>
<td>May</td>
<td>1.11</td>
<td>1.80</td>
<td>1.11</td>
<td>1.12</td>
</tr>
<tr>
<td>June</td>
<td>1.15</td>
<td>1.89</td>
<td>1.17</td>
<td>1.14</td>
</tr>
<tr>
<td>July</td>
<td>1.16</td>
<td>1.93</td>
<td>1.18</td>
<td>1.16</td>
</tr>
<tr>
<td>August</td>
<td>1.14</td>
<td>1.84</td>
<td>1.16</td>
<td>1.15</td>
</tr>
<tr>
<td>September</td>
<td>1.15</td>
<td>1.90</td>
<td>1.18</td>
<td>1.15</td>
</tr>
<tr>
<td>October</td>
<td>1.10</td>
<td>1.80</td>
<td>1.11</td>
<td>1.10</td>
</tr>
<tr>
<td>November</td>
<td>1.11</td>
<td>1.98</td>
<td>1.13</td>
<td>1.12</td>
</tr>
<tr>
<td>December</td>
<td>1.13</td>
<td>2.01</td>
<td>1.16</td>
<td>1.15</td>
</tr>
</tbody>
</table>
Using Proxy K-Factors

A Proxy K-factor is selected for each road using one or more similar facilities from the K&D Factor Report. For Cincinnati-Dayton Road, urban minor arterial roads with a similar AADT values are identified from the database of continuous count stations as shown in Exhibit 2-18. Roads of this functional classification typically have a K-factor of 9-14%, but the highest AADT of these roads is much lower than that calculated for Cincinnati Dayton Road. At this intersection, the AADT on Cincinnati Dayton is about 35,000 to 45,000 vpd, while the highest AADT represented by the continuous count stations is only 10,400 vpd for this functional classification. Data for urban principal arterial roads is then investigated for a closer AADT match. The data summarized in Exhibit 2-19 shows that there are two count stations with similar AADTs have a K-factor of 9-11%. A Proxy K of 10% is chosen for Cincinnati Dayton Road because this falls within the mid-range of K-factors for an urban minor arterial road.

For the SR 129 ramps, urban freeways/expressways are investigated for similar AADTs. The AADT of the SR 129 mainline should be considered in selecting a Proxy K-factor and not the AADT of the ramps alone. The AADT of mainline SR 129 ranges from 40,000 vpd to 45,000 vpd (not shown in Exhibit 2-15). K-factors for all urban freeway/expressway ATR locations are between 9% and 11.5%, and those locations with a similar AADT range to SR 129 have an average K-factor of 10%. A Proxy K-factor of 10% is chosen for the SR 129 ramps.
These K-factors are then checked by calculating the resulting DHV Factor on each leg:

**North Leg:**

\[
DHV\ Factor_N = \frac{10\% \times (22,170 + 22,580)}{1,425 + 2,128} = 1.26 > 1 \quad OK
\]

**South Leg:**

\[
DHV\ Factor_S = \frac{10\% \times (18,380 + 14,920)}{1,201 + 1,275} = 1.34 > 1 \quad OK
\]

**East Leg:**

\[
DHV\ Factor_E = \frac{10\% \times 9,080}{1,083} = 0.83 > 1 \quad Modify
\]

**West Leg:**

\[
DHV\ Factor_W = \frac{10\% \times 6,210}{454} = 1.37 > 1 \quad OK
\]

The K-factors as chosen yield DHV Factors of greater than one on all but the east leg of the intersection. In this case, the design hour volume for the east leg can be taken as the counted peak hour volume of 1,080 vph (rounded), and the K-factor would be:

\[
K_E = \frac{1,080}{9,080} \times 100\% = 11.9\% \approx 12\%
\]

Proxy K-factors are typically selected for a facility as a whole and not each individual link of road. However, the selected K-factor should be checked against the counted K-factor for each link. This check is integrated into the NCHRP 255 spreadsheet tool as discussed in Section 3.6.4.

The key takeaway from this example is that while selecting a Proxy K-factor is based on data, sufficient engineering judgment must be used to assess the data. The forecaster may deviate from the guidelines for selecting a similar facility based on their knowledge of the project area.

K-factors are selected for the highest peak hour only (AM or PM); design hour volumes for the lower peak hour(s) are estimated as a proportion of the higher design hour. DHV explicitly refers to a single hour (30 HV), however, traffic analysis typically includes at least two hours of data (AM peak and PM peak).
Table 2-11 provides a comparison of the chosen K-factors from each method. Since there was no urban minor arterial ATR with a similar AADT to Cincinnati-Dayton Road, it may be preferable to use the K-factors obtained from the Statewide Average DHV Factor method. However, both methods are acceptable. Both methods should be considered in cases where they yield drastically different values.

<table>
<thead>
<tr>
<th>Road Name</th>
<th>Leg</th>
<th>K-Factor</th>
<th>Statewide Average DHV Factor</th>
<th>K&amp;D Factor Report</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cincinnati-Dayton Road</td>
<td>North</td>
<td>9.1%</td>
<td>10%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>South</td>
<td>8.3%</td>
<td>10%</td>
<td></td>
</tr>
<tr>
<td>SR 129 WB On Ramp</td>
<td>East</td>
<td>13.4%</td>
<td>12%</td>
<td></td>
</tr>
<tr>
<td>SR 129 WB Off Ramp</td>
<td>West</td>
<td>8.2%</td>
<td>10%</td>
<td></td>
</tr>
</tbody>
</table>

2.8.5 Calculating D-Factor from Peak Hour Data

Location
- Liberty Township, OH (Urban)
- Intersection of Cincinnati Dayton Road and SR 129 Westbound Ramps

Data Available
- Classified Turning Movement Count from 6:30 - 9:00 AM and 4:00 - 7:00 PM on Monday, November 16, 2015
- Cincinnati Dayton Road - Minor Arterial
- SR 129 Westbound Ramps - Freeway

The counted PM Peak Hour traffic volumes at the study intersection, illustrated in Exhibit 2-21, are assumed to be representative of the directional volumes during the 30th Highest Hour of the year.

The directional factors on Cincinnati Dayton Road are calculated as:

North Leg:

\[ D_N = \frac{2,128}{2,128 + 1,425} = 0.60 \]

South Leg:

\[ D_S = \frac{1,275}{1,275 + 1,201} = 0.51 \]
Chapter 3. High Risk (Certified) Design Traffic Forecasting Procedure

Following the information provided in Volume 1, the High Risk Design Traffic forecasting procedure must be followed for roadway design projects that meet at least one of the following criteria:

- Classified as PDP Path 4 or 5
- Project adds or removes through lanes on roadways
- Project adds or removes a road
- Project adds or removes interchange or ramp connections
- Project requires an IMS/IJS/IOS
- Project involves land use changes that would meet the criteria for a Level 2 TIS per the State Highway Access Management Manual (SHAMM)
- Project location is in an oversaturated condition

These projects will require TDF modeling as a basis for the traffic forecast. Modeling results may be pulled directly from the existing Model of Record. However, project-specific modeling efforts are oftentimes required for high risk projects, especially if:

- The project Build condition is expected to cause a major diversion in traffic
- There are multiple alternatives to be considered
- The interaction between land use, road network, and socioeconomic factors is complex

TDF model results provide invaluable information regarding the relative change in traffic patterns over time and between alternatives. However, model outputs must be adjusted in relation to existing count data and realistic network constraints to ensure that the final forecast is practical and appropriate for use as a design input. The following sections summarize the reasons for these adjustments, as well as the widely-accepted adjustment methods applied to ODOT Certified High Risk Design Traffic (or simply Certified Design Traffic) forecasts. Lastly, detailed instructions are provided on the use of the State-developed spreadsheet adjustment tool.

3.1 Early Coordination Meeting

For Certified Design Traffic forecasts, an Early Coordination Meeting is held to ensure that all parties agree on the forecast scope, helping to avoid delays at later phases in the project. The participants of this meeting will include, at a minimum, representatives from ODOT M&F and the District representative. All forecast parameters will be decided at this meeting, including:

- Study Area
- Analysis Year(s)
- Analysis Time Periods (i.e. AM, PM)
- Project Alternatives
- Existing count data availability
3.2 Modeling Error

A certain amount of error intrinsic to TDF model forecasts exists which may result from model assumptions or the principles behind the model. After all, the nature of the exercise is to predict future conditions using the best information and procedures that are currently available. Conducting a modeling error check will help to reduce the volume errors which may occur as a result of the modeling exercise. The error check is an important part of the process given that the traffic forecasts will likely be used to make planning and design-related decisions for the subject project.

NCHRP 765 contains a detailed discussion about modeling errors. As stated in NCHRP 765, errors can often result from the following:

- Differences between the actual future and assumptions made about the future within the model;
- Inadequate theory;
- Imprecise application of theory;
- Inadequate model specification;
- Lack of spatial or temporal resolution;
- Input data;
- Calibration data; and
- Computation, such as lack of convergence of iterative processes.

Addressing modeling errors is a balancing act. Efforts to make a model flawless are impossible since the data to judge flawlessness are not flawless, however action can be taken to reduce errors to the point where the model and its results are still valid.

Volume 3 may be used to evaluate model performance and reduce modeling errors. However, modeling error checks are still necessary when working with traffic forecasts and often involve a volume and or speed check for reasonableness. Differences between the output of a base condition travel demand model and actual ground counts is a commonly implemented method. If these differences are substantial, the model may be reviewed to determine any potential corrective measures. If the errors are considered tolerable, the adjustment processes specified here are implemented to resolve any residual error so that forecasts and the agreed upon project counts are consistent with one another.

If warranted, refined alternative level traffic can be generated using matrix estimation or other techniques to refine travel demand results for traffic operations simulation, as discussed in Volume 3. This level of refinement results in forecasts that are suitable for direct use in operational level models such as Synchro or TransModeler.
3.3 Technical Process

Exhibit 3-1 provides an overview of the steps required to develop High Risk Design Traffic forecast.

*Refer to Volume 3 for Modeling Techniques

Exhibit 3-1. High Risk Design Traffic Forecasting Procedure
3.4 Model Runs and Their Temporal Relationship

TDF models are generally provided for at least two points in time:

- The **Model Base Year** represents the existing land uses, road network, and population characteristics at the time it was developed. The Model Base Year typically represents a point in time prior to the year that the study is performed.

- The **Model Forecast Year** represents the land uses, road network, and population characteristics that are expected at some point in the future. This model includes future developments and transportation improvements as agreed upon during the Early Coordination Meeting. Traditionally, the official MPO land use forecast from their most recent long range plan and the future projects from the Transportation Improvement Program (TIP, also known as committed projects) have served as the default future No Build model condition. However, other specific developments and long range plan projects are often included as well to provide the best forecast for a given project. The Model Forecast Year may represent a point in time that is before or after the Project Design Year.

- If project-specific model work is being performed, a **Model Opening Year** may also be supplied. The Model Opening Year represents a point in time between the Model Base Year and Model Forecast Year. If needed, Opening Year Model results will be provided for all scenarios for which project modeling is performed (in particular including No Build Opening Year Model results). The Opening Year Build models will include development and road network changes proposed by the project Build condition. In these cases, Forecast Year Build computations often require the Opening Year No Build results as well as the Build to ensure that any temporal interpolations use the correct trend line.

The year for which project count data is available (i.e. **Count Year**) typically falls between the **Model Base Year** and the **Model Opening Year**. However, so long as the count year is within a few years of the model base year, it can be used to adjust the model results whether before or after the model base year. If project count data is more recent than this, then the “recent counts” feature of the adjustment process will be used and it is necessary that those counts adhere to this temporal relationship. Exhibit 3-2 illustrates this.

