Collection and Estimation of Annual Average Daily Traffic on Non-Federal Aid System Roads

VIRGINIA DEPARTMENT OF TRANSPORTATION

INNOVATIVE PROCEDURES IN TRAFFIC VOLUME ESTIMATION

CASE STUDY

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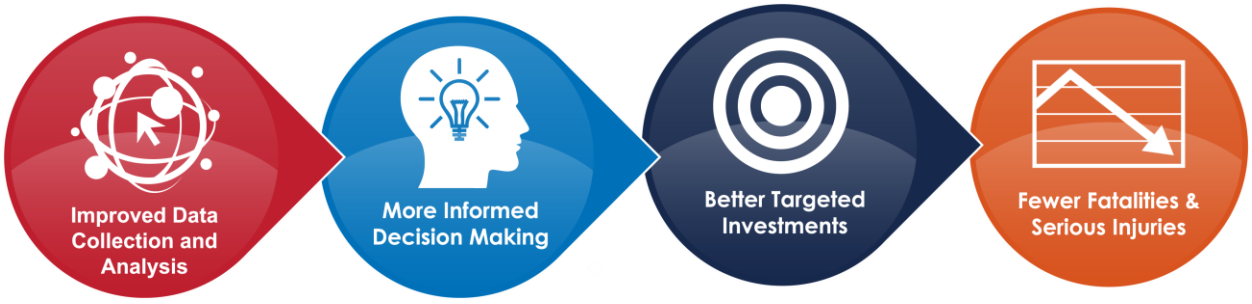

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ACRONYMS

Table 1. Acronyms.

Acronym	Description
AADT	Annual Average Daily Traffic
ADT	Average Daily Traffic
CCS	Continuous Count Station
CO-TED	Central Office–Traffic Engineering Division
FHWA	Federal Highway Administration
ITE	Institute of Transportation Engineers
VDOT	Virginia Department of Transportation

EXECUTIVE SUMMARY

This case study presents how the Virginia Department of Transportation (VDOT) estimates traffic volumes on secondary local roadways using a trip generation method instead of taking short-duration counts in the field. The use of trip generation estimates was an outcome of a review process that aimed to reduce data collection costs and achieve labor savings by establishing a local secondary count program. As part of this program, VDOT provided guidelines to its staff on how to identify eligible traffic links and generate traffic volume estimates using the trip generation method. According to this program, region and district staff are responsible for reviewing candidate segments using aerial photos, determining potential development and roadway connectivity, evaluating roadway eligibility criteria, documenting the trip generation estimate process used, developing estimates, and submitting the estimates to the Central Office–Traffic Engineering Division. After implementing the method, VDOT realized several benefits, such as reduction in data collection costs, time savings, increased efficiency of VDOT's data collection program, elimination of duplicate data collection efforts, easy validation of existing traffic volume estimates, and quick access and dissemination of traffic estimates among various entities within VDOT. Because of the positive experience and feedback received with this effort, VDOT will continue to promote and improve the use of the trip generation method.

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INTRODUCTION

The purpose of this case study is to highlight current practices at the Virginia Department of Transportation (VDOT) regarding traffic volume estimation using trip generation techniques. On September 23, 2009, VDOT's regional traffic engineers agreed that a trip generation estimate method could be used for certain secondary local roadways rather than actual field counts. The use of trip generation estimates was an outcome of a review process that aimed to reduce data collection costs and achieve work force savings by establishing a local secondary count program. As part of the local secondary program, VDOT established criteria for eligible traffic links and provided guidance to its staff on how to use the trip generation theory based method. The Institute of Transportation Engineers (ITE) endorsed and published this method.

Over time, VDOT has realized several benefits from using the trip generation method to estimate traffic volumes. Most benefits involve time, cost savings, and include:

- Reduced data collection costs because using the trip generation method requires fewer resources and fewer person-hours than conducting short-duration counts in the field.
- Minimized need for purchasing, maintaining, and calibrating traffic equipment, resulting in additional cost savings.
- The trip generation method is significantly faster than collecting traffic data in the field and processing the data in the office. VDOT staff can allocate the time saved to other tasks.
- VDOT's data collection program increased efficiency by eliminating potential duplicate data collection efforts.
- Easy validation of existing traffic volume estimates.
- Quick access of traffic volume estimates by entities within VDOT.
- Fast and easy generation of traffic volume estimates even in cases where the installation of portable traffic equipment and collection of short-duration data is difficult (e.g., during inclement weather conditions or when pavement is covered with snow or ice).

BACKGROUND

VDOT operates the third largest state-maintained highway system in the country, including secondary roads. They have established an extensive traffic-monitoring program. Specifically, VDOT maintains 58,430 centerline miles of roadway, which is comprised of approximately 78 percent of the 74,748-centerline miles of public roads. VDOT has collected roadway inventory data for 85,824 (95 percent) of the 90,614 intersections in the Commonwealth.

VDOT's traffic monitoring program includes more than 600 continuous count sites (CCSs) on all roadway functional classes. VDOT has counted approximately 98 percent of Virginia's local roads. District office personnel, who are familiar with local roads in their jurisdiction, take local-road traffic counts on a six-year cycle. From 2006 through 2015, VDOT collected 125,202 24-hour counts on roadway segments functionally classified as local. Unlike many agencies, VDOT does not use adjustment factors to expand the short-duration counts to annual average daily traffic (AADT) estimates. Instead, it uses the raw average daily traffic (ADT) value of each count.

TRIP GENERATION ESTIMATES

IMPLEMENTATION PROCESS

According to VDOT's secondary program, region and district staff performs several actions that mainly involve:

- Reviewing candidate segments using aerial photos,
- Determining potential development and roadway connectivity,
- Evaluating whether specific criteria are met,
- Documenting the trip generation estimate process used, and
- Developing and submitting the estimates to the Central Office–Traffic Engineering Division (CO-TED).

This document describes these actions and provides relevant estimation examples for those interested in learning how to use the methods.

Implementation Guidelines

To support the implementation of the trip generation method, VDOT developed the following guidelines:

- Roadways that are subject to use of trip generation techniques for traffic volume estimates are those that have one point of entry (e.g., cul-de-sacs), are residential in nature, and have a length of 0.5 mile or less.
- Region/district staff should choose which method to use (24-hour traffic count volume or trip generation estimate).
- Regional traffic engineers should coordinate their decision with their VDOT residency customers