Exhibit 3-2. Assumed Temporal Relationship between Model Years and Count Year
3.5 General Procedure for Adjusting Model Results with Counts

Volume adjustments are based on the comparison between the traffic counts and the Model Base Year assignments. If the Model Base Year is different than the year of the count data, Model Base Year assignments are interpolated to estimate Model Count Year assignments. The computed adjustment from this comparison between the existing counts and Model Base/Count Year assignment can be carried forward proportionately to the future year forecasts. This allows for consideration and accounting of plausible modeling assignment errors.

The standard process for estimating future year traffic forecasts is illustrated in Exhibit 3-3. Inputs for this procedure include, at a minimum, existing count data (A), the Model Base Year assignment (B), and the Model Forecast Year assignment (C).

```
Exhibit 3-3. Standard Interpolation of Model Assignments and Future Year Forecasts
```

Adj. = Selected Difference Adjustment
A = Count Data
B = Model Base Year Assignment
C = Model Forecast Year Assignment
1 = Interpolated Count Year Model Assignment
2 = Model Forecast Year AADT
3 = Interpolated Project Opening Year AADT
4 = Interpolated Project Design Year AADT
If the Model Base Year and year of the count are different, the Model Count Year assignment (Point 1) is interpolated between the Model Base Year Assignment (B) and the Model Forecast Year assignment (C). As described below, the volume adjustment is calculated using this interpolated Model Count Year assignment as a basis. The adjustment is then applied to the Model Forecast Year assignment to yield a Model Forecast Year AADT (2). Finally, the Project Opening Year AADT (3) and Project Design Year AADT (4) are interpolated using the trendline formed by the existing count (A) and the Model Forecast Year AADT (2).

The volume adjustment factor is based on three different methods:

1) **Difference** - The numerical difference between the existing traffic count and the interpolated count year TDF model assignment.

   \[ \text{Difference} = \text{Count} - \text{Model Count Year Assignment} \]

2) **Ratio** - The standard ratio method is based on the ratio of the existing traffic count to the base year TDF model assignment.

   \[ \text{Ratio} = \frac{\text{Count}}{\text{Model Count Year Assignment}} \]

3) **Model Growth Ratio** - ODOT M&F also employs a “modified” ratio method that considers the change in TDF model growth between the base/count year and the design year.

   \[ \text{Modified Ratio} = \frac{[(MR - 1) \times AADT_{\text{Difference}} + AADT_{\text{Ratio}}]}{MR} \]

   where

   \[ \text{MR }= \text{Model Growth Ratio} = \frac{\text{Model Count Year Assignment}}{\text{Design Year Model Assignment}} \]

   \[ AADT_{\text{Difference}} = \text{Difference} + \text{Model Assignment} \]

   \[ AADT_{\text{Ratio}} = \text{Ratio} \times \text{Model Assignment} \]

The adjustment method is selected following the procedure shown in Exhibit 3-4. This somewhat complex selection of the adjustment process ensures that the adjustments are both continuous and well behaved across all possible relationships between count, base model and forecast model results.
Count data may not be available to calculate volume adjustments using these methods. In this case, the volume adjustment can be estimated using a screenline across multiple roadways. A screenline is an imaginary line that cuts across several major travel roadways in an area. The Screenline Ratio adjustment is based on the comparison between counts and Model Count Year assignments on all screenline roads and is calculated as:

\[
\text{Screenline Ratio} = \frac{\sum \text{Counts}}{\sum \text{Model Count Year Assignments on Roads with Counts}}
\]

For the location that does not have count data, the adjusted Model Base Year and Model Forecast year assignments are determined as follows:

\[
\text{AADT}_{\text{Screenline Ratio}} = \text{Screenline Ratio} \times \text{Model Assignment}
\]

The Project Opening Year and Project Design Year AADTs will then be interpolated between the Model Year assignments that have been adjusted using the Screenline Ratio, denoted by the yellow line in Exhibit 3-5.

If there are no counts available on screenline roads, the Project Opening Year and Project Design Year AADTs will be interpolated between unadjusted model results, indicated by the orange line in Exhibit 3-5.
This section details the use of the NCHRP 255 forecast adjustment tool spreadsheet developed by ODOT, including the required data inputs, data outputs, and post-processing. The NCHRP 255 Spreadsheet tool utilizes Count Year traffic data, K-factors, and Base and Future Travel Demand Model results to estimate the Future Year link volumes and intersection turning movement volumes. As discussed under a previous section, the concepts presented in NCHRP 765 are based on NCHRP 255, and thus the NCHRP 255 Excel Spreadsheet tool is still generally consistent with NCHRP 765, though containing many enhancements implemented by ODOT over the years.

The current version of the spreadsheet tool is titled “nchrp255_revised_volume_adjuster_v7 w_ix_diagram”.

Exhibit 3-5. Interpolation of Model Assignments and Future Year Forecasts without Link Volume Count
3.6.1 Spreadsheet Overview

The NCHRP Spreadsheet Tool can be obtained by contacting ODOT M&F. The NCHRP 255 Excel spreadsheet tool includes seven worksheets, as shown in Table 3-1.

Table 3-1. NCHRP 255 Excel Spreadsheet Tool Worksheets

<table>
<thead>
<tr>
<th>Worksheet Tab Name</th>
<th>Description</th>
<th>Referenced in this Report</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOC</td>
<td>Description of each of the tabs included in the spreadsheet.</td>
<td>Not Applicable</td>
</tr>
<tr>
<td>Regression</td>
<td>Utilized to perform a regression analysis using historic AADT and B&amp;C counts for each intersection leg.</td>
<td>Not Applicable</td>
</tr>
<tr>
<td>NCHRP255_link</td>
<td>Allows for adjustments to the travel demand model output at the link level and establishes growth rates for application to intersection turning movement calculations. Contains optional capacity adjuster to factor link volumes on a screenline. Opening Year and Design Year link volumes result.</td>
<td>Section 3.6.3</td>
</tr>
<tr>
<td>PM_turns</td>
<td>Calculates Highest Peak Hour (assumed PM) intersection turning movement volumes for the Opening Year and the Design Year.</td>
<td>Section 3.6.4</td>
</tr>
<tr>
<td>AM_turns</td>
<td>Calculates other Peak Hour (assumed AM) intersection turning movement volumes for the Opening Year and the Design Year.</td>
<td>Section 3.6.4</td>
</tr>
<tr>
<td>24_turns</td>
<td>Calculates AADT intersection turning movement volumes for the Opening Year and the Design Year.</td>
<td>Section 3.6.4</td>
</tr>
<tr>
<td>IX_Plates</td>
<td>Four-legged intersection plate template that is populated automatically with the results from the previous tabs.</td>
<td>Section 3.6.5</td>
</tr>
</tbody>
</table>

3.6.2 Setup

Selecting the Correct Years

It is imperative that the forecaster input the correct model and project years because the forecasts are ultimately based on linear interpolation between these years. All model, project, and count year inputs are contained on the “NCHRP255_link” worksheet. These inputs are summarized in Table 3-2.

The Model Base, Opening, and Forecast Years are provided by the modeler. The Project Opening and Design Years will be determined during the scoping process or at the Early Coordination Meeting. However, the forecaster is responsible for selecting the correct count years. While this task may seem straightforward, there are special cases to keep in mind.

Firstly, the count year and AADTS contained in Columns 4 and 5 should be from a year that is relatively close to the Model Base Year (usually within a few years). However, counts collected for the project may be significantly more recent. The count year and AADTs for the most recent data will be input in Columns 14 and 15. For example, a forecaster may be provided with Model Base Year assignments which represent the year 2010 and have traffic count data from 2012 and 2018. The forecaster inputs the year 2012 into Column 4 and 2018 into Column 14.
Table 3-2. “NCHRP255_link” Worksheet Model, Project, and Count Year Inputs

<table>
<thead>
<tr>
<th>Column</th>
<th>Row(s)</th>
<th>Title</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>23</td>
<td>Model Base</td>
<td>The TDF Model Base Year.</td>
</tr>
<tr>
<td>1</td>
<td>24</td>
<td>Model Opening</td>
<td>The TDF Model Opening Year.</td>
</tr>
<tr>
<td>1</td>
<td>25</td>
<td>Model Forecast</td>
<td>The TDF Model Forecast Year.</td>
</tr>
<tr>
<td>1</td>
<td>26</td>
<td>Project Opening</td>
<td>The Opening Year for the subject project.</td>
</tr>
<tr>
<td>1</td>
<td>27</td>
<td>Project Design</td>
<td>The Design Year for the subject project.</td>
</tr>
<tr>
<td>4</td>
<td>10 - 19</td>
<td>Near Base Model Count Year</td>
<td>The year of count data nearest the Model Base Year in row 23.</td>
</tr>
<tr>
<td>14</td>
<td>10 - 19</td>
<td>Most Recent Count Year</td>
<td>The year of the count data more recent than the data shown in Column 4.</td>
</tr>
</tbody>
</table>

It is possible to have the Model Base Year and Model Opening Year the same. In this case, the Model Opening Year No Build is equivalent to the Model Base Year, which is used to establish the adjustment factors. For spreadsheet input, do not use “Recent Count Year” data in this case as that year must be between (inclusive) the base year and opening year (since they are the same in this case any count will be in Column 4). Note that this is simply an expedient that relieves the modeler of the need to create separate Opening Year modeling when the Model Base Year is sufficiently recent.

**Peak Hours**

The worksheets titled “PM-turns”, “AM_turns”, and “24-turns” calculate the intersection turning movement forecasts, if needed. The workbook is currently set up assuming that the PM Peak Hour volume is greater than the AM Peak Hour volume. The higher peak hour is assumed to be the design hour. If the opposite condition exists for the subject project, the sheets can be renamed and used interchangeably.

Commercial areas often have high midday peaks that may exceed the typical high peaks that occur during the AM Peak Hour or PM Peak Hour. If possible, consult the hourly distribution from a 24-hour or 48-hour traffic count to assess the need for a midday Peak Hour assessment.

**Number of Rows/Columns**

The “NCHRP255_link” worksheet contains a total of ten rows for link forecasts (rows 16 through 19 are hidden). The user may insert additional rows to accommodate as many link forecasts and alternatives as necessary.

The “PM-turns”, “AM_turns”, and “24-turns” worksheets are formatted for use in developing estimates for four-legged intersections by default. However, the turning movement worksheets contain hidden cells that allow the user to change the scenario to a five-legged or six-legged intersection.
Zero and Blank Values

Zero and blank mean different things in this tool. Leaving a cell blank means that the item will be ignored while a value of zero means that the value of the item should be zero. Rows that are not needed on the “NCHRP255_link” worksheet should be left blank (do not input “0”). On the “PM-turns”, “AM_turns”, and “24-turns” worksheets, volumes on the non-existing fourth leg of a three-legged intersection should be left blank (do not input “0”).

New links that are added, or existing links that are removed, under the project Build condition require special attention. These situations should be coded as follows:

- Existing links/movements that do not exist in a Build condition should be coded as “0” in that alternative to explicitly tell the tool to zero them out.
- Links/movements that are added in the Build condition should be coded blank in the existing conditions to tell the tool to ignore count based adjustments of those Build model volumes.

If the forecaster is unsure if a link/movement should be coded as “0” or left blank, it is recommended to try it both ways to find the desired result.

Multiple and Single Forecast Workbooks

One single workbook can be used to develop link forecasts for multiple locations, as long as the turning movement forecasts are not needed. The forecaster simply populates the “NCHRP255_link” worksheet with count data and TDF model assignments for each link. A typical application of this is when preparing interstate and interstate ramp forecasts. However, a separate workbook should be created for each alternative, even if only link volume estimates are needed.

When turning movement forecasts are also needed, the forecaster must prepare a separate workbook for each intersection.

3.6.3 Link Forecasts

The “NCHRP255_link” worksheet calculates the AADT traffic forecasts for each link. This sheet also determines link growth factors, which are used to calculate turning movement forecasts on other worksheets when employing the Factoring Turn Counts method. This worksheet must therefore be populated prior to developing any forecasts at the turning movement level.

This sheet allows for the following:

- **Standard AADT Estimation** - Estimate of Opening Year and Design Year AADTs using AADTs from a TDF model or a linear regression.
- **Model Opening Year Interpolation** - Interpolation of Opening Year and Design Year AADTs with consideration of Model Opening Year assignments.
- **Most Recent Count Adjustment** - Adjustment of interpolated Opening Year and Design Year AADTs using more recent count data.
- **Optional Capacity Adjuster** - Allows for traffic forecasts to be adjusted to consider capacity constraints as identified through a screenline analysis.
**Standard AADT Estimation**

The data entry required for Standard AADT Estimation is listed in Table 3-3. The other two tasks are considered optional and dependent upon available data and each specific project.

Table 3-3. “NCHRP255_link” Worksheet Inputs and Outputs, Standard AADT Estimation

<table>
<thead>
<tr>
<th>Cell Type</th>
<th>Column</th>
<th>Row(s)</th>
<th>Title</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input</td>
<td>1</td>
<td>10-19</td>
<td>Road/Link</td>
<td>Name/route number for each intersection leg.</td>
</tr>
<tr>
<td>Input</td>
<td>1</td>
<td>23</td>
<td>Model Base</td>
<td>The TDF Model Base Year.</td>
</tr>
<tr>
<td>Input</td>
<td>1</td>
<td>25</td>
<td>Model Forecast</td>
<td>The TDF Model Forecast Year.</td>
</tr>
<tr>
<td>Input</td>
<td>1</td>
<td>26</td>
<td>Project Opening</td>
<td>The Opening Year for the subject project.</td>
</tr>
<tr>
<td>Input</td>
<td>1</td>
<td>27</td>
<td>Project Design</td>
<td>The Design Year for the subject project.</td>
</tr>
<tr>
<td>Selection</td>
<td>2</td>
<td>10-19</td>
<td>Min Diff</td>
<td>The minimum ratio for using the Difference adjustment method. Below this value, use only Ratio adjustment (Default = 0.5). Can be increased to force Ratio adjustments.</td>
</tr>
<tr>
<td>Selection</td>
<td>3</td>
<td>10-19</td>
<td>Max Rat</td>
<td>The maximum ratio for using the Ratio adjustment method. Above this value, use only Difference adjustment (Default = 2). Can be decreased to force Difference adjustments.</td>
</tr>
</tbody>
</table>
| Selection | 3.5    | 10-19  | Use SL             | Defines the use of screenline ratio when a link count is not available:  
|           |        |         |                     | ▪ Enable = allow Screenline Ratio adjustment of model results  
|           |        |         |                     | ▪ Disable = do not allow Screenline Ratio adjustment to model results (e.g. new intersection on existing road)  
|           |        |         |                     | ▪ Force = use Screenline adjustment even if there is a link count          |
| Input     | 4      | 10-19  | Count Year         | The year of count data nearest the Model Base Year in row 23.              |
| Input     | 5      | 10-19  | Count Data         | The traffic count for the year nearest the Model Base Year (AADT).         |
| Input     | 6      | 10-19  | Ab                 | The Model Base Year travel daily volume assignment.                        |
| Input     | 8      | 10-19  | Af-D               | The Model Forecast daily volume assignment.                                |
| Output    | 17     | 10-19  | Opening Year       | Opening Year AADT                                                          |
| Output    | 18     | 10-19  | Design Year        | Design Year AADT                                                           |
| Output    | 19     | 10-19  | Growth Factor, Opening Year | Count Year to Opening Year Growth Factor                                    |
| Output    | 20     | 10-19  | Growth Factor, Design Year | Count Year to Design Year Growth Factor                                    |
Example data inputs for the Standard AADT Estimation procedure are shown in Exhibit 3-6. If the tool is also being used for intersection turning movement forecasts, a separate workbook should be completed for each intersection.

Exhibit 3-6. Example “NCHRP255_link” Worksheet Data Inputs, Standard AADT Estimation

The resulting annual growth rates are contained in Columns 19 and 20. Values that are in excess of 3% are highlighted in red and will trigger uncertainty notes on AADT traffic forecast plates (see Volume 1, Section 2.4.4).

Opening and Design Year AADT forecasts are contained in Columns 17 and 18. If turning movements are not required (i.e. mainline volumes), the remaining sheets of the spreadsheet are not utilized.
**Model Opening Year Interpolation**

Model Opening Year assignments may be required to adjust the interpolated future year forecasts when the project Build condition causes a significant change in traffic volumes. If used, Model Opening Year assignments may be input for the No Build condition only, or for both the No Build and Build conditions. However, Model Opening Year assignments should not be input for the Build condition only (except for new links that only exist in the Build). When working with Build alternatives, both the Opening Year Build and No Build are entered in the spreadsheet. Note that there is no separate location for Design Year No Build, this would be a separate alternative requiring a separate spreadsheet (which in that case would not include Opening Year Build model results).

The supplemental data entry associated with the Model Opening Year Adjustments is shown in **Table 3-4**. The results shown in Columns 17 and 18 will be updated automatically.

**Table 3-4. Supplemental “NCHRP255_link” Worksheet Inputs and Outputs, Model Opening Year Interpolation**

<table>
<thead>
<tr>
<th>Cell Type</th>
<th>Column</th>
<th>Row(s)</th>
<th>Title</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input</td>
<td>1</td>
<td>24</td>
<td>Model Opening</td>
<td>The TDF Model Opening Year. If using base year Build/No Build results to establish trends, set this to the model base year.</td>
</tr>
<tr>
<td>Input</td>
<td>8a</td>
<td>10 - 19</td>
<td>Af-ON</td>
<td>The Model Opening Year No Build daily volume assignment. If using base year Build/No Build results to establish trends set this equal to Ab (defined in Table 3-2).</td>
</tr>
<tr>
<td>Input</td>
<td>8b</td>
<td>10 - 19</td>
<td>Af-OB</td>
<td>The Model Opening Year Build daily volume assignment. If a link is removed in the Build case, code this as zero.</td>
</tr>
</tbody>
</table>

As shown in **Exhibit 3-7**, Model Opening Year results can have a notable impact on the interpolated Project Opening Year and Project Design Year AADT forecasts. If Model Opening Year TDF model results are provided, the Project Opening Year and Project Design Year AADTs will be interpolated between the adjusted Model Opening Year assignment (Build condition, if available) and adjusted Model Forecast Year assignment. The requirement for a Model Opening Year run will be determined at the **Early Coordination Meeting**.
Exhibit 3-7. Interpolation of Model Assignments and Future Year Forecasts, Model Opening Year Interpolation

Adj. = Selected Difference Adjustment
A = Count Data
B = Model Base Year Assignment
C = Model Forecast Year Assignment
D = Model Opening Year No Build Assignment
E = Model Opening Year Build Assignment
1 = Interpolated Count Year Model Assignment
2 = Model Forecast Year AADT
3 = Model Opening Year AADT
4 = Interpolated Project Opening Year AADT

Adj. = Selected Difference Adjustment
A = Count Data
B = Model Base Year Assignment
C = Model Forecast Year Assignment
D = Model Opening Year No Build Assignment
E = Model Opening Year Build Assignment
1 = Interpolated Count Year Model Assignment
2 = Model Forecast Year AADT
3 = Model Opening Year AADT
4 = Interpolated Project Opening Year AADT
**Most Recent Count Adjustment**

The Most Recent Count Adjustment inputs can be used if count data is available from more than one year. Count data contained in Columns 4 and 5 is always selected to be from the year that is closest to the Model Base Year (usually within a year or two) whereas counts collected for the project may be significantly more recent. The supplemental data entry associated with the Most Recent Count Interpolation is shown in Table 3-5. The results shown in Columns 17 and 18 will be updated automatically.

When project specific modeling is conducted, the Model Base Year of the project can be set to the year in which project counts were conducted during the model adjustment/refinement process shown in Volume 3, in which case these fields would be unnecessary.

<table>
<thead>
<tr>
<th>Cell Type</th>
<th>Column</th>
<th>Row(s)</th>
<th>Title</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input</td>
<td>14</td>
<td>10-19</td>
<td>Most Recent Count Year</td>
<td>The year of the count data more recent than the data shown in Column 4.</td>
</tr>
<tr>
<td>Input</td>
<td>15</td>
<td>10-19</td>
<td>Most Recent Count Data</td>
<td>The AADT of the count data more recent than the data shown in Column 5.</td>
</tr>
</tbody>
</table>

If count data was available for the years of 2013 and 2016 for the intersection in Exhibit 3-6, the inputs would be as shown in Exhibit 3-8.

**Exhibit 3-8. Example “NCHRP255_link” Worksheet Data Inputs, Most Recent Count Adjustment**

The adjustment procedure compares the interpolated/adjusted AADT for the most recent count year to the actual count. This difference is applied to the interpolated Project Opening Year and Project Design Year AADTs to obtain final forecasted volumes, illustrated in Exhibit 3-9. This functionality should not be used if Model Opening Year and Model Base Year have been set equal as discussed previously.
Exhibit 3-9. Interpolation of Model Assignments and Future Year Forecasts, Most Recent Count Adjustment
Optional Capacity Adjuster

The Optional Capacity Adjuster is used if the forecasted volumes exceed the link’s capacity and there are other parallel roads that may absorb some of the traffic growth. The user will input the total link capacity of each of the screenline roads. If the forecasted volume for any link exceeds its capacity, the link forecast will be adjusted to be equal to its capacity. Any remaining unmet demand is then redistributed to the other screenline roads in proportion to their remaining capacities. The supplemental data entry associated with the Optional Capacity Adjuster is shown in Table 3-6.

Table 3-6. Supplemental “NCHRP255_link” Worksheet Inputs and Outputs, Optional Capacity Adjuster

<table>
<thead>
<tr>
<th>Cell Type</th>
<th>Column</th>
<th>Row(s)</th>
<th>Title</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input</td>
<td>AU</td>
<td>10 - 19</td>
<td>Capacity</td>
<td>The actual capacity of the segment, as determined through a screenline analysis.</td>
</tr>
<tr>
<td>Output</td>
<td>AX</td>
<td>10 - 19</td>
<td>Revised Volume, Opening Year</td>
<td>Revised Opening Year AADT</td>
</tr>
<tr>
<td>Output</td>
<td>AY</td>
<td>10 - 19</td>
<td>Revised Volume, Design Year</td>
<td>Revised Design Year AADT</td>
</tr>
</tbody>
</table>

The capacity adjuster should not to be used for intersection approaches. All roadway sections included in the capacity reallocation must be viable alternatives to one another. Similarly, if any of the routes on the screenlines is a toll road in the scenario under study, this procedure should not include that location since capacity is not the main route choice determinant in that case. If the Adjuster component is utilized, the traffic forecasts shown in Columns 17 and 18 are the unadjusted traffic forecasts, while the traffic forecasts shown in Columns AX and AY are the adjusted traffic forecasts. The revised growth rates computed by the capacity adjustment process are not carried over to the turning movement sheets since these processes are incompatible.

3.6.4 Intersection Turning Movement Forecasts

The worksheets titled “PM-turns”, “AM_turns”, and “24-turns” calculate the intersection turning movement forecasts, if needed. These sheets utilize the growth factors determined on the “NCHRP255_link” worksheet; the “NCHRP255_link” sheet should therefore be completed prior to filling in the turning movement sheets. If a new link is added on the links sheet (i.e. a link that does not exist in the No Build case), it will have a growth rate of 1.0 by default. In such cases, the Optional Factoring of Model Turn Movements procedure described below should be used instead of the Standard Procedure. Alternatively, in this case as well as cases where links simply don’t exist in the model, an exogenously supplied growth rate can be typed over the formulas in Columns 19/20 of the links spreadsheet. If this is done, the cell highlighting color should be changed and a note inserted indicating the source of the growth rate.

The Excel file is currently set up assuming that the PM Peak Hour volume is greater than the AM Peak Hour volume. The higher peak hour is assumed to be the design hour. If the opposite condition exists for the

---

The spreadsheet tool assumes that the PM Peak Hour is higher than the AM Peak Hour.
subject project, the sheets can be renamed and used interchangeably.

The “AM_turns” sheet allows for a forecast for an hour other than the Design Hour. If a third, or additional forecast hours are needed, copies of the “AM_turns” sheet can be created and populated accordingly. The Design Hour worksheet (“PM_turns” sheet) will need to be populated prior to developing any additional forecast hours beyond the PM Peak Hour.

These worksheets allow for the following:

- **Standard Turning Movement Estimation (Factoring Turn Counts)** - Estimate of Opening Year and Design Year turning movement volumes using growth rates derived from the adjusted link volumes developed on the “NCHRP255_link” tab.
- **Optional Link Volume Forcing** - Force forecast volumes to match a link volume total from an adjacent intersection.
- **Optional Factoring of Model Turn Movements** - Estimate of Opening Year and Design Year turning movement volumes with supplemental model turn information and NCHRP 255 adjustments. This method is typically only used for new or radically altered turning movements unless special model processing has occurred to refine the modeled turning movements.

Using Iterative Proportional Fitting, the spreadsheet tool calculation procedure iterates until a convergence is reached, or a maximum of 10 iterations. This factoring procedure is necessary because each leg of the intersection may have a different growth rate and/or varying design hour designations (K-factors and D-factors). Iterative Proportional Fitting reconciles the unfactored turning movement counts to the factored design hour volumes based on the AADTs developed on the NCHRP255_link” tab.
Standard Turning Movement Estimation

The data entry associated with the Standard Turning Movement Estimation is listed in Table 3-7. The “AM_turns” and “24_turns” sheets include cells which reference data inputs from the “PM_turns” sheet and therefore require less data input. Model turn movement inputs are considered optional and dependent upon the requirements of each specific project.

Table 3-7. “PM_turns”, “AM_turns”, and “24_turns” Worksheet Inputs and Outputs, Standard Turning Movement Estimation

<table>
<thead>
<tr>
<th>Cell Type</th>
<th>Applicable Worksheets</th>
<th>Column</th>
<th>Row(s)</th>
<th>Title</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input</td>
<td>“PM_turns”</td>
<td>H - P</td>
<td>1</td>
<td>Intersection</td>
<td>Intersecting roadway names.</td>
</tr>
<tr>
<td>Input</td>
<td>“PM_turns”, “AM_turns”</td>
<td>H - K</td>
<td>2</td>
<td>P.M./A.M. peak hour</td>
<td>The starting time of the Peak Hour. This value is carried forward to Column G at the intersection volume data entry rows.</td>
</tr>
<tr>
<td>Input</td>
<td>“PM_turns”</td>
<td>G</td>
<td>6 - 11</td>
<td>ADT</td>
<td>The AADT by intersection leg. This value is the total of both directions of travel and is from the actual count data for the Count Year identified in Column G, Row 13. It represents total volume (P&amp;A added to B&amp;C).</td>
</tr>
<tr>
<td>Input</td>
<td>“PM_turns”</td>
<td>H</td>
<td>6 - 11</td>
<td>B&amp;C</td>
<td>The B&amp;C AADT volume by intersection leg. This value is the total of both directions of travel and is from the actual count data for the Count Year identified in Column G, Row 13. The volume is only the B&amp;C count data.</td>
</tr>
<tr>
<td>Input</td>
<td>“PM_turns”</td>
<td>M</td>
<td>6 - 11</td>
<td>Chosen PM K</td>
<td>The K-Factor chosen for each intersection leg using one of the methods described in Section 2.7.2. When using the Statewide Average DHV method, the selected DHV factor must be multiplied by the value in column I before entry here. This analysis assumes that the PM Peak Hour volume is greater than the AM Peak Hour volume.</td>
</tr>
<tr>
<td>Input</td>
<td>“PM_turns”</td>
<td>G</td>
<td>13</td>
<td>Count Yr</td>
<td>The year in which the intersection turning movement count data was collected.</td>
</tr>
<tr>
<td>Input</td>
<td>“PM_turns”, “AM_turns”, “24_turns”</td>
<td>G - L</td>
<td>16 - 19; 23 - 26; 30 - 33; 37 - 40; 44 - 47; 51 - 54</td>
<td>LT, Thru, RT for P&amp;A and B&amp;C</td>
<td>Directional left, through, and right PM Peak Hour turning movement volume, by approach, entered for Cars (P&amp;A) and Trucks (B&amp;C).</td>
</tr>
<tr>
<td>Output</td>
<td>“PM_turns”, “AM_turns”, “24_turns”</td>
<td>B - T</td>
<td>324 - 373</td>
<td>X-Leg Diagram</td>
<td>The Opening Year Forecast Turning Movements.</td>
</tr>
</tbody>
</table>
Example data inputs for the Standard Turning Movement Estimation procedure are shown in Exhibit 3-10.

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>J</th>
<th>K</th>
<th>L</th>
<th>M</th>
<th>N</th>
<th>O</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>INTERSECTION</td>
<td>West Broad St and Roys Ave</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>P M peak hour</td>
<td>5:00 PM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>If AM is the design hour you can rename this sheet AM, other to PM and change the above 2 cells to reflect this</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>existing</td>
<td>existing</td>
<td>existing</td>
<td>existing</td>
<td>CHosen</td>
<td>Int. growth</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Road</td>
<td>ADT</td>
<td>B &amp; C</td>
<td>% K</td>
<td>D</td>
<td>T24</td>
<td>P.M T&amp;D</td>
<td>P.M K</td>
<td>Chng factor</td>
<td>Open design</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>W Broad St</td>
<td>E LEG</td>
<td>8570</td>
<td>640</td>
<td>0.086</td>
<td>0.580</td>
<td>0.034</td>
<td>0.11</td>
<td>1.14</td>
<td>1.017</td>
<td>1.105</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>N. Roys Ave</td>
<td>N LEG</td>
<td>140</td>
<td>20</td>
<td>0.002</td>
<td>0.571</td>
<td>0.053</td>
<td>0.000</td>
<td>0.10</td>
<td>1.21</td>
<td>1.029</td>
<td>1.179</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>W Broad St</td>
<td>N LEG</td>
<td>8320</td>
<td>640</td>
<td>0.007</td>
<td>0.394</td>
<td>0.038</td>
<td>0.017</td>
<td>0.11</td>
<td>1.13</td>
<td>1.015</td>
<td>1.004</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>S. Roys Ave</td>
<td>S LEG</td>
<td>1530</td>
<td>40</td>
<td>0.075</td>
<td>0.357</td>
<td>0.020</td>
<td>0.010</td>
<td>0.10</td>
<td>1.34</td>
<td>1.011</td>
<td>1.065</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*assumes PM peak hour volume if no count given (say a new road)

Exhibit 3-10. Example “PM_turns” Worksheet Data Inputs, Standard Turning Movement Estimation
Turning movement data may be entered as 15-minute volumes or as hourly volumes without impacting the forecasts. Hourly volumes may be entered into the first row only. Also, if B&C data is not available, the total volume may be entered into the P&A columns. Some acceptable variations in turning movement inputs are shown in Exhibit 3-11.

<table>
<thead>
<tr>
<th>E LEG</th>
<th>LT(S)</th>
<th>THRU(W)</th>
<th>RT (N)</th>
<th>LT(S)</th>
<th>THRU(W)</th>
<th>RT (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5:00 PM</td>
<td>0</td>
<td>253</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>5:15 PM</td>
<td>0</td>
<td>276</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>5:30 PM</td>
<td>0</td>
<td>236</td>
<td>3</td>
<td>0</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>5:45 PM</td>
<td>0</td>
<td>219</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>total</td>
<td>0</td>
<td>984</td>
<td>4</td>
<td>0</td>
<td>14</td>
<td>0</td>
</tr>
</tbody>
</table>

a. Example “PM_turns” Turning Movement Inputs, 15-minute Volumes, Classified

<table>
<thead>
<tr>
<th>E LEG</th>
<th>LT(S)</th>
<th>THRU(W)</th>
<th>RT (N)</th>
<th>LT(S)</th>
<th>THRU(W)</th>
<th>RT (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5:00 PM</td>
<td>0</td>
<td>984</td>
<td>4</td>
<td>0</td>
<td>14</td>
<td>0</td>
</tr>
<tr>
<td>5:15 PM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5:30 PM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5:45 PM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>total</td>
<td>0</td>
<td>984</td>
<td>4</td>
<td>0</td>
<td>14</td>
<td>0</td>
</tr>
</tbody>
</table>

b. Example “PM_turns” Turning Movement Inputs, Hourly Volumes, Classified

<table>
<thead>
<tr>
<th>E LEG</th>
<th>LT(S)</th>
<th>THRU(W)</th>
<th>RT (N)</th>
<th>LT(S)</th>
<th>THRU(W)</th>
<th>RT (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5:00 PM</td>
<td>0</td>
<td>998</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5:15 PM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5:30 PM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5:45 PM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>total</td>
<td>0</td>
<td>998</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

c. Example “PM_turns” Turning Movement Inputs, Hourly Volumes, Not Classified

Exhibit 3-11. Example “PM_turns” Turning Movement Input Variations

Once the data is input on the “PM_turns” sheet, the user must check that the DHV factor is greater than or equal to one. As stated in Section 2.7.1, it is ODOT policy to assume that the counted peak hour volume is not higher than the actual 30th Highest Hour volume (i.e. DHV Factor ≥ 1.0). The “PM_turns” spreadsheet automatically checks the selected K-factor against the actual PM Peak Hour K-factor obtained from the count. The resulting DHV Factor for each leg is provided in Column N, Rows 6 - 11, and values less than one are highlighted in red. If the DHV Factor is less than one, the user should adjust the input K-Factor to equal the existing PM K-factor, yielding a DHV of one.

If the selected K-factor returns a DHV factor that is less than one, set the K-factor equal to the existing PM K-Factor.
The worksheet then balances the traffic entering and leaving the intersection in up to ten (10) alternative row/column iterations until a preset convergence (±10%) is reached. If convergence (within ±10%) is not obtained after ten iterations, the percentages in Columns O and BL, Rows 317 - 322 are highlighted in red. In this case, the user should check and reassess the input turning movement volumes, future link volumes, and K-Factors.

The rounded traffic forecast results for four-legged intersections are shown in graphical form in rows 361 through 374. If the subject intersection is a five-legged intersection or a six-legged intersection, the traffic forecasts are shown in rows 324 through 360. The entered traffic counts are shown in rows 376-426 in the same format for comparison.

**Optional Link Volume Forcing**

The spreadsheet tool has input cells located in Columns AT - BH, Rows 19 - 27 for the purpose of forcing forecast volumes on a particular link to match the directional link volumes from an adjacent intersection. This may be used if a forecast has already been completed for an adjacent intersection and needs to be matched (balanced). Optional link forcing inputs should only be used if the forecast from an adjacent intersection is considered constant. Link volume forcing should not be used to completely replace Balancing/Smoothing efforts, which should be done after inspecting forecast volumes at all intersections holistically. Link volume forcing should be used on no more than two legs of an intersection. If possible, link volume forcing should be limited to one leg of an intersection, although it is acceptable to employ volume forcing on up to two legs.

The graphics showing Opening Year and Design Year traffic forecast results are updated automatically based on link volume forcing inputs. This option does not always produce the desired outcome if convergence cannot be reached.

**Optional Factoring of Model Turn Movements**

Using model turning movements should be done with caution, as the models are not usually validated at the turning movement level, only the link level unless refined alternative level traffic has been developed as documented in Volume 3. In some cases, such as a new road or significant changes to the network that will affect travel patterns, it cannot be avoided and the model turns must be used. Thus model turn movements are usually only applied for project Build conditions; they may be used for the No Build condition as a check of model results. The model period factor will need to be entered if the model turns are used. The supplemental data entry associated with the Optional NCHRP 255 Method is shown in Table 3-8. The graphic showing Opening Year and Design Year traffic forecast results is updated automatically based on model turn volume inputs.
### Table 3-8. Supplemental “PM_turns”, “AM_turns”, and “24_turns” Worksheet Inputs and Outputs, Optional NCHRP 255 Method

<table>
<thead>
<tr>
<th>Cell Type</th>
<th>Applicable Worksheets</th>
<th>Column</th>
<th>Row(s)</th>
<th>Title</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input</td>
<td>“PM_turns”, “AM_turns”</td>
<td>G</td>
<td>72</td>
<td>Model Period to Hour Factor</td>
<td>This factor scales down model period volumes that represent more than one hour’s worth of volume. It represents the fraction of traffic in the peak hour divided by the total traffic in that model period. The value is generally obtained from the modeler, although some examples are given in the spreadsheet.</td>
</tr>
<tr>
<td>Input</td>
<td>“PM_turns”</td>
<td>H</td>
<td>120</td>
<td>Model Base Year</td>
<td>The travel demand model Base Year.</td>
</tr>
<tr>
<td>Input</td>
<td>“PM_turns”</td>
<td>H</td>
<td>121</td>
<td>Model Opening Year (Optional)</td>
<td>The travel demand model Opening Year, if available.</td>
</tr>
<tr>
<td>Input</td>
<td>“PM_turns”</td>
<td>H</td>
<td>122</td>
<td>Model Forecast Year</td>
<td>The travel demand model Forecast Year.</td>
</tr>
<tr>
<td>Input</td>
<td>“PM_turns”, “AM_turns”, “24_turns”</td>
<td>I</td>
<td>77 - 81; 84 - 88; 91 - 95; 98 - 102</td>
<td>Ab</td>
<td>The Base Year travel demand model period volume assignment, entered by approach and movement.</td>
</tr>
<tr>
<td>Input (Optional)</td>
<td>“PM_turns”, “AM_turns”, “24_turns”</td>
<td>J</td>
<td>77 - 81; 84 - 88; 91 - 95; 98 - 102</td>
<td>Af-ON</td>
<td>The Opening Year No Build travel demand model period volume assignment, entered by approach and movement.</td>
</tr>
<tr>
<td>Input (Optional)</td>
<td>“PM_turns”, “AM_turns”, “24_turns”</td>
<td>K</td>
<td>77 - 81; 84 - 88; 91 - 95; 98 - 102</td>
<td>Af-OB</td>
<td>The Opening Year Build travel demand model period volume assignment, entered by approach and movement. As with link adjustments, only enter Build volumes if have No Build volumes unless the movement only exists in the Build.</td>
</tr>
<tr>
<td>Input</td>
<td>“PM_turns”, “AM_turns”, “24_turns”</td>
<td>L</td>
<td>77 - 81; 84 - 88; 91 - 95; 98 - 102</td>
<td>Af-D</td>
<td>The Design Year travel demand model period volume assignment, entered by approach and movement.</td>
</tr>
</tbody>
</table>
| Input     | “PM_turns”, “AM_turns”, “24_turns” | M      | 77 - 81; 84 - 88; 91 - 95; 98 - 102 | Type | Choose one of the following from the pull-down options for each movement, by direction (while these options are provided in a drop-down list, it is also possible to use copy/paste to quickly change all of them at once):  
  - **Both** - Utilizes both travel demand model results and traffic counts.  
  - **Count** - Use of count data only.  
  - **Model** - Utilizes the travel demand model values directly. |
Exhibit 3-12 shows the input fields associated with the Optional Model Factoring Method. The user has the option to select from the following NCHRP 255 adjustments:

- **Both** - Utilizes both travel demand model results and traffic counts with NCHRP 255 process adjustments as was shown previously for link volume adjustment.
- **Count** - Forces the use of count data only. If model results are entered into the spreadsheet, they are not considered.
- **Model** - Utilizes the travel demand model values directly. Model results can refer to any over-ride values provided for example to force a result to zero for links that are abandoned in the future condition. This method does not consider any count data entered.

These toggles allow the analyst to quickly inspect the impact of using modeled turning movements on various turning movements without changing the inputs. Note that as this functionality is provided by turning movement, it is acceptable to use model results on some turning movements and not others.

<table>
<thead>
<tr>
<th>Model Period to Hour Factor</th>
<th>Example Model Period Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hourly 1.00</td>
</tr>
<tr>
<td></td>
<td>Daily 0.09</td>
</tr>
<tr>
<td></td>
<td>OMS PM 0.26</td>
</tr>
<tr>
<td></td>
<td>OMS AM 0.35</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Model Period to Hour Factor</th>
<th>Example Model Period Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ab</td>
</tr>
<tr>
<td>E LEG LT(S)</td>
<td></td>
</tr>
<tr>
<td>E LEG THRU(V)</td>
<td></td>
</tr>
<tr>
<td>E LEG RT (N)</td>
<td></td>
</tr>
<tr>
<td>N LEG LT (E)</td>
<td></td>
</tr>
<tr>
<td>N LEG THRU(S)</td>
<td></td>
</tr>
<tr>
<td>N LEG RT (W)</td>
<td></td>
</tr>
<tr>
<td>V LEG LT (N)</td>
<td></td>
</tr>
<tr>
<td>V LEG THRU (E)</td>
<td></td>
</tr>
<tr>
<td>V LEG RT (S)</td>
<td></td>
</tr>
<tr>
<td>S LEG LT (V)</td>
<td></td>
</tr>
<tr>
<td>S LEG THRU (N)</td>
<td></td>
</tr>
<tr>
<td>S LEG RT (E)</td>
<td></td>
</tr>
</tbody>
</table>

Note: reenter model years but not project years; it is not required that the turn move volume model years match the link volume model years.

Exhibit 3-12. “PM_turns”, “AM_turns”, and “24_turns” Worksheet Data Inputs, Optional NCHRP 255 Method
Obtaining Modeled Turning Movements

While obtaining modeled link volumes from an assigned network is a fairly straightforward process of opening a Cube NET file and reading the appropriate field, accessing modeled turn movements is somewhat more complicated. All models in Ohio use the same traffic assignment process and produce the same outputs discussed here. To begin, the same assigned network file used to obtain link volume forecasts must be opened. Next, the Intersections Tab is accessed as shown in Exhibit 3-13.

![Exhibit 3-13. Cube Intersections Tab](image)

There are two different file formats containing the output turning movements; both will be in the same folder as the assigned network NET file. The first is a DBF format file named `mpoyrJTURNS24alt.DBF` (italicized portions of the filename are variable). This file contains turn movement assignments for cars, trucks and total for each period of the day as well as the daily turn movements. It can be read with database or spreadsheet software as seen in Exhibit 3-14. In this file, the columns labeled A, B, C are the from, through, and to nodes from the network which uniquely identify each turn movement. The column labeled T is the total turn movement assignment, T1 is the cars and T2 the trucks. Sub-daily period volumes have an additional suffix, such as _PM for the afternoon peak period.

![Exhibit 3-14. DBF Version of Model Turning Movements](image)

This file can also be displayed in Cube. It must be loaded by selecting “Turn Volume File” from the Intersections Tab and then selecting the appropriate file name. To display volumes, an intersection node must be selected and then the “Display Volumes…” tool from the Intersections Tab must be used. This tool only allows the daily volumes from the above file to be displayed and produces a grid based display as shown in Exhibit 3-15. There are corresponding files called `mpoyrJTURNSPMalt.DBF` etc. with only the named period volumes that can be loaded to display the sub-daily volumes in this way.
The second output turn volume format data is a set of binary Cube files called `mpoyr.JTURNSPMalt.INT`. These files may not exist if the assignment did not use the junction process, and since they are binary files, they can only be accessed through Cube. There is also no daily version of the turn volumes available, and each individual model period’s file must be accessed individually. To access these, select “Output File” from the Intersections Tab and choose the appropriate file name. After this, when a node is selected a cross hairs icon will appear on the Highway Nodes data pane, and selecting this will bring up a turning flow diagram as shown in Exhibit 3-16. This file has the advantages of providing a nicer turn diagram display, and it allows the model period volumes to be automatically converted to hourly values by selecting the “Hourly units” check box. This file also provides access to level of service and delay information from the Cube Junction Model (an implementation of Highway Capacity Manual). However, as mentioned previously, you cannot directly get daily values nor directly import these results into other software as with the first format.

### 3.6.5 Spreadsheet Tool Plates

The Excel spreadsheet tool has a sheet titled “IX_Plates” which includes a standard four-legged intersection plate template that is automatically populated with the data calculated in
“PM_turns”, “AM_turns”, and “24_turns” sheets. The project information including County/Route/Log, PID, and date should be updated if the “IX_Plates” graphic is utilized for the subject project.

3.6.6 Additional Considerations

Interchange Forecasting

A modified technique can be used when the spreadsheet tool is utilized to develop interchange forecasts. Rather than creating separate spreadsheets for each of the individual intersections that comprise the interchange, the interchange be treated as one single intersection. The benefits of this technique include:

- Helps to ensure consistency between the various interchange movements.
- Takes into consideration mainline interstate forecasts when developing the ramp forecasts; TDF models tend to be more reliable on interstates than on interstate ramps.

As an example, Exhibit 3-17 shows how a standard diamond interchange would be converted into one “intersection” for input into the spreadsheet tool. Exhibit 3-18 then illustrates how the traffic forecast outputs from the tool would be re-distributed to the two intersections at the interchange.

While this technique is effective for many interchange types, not all interchanges can be translated into one intersection. Additionally, this technique cannot be used if TDF model outputs do not contain interstate forecasts. This procedure is therefore recommended for use when possible, but it is not required by the ODOT M&F.

Exhibit 3-17. Existing Interchange to Intersection Conversion
Traffic forecasts sometimes require additional information to complete a comprehensive traffic operations analysis. When the traffic analysis study area includes a section of interstate or limited access highway where a weave exists, the forecasts should include the anticipated weave movement forecasts.

For weaving segments, and for all non-interchange mainline or ramp segments, forecasts are developed by completing the “NCHRP255_link” worksheet. A separate row is populated with the applicable data for each ramp entering and exiting the weave area to obtain project AADT forecasts. Completion of “PM_turns”, “AM_turns”, and “24Turns” is not necessary.

Additional information is then required to estimate the distribution of traffic volumes within the weave segment. A select link analysis can be performed using the TDF model to provide origin and destination information for a segment. Additionally, origin-destination information from StreetLight Data can be used as a validation source for the model results. This information will be used to derive weave distribution percentages, which are applied to determine how the volume forecasts are distributed within a weaving area. Weave volumes can be calculated as (1) a percentage of downstream (destination) traffic, or (2) a percentage of upstream (origin) traffic.
As an example, Exhibit 3-19 shows a set of DHVs as would be output from the “NCHRP255_link” worksheet.

![Diagram of Design Hour Volumes with Unknown Weave Distribution](image)

**Exhibit 3-19. Example Design Hour Volumes with Unknown Weave Distribution**

At this stage, the weave distribution is unknown but can be determined with a select link analysis. Exhibit 3-20 contains sample select link analysis results that could be obtained from a TDF model. The select link analysis is performed on each of the downstream ramps.

![Diagram of Select Link Analysis Results](image)

**Exhibit 3-20. Example Select Link Analysis Results**
The percentage of downstream (destination) traffic can be directly calculated as:

**Link 1-3 to Link 4-5:**

\[
\text{Downstream Percentage}_{4-5 \text{ from } 1-3} = \frac{\text{Model Assignment}_{1-3 \text{ to } 4-5}}{\text{Model Assignment}_{4-5}} \times 100\% = \frac{40}{700} \times 100\% = 6\%
\]

**Link 1-3 to Link 4-6:**

\[
\text{Downstream Percentage}_{4-5 \text{ from } 2-3} = \frac{\text{Model Assignment}_{2-3 \text{ to } 4-6}}{\text{Model Assignment}_{4-5}} \times 100\% = \frac{660}{700} \times 100\% = 94\%
\]

**Link 2-3 to Link 4-5:**

\[
\text{Downstream Percentage}_{4-6 \text{ from } 1-3} = \frac{\text{Model Assignment}_{1-3 \text{ to } 4-6}}{\text{Model Assignment}_{4-6}} \times 100\% = \frac{710}{3,900} \times 100\% = 18\%
\]

**Link 2-3 to Link 4-6:**

\[
\text{Downstream Percentage}_{4-6 \text{ from } 2-3} = \frac{\text{Model Assignment}_{2-3 \text{ to } 4-6}}{\text{Model Assignment}_{4-6}} \times 100\% = \frac{3,190}{3,900} \times 100\% = 82\%
\]

Holding the downstream ramp volumes constant, the resulting weave volumes and upstream ramp volumes are illustrated in Exhibit 3-21. The upstream ramp DHVs each vary by 30 vph in comparison to the volumes shown in Exhibit 3-19.

---

Exhibit 3-21. Design Hour Volumes with Downstream Weave Distribution
Weave volumes based on downstream and upstream traffic distributions will oftentimes not be equal. Thus, weave volumes should also be calculated using the distribution of upstream (origin) traffic. The percentage of upstream (origin) traffic can be calculated as:

**Link 1-3 to Link 4-5:**

\[
Upstream \text{ Percentage}_{1-3 \rightarrow 4-5} = \frac{Model \text{ Assignment}_{1-3 \rightarrow 4-5}}{\sum Model \text{ Assignment}_{1-3}} \times 100% = \frac{40}{40 + 710} \times 100% = 5\%
\]

**Link 1-3 to Link 4-6:**

\[
Upstream \text{ Percentage}_{1-3 \rightarrow 4-6} = \frac{Model \text{ Assignment}_{1-3 \rightarrow 4-6}}{\sum Model \text{ Assignment}_{1-3}} \times 100% = \frac{710}{40 + 710} \times 100% = 95\%
\]

**Link 2-3 to Link 4-5:**

\[
Upstream \text{ Percentage}_{2-3 \rightarrow 4-5} = \frac{Model \text{ Assignment}_{2-3 \rightarrow 4-5}}{\sum Model \text{ Assignment}_{2-3}} \times 100% = \frac{660}{660 + 3,190} \times 100% = 17\%
\]

**Link 2-3 to Link 4-6:**

\[
Upstream \text{ Percentage}_{2-3 \rightarrow 4-6} = \frac{Model \text{ Assignment}_{2-3 \rightarrow 4-6}}{\sum Model \text{ Assignment}_{2-3}} \times 100% = \frac{3,190}{660 + 3,190} \times 100% = 83\%
\]

Holding the upstream ramp volumes constant, the resulting weave volumes and downstream ramp volumes are illustrated in **Exhibit 3-22**. The downstream ramp DHVs each vary by 120 vph in comparison to the volumes shown in **Exhibit 3-19**.

![Exhibit 3-22. Design Hour Volumes with Upstream Weave Distribution](image)

In this case, the downstream traffic distribution produced a result that was much closer to the actual design hour volumes. The forecaster can use the volumes in **Exhibit 3-21** as the final forecast volumes because they are very close to the “NCHRP255_link” worksheet outputs. Alternatively, the forecaster can choose to match the forecasted upstream DHVs from the “NCHRP255_link” worksheet and adjust the weave volumes as illustrated in **Exhibit 3-23**.
Exhibit 3-23. Design Hour Volumes with Downstream Weave Distribution, Adjusted

If neither the downstream nor upstream weave distributions are close to the forecasted DHVs, the forecaster should also check the distributions from StreetLight.

3.6.7 Available Files

At the time of this manual development, the latest version of the spreadsheet tool was titled “nchrp255_revised_volume_adjuster_v7 w_ix_diagram.” The latest version of the Excel spreadsheet tool can be obtained from ODOT M&F. In addition to this file, ODOT has developed example files for the following variations:

- Removal of an existing link. *File Name = nchrp255_v7_example1 (int14_leg_removed)*
- Employment of model turning movements at an unchanged intersection to reflect changes in turning movement patterns, allows testing different combinations of the turning movement forecasting method between BOTH, MODEL and COUNT to see how the final results are changed. *File Name = nchrp255_v7_example2 (int15_certain_TM_different)*
- An existing four-legged intersection with missing data on one of the intersection legs. *File Name = nchrp255_v7_example3 (int18_5leg_missingroad_newleg)*
- Addition of a new intersection on an existing road where none previously existed. *File Name = nchrp255_v7_example4 (int25_new_intersection)fixed*

3.7 General Rules

- Balancing/Smoothing should be conducted on traffic forecasts, as appropriate.
- Intersection turning movement traffic forecasts should be rounded to the nearest 10. Rounding is recommended for the sake of simplicity, and to avoid implying a level of accuracy that does not exist when developing forecasts.
- A minimum volume of 10 is used for all allowed movements.
- An understanding of the area context and travel patterns is important when confirming the validity of the traffic forecasts.
- The Institute of Transportation Engineers Trip Generation Manual is an acceptable source of directional factors for new facilities when existing count data is not available.
- Traffic forecasts should be treated as estimates rather than actual values.
3.8 Consistency Checks

Oftentimes balancing/smoothing or other manual adjustments result in traffic volumes that are not consistent between forecast years and scenarios. A comparison of forecasts should be conducted to determine the consistency and reasonableness of the forecasts. The forecaster should check the following comparisons to identify potential issues:

- **Study Year Check** - For a given scenario (i.e. No Build or Build) forecasts do not decrease and typically increase over time except where the Build condition has rerouted traffic away from the location. For example, the forecaster should ensure that Design Year No Build traffic volumes are not less than Opening Day No Build traffic volumes at the turning movement level. The forecaster should also check that the growth rate is consistent with travel demand model predictions.

- **Alternative Scenario Check** - The forecaster should confirm that the redistribution of traffic volumes between scenarios is logical. Three cases may exist:
  - **Reduction in Forecast Volumes** - If the Build condition is expected to divert traffic to an alternate facility, then the Build forecast volumes should be lower than the No Build forecast volumes. Travel demand model outputs should be referenced for determining the appropriate application of this check.
  - **No Change in Forecast Volumes** - Additionally, the forecaster should check for locations that should not be impacted by the project alternatives. If the travel demand model results on a given link are identical between alternatives, then the link and contributing turning movement volumes should be identical as well.
  - **Increase in Forecast Volumes** - If a new development is associated with the Build condition, then the Build forecast volumes should be higher than the No Build forecast volumes.

- **Directional Split Imbalance** - Traffic generally flows consistently by direction and time of day. Hourly forecasts should reflect the likely directional movements within the study area and should show a peak AM direction and a peak PM direction unless a non-typical peak is being forecasted.
**Chapter 4. Low Risk Design Traffic Forecasting Procedure**

*Volume 1* explains that a simplified forecasting procedure may be followed for roadway design projects that are considered to be “low risk”. Such projects include simple resurfacing, routine maintenance, and minor widening. Design traffic forecasts for these projects may be completed by District staff without involving ODOT M&F. Such projects typically do not require project-specific TDF modeling efforts, and design traffic is estimated by applying a growth rate to existing traffic volumes. This process requires significantly less time and effort.

### 4.1 Technical Process

*Exhibit 4-1* provides an overview of the steps required to develop Low Risk Design Traffic forecast.

---

**Exhibit 4-1. Low Risk Design Traffic Forecasting Procedure**
4.2 Linear Regression

4.2.1 Concept

For projects that are not located on the State system or within an MPO boundary, a trend line analysis may be conducted to estimate growth rates and future traffic forecasts. According to NCHRP 765, linear regression is the most commonly used method for trend line analysis. ODOT supports the use of a trend line analysis when trends are relatively stable in an area and the project being examined is not likely to change travel patterns. A trend line analysis can be used to project future AADTs and truck percentages using historic traffic data to develop a best-fit line with coefficients. The linear regression equation is as follows:

\[ y = bx + a \]

where

- \( y \) = Future Year AADT
- \( x \) = Future Year
- \( a \) = intercept of linear trendline
- \( b \) = slope of linear trendline

When conducting a trend line analysis, the data is often smoothed. A minimum of five (5) data points over a 20-year period, preferably in non-consecutive years, are desired. Data outliers should be discarded to avoid improper influence on the linear regression coefficients and resulting traffic forecasts. Outliers are often identified at locations where construction occurred during the count year, or perhaps the roadway was utilized as a detour for a project nearby. Usually, only data from the last 20 years is used to establish the trend line.

Growth rates obtained from linear regression are stated as simple (non-compounded) annual growth and are typically applied to the latest available count unless reason exists to believe that count is not representative. Most low-risk locations in Ohio exhibit relatively linear growth trends. Nonlinear growth rate methods such as compounded growth or Box-Cox transformations are not explicitly disallowed; however, justification should be provided when selecting such non-standard methods. When more complex growth trends are anticipated, TDF models are generally used to capture that effect, and the full High Risk Design Traffic procedure is used (Chapter 3).
The equation for calculating the linear annual growth rate from the linear regression line is:

\[ \text{Growth Rate} = \frac{b}{\text{Most Recent Count}} \times 100\% \]

The equation for calculating the forecast volume is

\[ \text{Forecast Volume} = (\text{Forecast Year} - \text{Recent Count Year}) \times b + \text{Most Recent Count} \]

Or

\[ \text{Forecast Volume} = (1 + \text{Growth Rate} \times (\text{Forecast Year} - \text{Recent Count Year})) \times \text{Most Recent Count} \]

Notice, this is not the same as applying the regression equation directly, the regression analysis produces the growth \( b \), but by convention this growth is applied to the most recent project counts. This is to be consistent with the philosophy used throughout this manual that those agreed upon most recent count volumes are to be respected in all cases and ensures that positive growth rates will always produce greater volumes than the most recent count.

4.2.2 Analysis Considerations

The appropriate application of a linear regression analysis should consider a number of factors. A linear regression analysis may not be appropriate if certain conditions either exist or are projected to exist in the future such as:

- **Land Use** - Existing land use that is not consistent with the land use that existed when the data points were collected, or potential land use changes in the future that aren’t consistent with the existing land use in terms of both scale and type.
- **Other Forecasts** - Forecasts developed for nearby or adjacent facilities should be reviewed to determine if the project forecasts are consistent and/or in line with the nearby forecasts, as appropriate.
- **Roadway Characteristics** - Existing roadway characteristics such as lane configurations and geometry should be consistent with the conditions that existed when the data points were collected, or potential changes to the roadway characteristics should be considered as they may impact the trend line.

Additionally, when DHV turning movements are required, iterative proportional fitting can be used to rectify any discrepancies between the approach and departure link growth rates.

4.2.3 Regression Methods

The following are some methods that the ODOT M&F has used when developing a linear regression:

- **Method I** uses all counts that are available; a maximum of six (6) counts has generally been applied due to ODOT’s three-year count cycle and the requirement to use data that is no more than 20 years old.
- **Method II** is similar to Method I, except that the count with the highest residual error from the Method I regression line is omitted.
- **Method III** excludes the oldest count from the calculation. This method is only used when a minimum of four (4) counts existed originally.
- **Method IV** is the same as Method III except that the count with the highest residual error from the Method III regression line is excluded. This method is only used when a minimum of five (5) traffic counts are available.
- **Method V** excludes the oldest two (2) counts. This method is only used when there are originally a minimum of five (5) counts.
- **Method VI** is the same as Method V, except that the count with the highest residual error from the Method IV regression line is excluded. This method is only used when there are originally a minimum of six (6) counts.

Ultimately, professional judgement should be used when determining the appropriate method to conduct a linear regression analysis. The story that the trend tells compared to the roadway and area in which it is located should be considered. Growth rates above 3% per year for cars or total traffic and 4% per year for trucks should be considered carefully as their impact on project design could be significant. Additionally, the ODOT M&F never uses growth rates below 0% as every roadway should, at a minimum, be able to serve existing volumes.

### 4.2.4 Examples

The first example in this section covers a standard step-by-step trend line analysis procedure. The second example shows a trend line analysis where the data requires more careful evaluation. These examples use the plot function within Excel to develop the graph and the trendline.

**Linear Regression Trend Line Analysis (Standard)**

1. Collect historic data for the analysis location from TMMS/MS2, or other sources. Volumes should be obtained for the same data point or location along the subject corridor.

   **US-33: Union Co. Line / W. Corp Dublin**

<table>
<thead>
<tr>
<th>Year</th>
<th>AADT</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>45,200</td>
</tr>
<tr>
<td>2003</td>
<td>48,610</td>
</tr>
<tr>
<td>2006</td>
<td>51,540</td>
</tr>
<tr>
<td>2010</td>
<td>49,490</td>
</tr>
<tr>
<td>2014</td>
<td>52,710</td>
</tr>
</tbody>
</table>

2. Check for inconsistencies in the data to determine any data outliers. Remove outliers from data set.

   **US-33: Union Co. Line / W. Corp Dublin**

<table>
<thead>
<tr>
<th>Year</th>
<th>AADT</th>
<th>T24</th>
<th>Years</th>
<th>Difference (Total)</th>
<th>Difference (Per Year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>45,200</td>
<td>0.16</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2003</td>
<td>48,610</td>
<td>0.16</td>
<td>2</td>
<td>3,410</td>
<td>1,705</td>
</tr>
<tr>
<td>2006</td>
<td>51,540</td>
<td>0.14</td>
<td>3</td>
<td>2,930</td>
<td>977</td>
</tr>
<tr>
<td>2010</td>
<td>49,490</td>
<td>0.12</td>
<td>4</td>
<td>-2,050</td>
<td>-513</td>
</tr>
<tr>
<td>2014</td>
<td>52,710</td>
<td>0.11</td>
<td>4</td>
<td>3,220</td>
<td>805</td>
</tr>
</tbody>
</table>
There is one data point that is atypical in the data set used for this example. However, the variation is relatively minor and does not require removal from the data set.

3. Plot charts with the year on the x-axis and the AADT volume on the y-axis.

4. Use regression analysis to estimate a line with coefficients that best fit the set of historical traffic volumes. Linear regression will result in a slope and y-intercept. Excel has the ability to generate the linear regression equation.
5. Using the linear regression equation, calculate the resulting linear annual growth rate from the trend line:

\[ \text{Growth Rate} = \frac{b}{\text{Most Recent Count}} \]

\[ \text{Growth Rate} = \frac{449}{52,710} \times 100\% = 0.85\% \]

6. Estimate the future year AADT by applying the calculated growth rate to the most recent count:

\[ AADT_{\text{Future}} = [1 + \text{Growth Rate} \times (\text{Future Year} - \text{Most Recent Count Year})] \times AADT_{\text{Recent}} \]

\[ AADT_{2040} = [1 + 0.0085(2040 - 2014)] \times 52,710 = 64,359 = 64,460 \text{ (rounded)} \]

**Linear Regression Trend Line Analysis (Non-Standard)**

1. Collect historic data for the analysis location from TMMS/MS2, or other sources. Volumes should be obtained for the same data point or location along the subject corridor over the past 20 years.

<table>
<thead>
<tr>
<th>SR-315 Spur: IR 670 in Columbus</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Year</strong></td>
</tr>
<tr>
<td>2001</td>
</tr>
<tr>
<td>2003</td>
</tr>
<tr>
<td>2006</td>
</tr>
<tr>
<td>2010</td>
</tr>
<tr>
<td>2014</td>
</tr>
</tbody>
</table>

2. Check for inconsistencies in the data to determine any data outliers. Remove outliers from data set.

<table>
<thead>
<tr>
<th>SR-315 Spur: IR 670 in Columbus</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Year</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>2001</td>
</tr>
<tr>
<td>2003</td>
</tr>
<tr>
<td>2006</td>
</tr>
<tr>
<td>2010</td>
</tr>
<tr>
<td>2014</td>
</tr>
</tbody>
</table>
The count taken in 2003 is the same as the 2001 count, which is questionable. The 2003 count has a note stating “IR 670 Construction.” The count data for the year 2003 is removed from the data set, resulting in four data points shown in the table below.

<table>
<thead>
<tr>
<th>Year</th>
<th>AADT</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>11,270</td>
</tr>
<tr>
<td>2006</td>
<td>9,790</td>
</tr>
<tr>
<td>2010</td>
<td>11,670</td>
</tr>
<tr>
<td>2014</td>
<td>18,760</td>
</tr>
</tbody>
</table>

3. Plot charts with the year on the x-axis and the volume on the y-axis for the AADT.
4. Use regression analysis to estimate a line with coefficients that best fits the set of historical traffic volumes. Linear regression will result in a slope and y-intercept. Develop trend line for AADT. Excel was utilized to generate the linear regression equation.

7. Using the linear regression equation, calculate the resulting linear annual growth rate from the trend line:

\[
Growth\ Rate = \frac{b}{(Most\ Recent\ Count)}
\]

\[
Growth\ Rate = \frac{542}{(18,760)} \times 100\% = 2.9\%
\]

The resulting growth rate is close to 3% per year and should be applied with caution. This growth could be verified, potentially using Model of Record outputs or count data from nearby locations.

8. Estimate the future year AADT by applying the forecast equation:

\[
AADT_{Future} = [b \times (Future\ Year - Most\ Recent\ Count\ Year)] + AADT_{Recent}
\]

\[
AADT_{2018} = [542 (2018 - 2014)] + 18,760 = 20,928 = 20,930\ \text{(rounded)}
\]

Note what would happen if the regression equation were applied directly:

\[
AADT_{2018} = [542 (2018)] - 1,076,021 = 17,735 < 18,760\ \text{recent count}
\]
4.3 SHIFT

Low Risk Design Traffic forecasts for projects that are located on Interstate or US/State Routes may be completed using the Simplified Highway Forecasting Tool (SHIFT).

SHIFT is a front-end software application that generates design designations using information contained in a Microsoft Access database file. This database is updated annually and contains not only historic traffic count information, but also TDF model results from Ohio’s statewide model of record. Forecasts for links can be performed without any data collection though the user can enter project traffic counts to refine the estimate. If turning movement forecasts are required, however, intersection turning movement count data must be input by the user. In this case, segment growth rates contained in the SHIFT database will be applied to the input turning movement volumes analogous to the procedures discussed in Chapter 3. SHIFT forecasts are completed by District personnel without any involvement from ODOT M&F. Additional information on SHIFT may be found in Volume 1 and the SHIFT documentation and training.

4.4 Other Growth Rate Methods

Low risk projects in rural areas may include roads that do not have historic traffic counts, are not on the State System, and are not within the boundary of a local MPO. Traffic forecasts on such roads cannot be developed directly using SHIFT or by using a site-specific growth rate. For ODOT-administered projects, growth rates may be “borrowed” from a nearby State System route in SHIFT. Alternatively, an areawide growth rate can be developed by considering growth patterns and historic trends covering a larger area. These more generalized growth rate methods should be applied with caution but are typically acceptable for low volume roads.
Chapter 5. Documentation Guidelines

5.1 Requirements

The ODOT M&F has envisioned a formalized documentation process to facilitate the certification of design traffic forecasts. The design traffic methodologies and calculations should be documented in a thorough and clear compilation of files such that ODOT M&F staff are able to reproduce the traffic forecast results. At a minimum, the documentation package should include:

- Technical Memorandums (not always required, see Volume 1):
  - Count Evaluation
  - Growth Rate Evaluation
- Early Coordination Meeting Minutes
- Certified Traffic request form
- All other relevant correspondence
- A transmittal letter/email with traffic “plates” and design designations
- A technical report which documents procedures and assumptions and references the required Appendix documents:
  - Project level travel demand modeling documentation as relevant
  - Spreadsheets
  - Manual adjustments, including smoothing and balancing
- Electronic files in Word, Excel, PDF, and/or Microstation uploaded to the ODOT Sharepoint Site

The traffic certification documentation should be well organized and easy to follow. All assumptions and data sources should be clearly identified.

5.2 Early Coordination Meeting Minutes

For high risk projects, the Early Coordination Meeting is the point at which all parameters related to the scope of the forecast will be determined including:

- Study Area
- Analysis Year(s)
- Analysis Time Periods (i.e. AM, PM)
- Project Alternatives
- Existing count data availability
- Need for new count data and data collection guidelines
- Model availability and applicability
- Need for project level modeling
- Other considerations, such as previous forecast attempts or studies
- Forecast Assignment
- Project Schedule

The participants of this meeting will include, at a minimum, representatives from ODOT M&F and the District representative. The Early Coordination Meeting Checklist will be distributed
to all meeting participants at least a week prior to the meeting. The checklist will be completed during the meeting and will serve as the meeting minutes.

5.3 Certified Traffic Request Form

The *Certified Traffic Request Form* is a two-page document used to transmit the request for the following Project Forecasts:

- **New**: No previous forecasts for the project exist.
- **Update**: Previous forecast(s) for the project exist. Updates are generally submitted due to a change in the future year, a change to the design alternative, a change to the project boundaries, or potentially other changes that may impact the project forecast.
- **Review**: ODOT review of a project forecast developed by a consultant or non-ODOT entity.

This is a standard form utilized by ODOT. An unpopulated PDF version of the form may be requested from ODOT M&F for use by the applicant.

5.4 Certified Traffic Plates

Unless otherwise directed by the ODOT M&F, the requested forecast volumes should always be displayed on plates in the form of link volumes and intersection turning movement volumes as applicable. If both opening year and design year volumes are requested, separate plates should be provided for AADT and each design hour (typically AM and PM) requested. Breaks caused by long distances and/or major traffic generators between traffic forecast locations should be explicitly indicated on plates using a break line symbol (Section 2.6). Exhibit 5-1 shows an example set of traffic certification plates following these guidelines.

Exhibit 5-1. Sample Traffic Certification Plate Set, Forecasted Volumes

If only one forecast year (opening or design) has been requested, it may be acceptable to combine design hour forecast volumes on a single plate.
Additionally, the ODOT M&F requires two sets of forecast volume plates:

1. Raw design traffic volumes, obtained directly from NCHRP 255 spreadsheet, with link balancing differential indicated
2. Final balanced/smoothed design traffic volumes

The level of detail required for truck design factors varies from project to project, and accordingly, the information can be displayed on plates or provided in tables. If TD and T24 are requested at the turning movement level, it is recommended that these values be displayed on plates as well. An example plate showing truck design factors is shown in Exhibit 5-2.

The documentation of a certified traffic forecast is not typically reviewed or referenced outside of the ODOT M&F. Plates are often distributed without the accompanying technical report which may detail particular uncertainties in the forecast of which to be cautious in the design phase. It is therefore important to note any elements that contribute to forecast uncertainty directly on the certification plates. Any design issues that are caused by the traffic forecast can then be addressed quickly and appropriately.

The ODOT M&F has created standardized notes to be placed on certification plates relating to the two main sources of forecast uncertainty: uncertainty due to lack of long term count data and uncertainty in future development. The forecaster is encouraged to modify these notes as necessary to fit the project at hand.

Table 5-1 contains the text for standardized uncertainty notes. Simplified and detailed versions are provided for each uncertainty note. The detailed notes may be incorporated into the body of the technical memorandum while the simplified version may be placed on the plates. However, the forecaster should be cautious that documentation is oftentimes not referenced by designers.
Table 5-1. Standardized Uncertainty Notes

<table>
<thead>
<tr>
<th>Uncertainty Type</th>
<th>Note Type</th>
<th>Note Text</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack of Long Term Count Data</td>
<td>Simplified</td>
<td>Design traffic conducted without the benefit of long term counts, numbers should be considered within ±15%.</td>
</tr>
<tr>
<td></td>
<td>Detailed</td>
<td>Design must use design traffic values. However, if 85% of design traffic (or current volume, whichever is greater) eliminates the need for costly design options, design team may ask District design traffic coordinator to request additional counts and re-evaluation of forecasts (must provide locations and reasons for the request). A meeting between the stakeholders (design team, OSPR, District) will be required to determine if additional count data might mitigate the problem and whether the project time line can accommodate the time required to collect the data.</td>
</tr>
<tr>
<td>Uncertain Future Development*</td>
<td>Simplified</td>
<td>Design traffic in high growth area, includes growth exceeding 3% per year on indicated links.</td>
</tr>
<tr>
<td></td>
<td>Detailed</td>
<td>Design must use design traffic values. However, if opening year traffic at an indicated location (including peak hour or turn movement volumes associated with the same link) eliminates the need for costly design options, design team may ask District design traffic coordinator to request additional coordination on development assumptions and re-evaluation of forecasts (must provide locations and reasons for the request). A meeting between the stakeholders (design team, OSPR, MPO, District) will be required to evaluate development assumptions.</td>
</tr>
</tbody>
</table>

*Place on AADT Plates Only

5.4.1 Rounding Rules

Design traffic forecasts, or otherwise estimated traffic volumes, should be rounded to at least the nearest 10 to communicate the level of precision in traffic forecasts. It is recommended that AADT and design hour link volumes be rounded to the nearest 10, while AADT and design hour turning movement forecasts be rounded to the nearest 10 and are a minimum of 30 for AADT and 10 for design hour.

5.4.2 Template

The ODOT M&F provides Microstation templates for Certified Design Traffic forecasts available through their Certified Traffic Webpage. This template contains sample traffic plate layouts, as pictured in Exhibit 5-3, that may be adapted to any project.
5.4.3 Transmittal Letter

A transmittal letter will accompany traffic plates and will be prepared by ODOT M&F staff. An example transmittal letter is shown in Exhibit 5-4.

Exhibit 5-3. Template for Certified Design Traffic Plates

Exhibit 5-4. Sample Certified Design Traffic Transmittal Letter
5.5 Technical Memorandums

It is important to identify issues with a design traffic forecast early in the process so that appropriate action can be taken without significantly impacting the project schedule. Prior to the preparation of design traffic, the ODOT M&F will review and approve two sequential technical memorandums if they are determined to be necessary during the Early Coordination Meeting.

5.5.1 Count Evaluation

The forecaster should assemble traffic count data from all available sources including the ODOT TMMS portal and the local MPO. Turning movement counts and short-term link counts should then be conducted to meet the remaining data collection requirements. A short Count Evaluation Memo will then be prepared to address the following items:

- Sources and dates of all available count data including indications of computed values (volumes estimated from adjacent count locations when no actual count has been conducted)
- Gaps and conflicts in the data
- Any special data collection efforts that are needed to fill in the gaps or resolve discrepancies
- System Peak Hour selection process
- References to adjustment factor reports that were consulted for the estimation of AADT
- AADT Estimates describing how short-term or partial day counts were adjusted, including the functional classification of roadways used to select the appropriate adjustment factors
- Balancing/smoothing efforts
- Traffic volume plates showing existing AM, PM, and daily volumes as needed. These plates should have indicators/annotations noting the sources, dates, gaps, and conflicts.

5.5.2 Growth Rate Evaluation

Once the existing count data has been reviewed and approved, the forecaster should compare future growth trends from various sources including: MPO model, Statewide Model, SHIFT, previously developed forecasts, population growth (Census, ODOD), employment growth (LEHD, InfoUSA, QCEW if allowed), MPO zonal data, and other known development activity. The available travel demand models should also be reviewed at this stage, including centroid connectors, special generators, external growth, ZD data, network coding, and future project coded.

The forecaster will then prepare a short Growth Rate Evaluation containing the following information:

- Travel Demand Forecasts describing which models were referenced (Statewide, MPO) and the version of the models
- Land use assumptions beyond the Model of Record and trip generation data
- Any potential problems with growth rates
- Whether or not project level modeling is required
- Assumed K-Factors and D-Factors, and how they were chosen
5.6 Technical Report

The technical report will be prepared and submitted for review with the design traffic. This report should not duplicate the information contained in the preceding technical memos, but rather reference these memos and include them in the Appendix.

5.6.1 Content Guidance

The certified traffic technical report should detail methodologies and assumptions such that the forecast may be reproduced by the reviewer, or ODOT M&F. This report should also be clear and concise; information contained in the Appendix should be referenced but should not be repeated in the body of the report. The report or technical memorandum sections and topics may vary based on the individual project or request. Report sections may be added or omitted as appropriate for each individual project.

The standard suggested contents of the report include:

1. Cover Page
   a. Project Name
   b. PID
   c. District Number
2. Introduction
   a. Brief description of the initiation of the forecast
3. Project Description
   a. Location
   b. Purpose of forecast
   c. Any development information pertaining to the forecast
   d. Summary of previous work including forecasts made for the same project, other alternatives and revisions to account for corrections, newer or better information, and expanded project limits.
4. Forecast Parameters
   a. List of study intersections, ramps, and mainline segments
   b. Alternatives
   c. Study Years
   d. Forecasted Volume Sets (AADT, AM PHV, PM DHV) and Design Designations (TD and T24, K, D) prepared
5. Other Studies
   a. Nearby traffic forecasts that were accounted for
   b. Planning, safety, and traffic impact studies
6. Data Sources
   a. Reference to data contained in Count Evaluation Memo and any special data collection efforts
   b. Reference to data contained in Growth Evaluation Memo
   c. Future land use assumptions, including:
      i. Variations between project No Build and Build conditions
      ii. Whether or not the land uses are included in TAZ data of the selected model
iii. Sources of land use quantities
iv. Trip rates applied, if different from default travel demand model implementation
d. Project level modeling efforts describing:
   i. Which model was used as a base (Statewide, MPO, or Consultant)
   ii. The version of the model
   iii. Any adjustments made to the model (land use, road network)
   iv. Summary of the outputs (ADT, model turn volumes)

7. Existing Traffic Volumes
   a. Reference to traffic volume plates accompanying Count Evaluation Memo

8. Design Traffic Volumes
   a. Model Adjustments detailing and providing justification for any manual adjustments that were made to travel demand model outputs
   b. NCHRP 255/765 Process providing a brief summary of what tools were used (i.e. spreadsheet adjustor tool) and how they were applied, including any specialized inputs such as link volume forcing
   c. Forecast Refinement detailing any manual adjustments to design traffic outputs from adjustor tools, including balancing/smoothing efforts
d. Uncertainties in the forecast
e. TD and T24 summarizing how these factors were estimated
f. Design Traffic for Certification referencing package of final traffic certification plates and design designations

5.6.2 Appendices/Exhibits

Exhibits and graphical representations of the forecast calculations are important components of a well-organized and easily comprehended report. It is recommended that two main appendices be provided for ease of review. The following is a suggested list of exhibits which may be included in the documentation:

Appendix A. Certification Documents
- Design Traffic Plates
- Design Designations

Appendix B. Technical Memos
- Count Evaluation Memo and Attachments
- Growth Rate Evaluation Memo and Attachments

Appendix C. Exhibits
- Project Location Map - showing the project boundary and individual study intersections/segments
- Diagrams illustrating design alternatives
- Land use assumptions
- Pertinent data from other studies
- Existing Turning Movement Count Data
- Short-Term Hourly Count Data
- ATR Station Count Data
- Planning Level Traffic (if developed previously)
▪ Base Year Travel Demand Model Output/Daily Volume Assignments
▪ Opening Year Travel Demand Model Output/Daily Volume Assignments (if applicable)
▪ Design Year Travel Demand Model Output/Daily Volume Assignments
▪ Hourly Percent by Vehicle Type Reports
▪ Seasonal Adjustment Factors Reports
▪ Partial Count Factor Form
▪ Unbalanced Existing Volume Plates
▪ Balanced Existing Volume Plates (if applicable)
▪ K&D Factor Report - including identification of data from the report utilized in the Project Forecast.
▪ NCHRP 255/8765 Spreadsheet Tool Worksheets
▪ Reasonableness Checks
▪ Unbalanced Project Forecast Plates

The report and its organization are particularly important when the traffic forecasts are complex. Creating well-defined and comprehensive documentation allows for a clear understanding of the estimation process, thus contributing to the credibility of the approved traffic forecasts.

5.7 Filesharing Guidelines

The ODOT M&F will provide the forecaster with the files necessary to inform certified traffic forecasts at the Early Coordination Meeting. Such files may include:

▪ Nearby project information
▪ Previous traffic forecasts
▪ ATR data web reports
▪ Turning movement counts from the OTS
▪ Model of Record assignments or networks and trip tables for each MPO

Once the certified traffic forecast has been completed, the forecaster will upload the files electronically to assist in the review. The medium used for filesharing will typically either by SharePoint or LiquidFiles. The files to be uploaded by the forecaster and the preferred file format include:

▪ Request for certified traffic (PDF)
▪ All count data (PDF or Excel)
▪ Documentation of travel demand model(s) to include, as relevant:
  o Traffic Assignments if project specific refinements were made to the Model of Record, and model runs that were made for the project.
  o Trip Tables, if trip tables were modified.
  o All model run data sets (scripts, macros, executables, etc.) such that model runs can be reproduced.
Volume 2: Traffic Forecasting Methodologies
Ohio Traffic Forecasting Manual

Documentation Guidelines

- Spreadsheets (Excel)
  - Partial Count Factor Form
  - Hourly Percent by Vehicle Type
  - System Peak Hour Selection
  - NCHRP 255 Adjuster
  - Volume Balancing
- Technical report (Word)
- Traffic forecast plates (Microstation and PDF)
- All relevant correspondence (PDF or Text)
- Read Me files (Word or Text)

5.8 Certification

The technical memorandum and *Certified Design Traffic Request Form* is sent to ODOT M&F through the District Representative. Once the forecast and documentation has been thoroughly reviewed, ODOT M&F will transmit Inter-Office Communication indicating that the forecast has been certified.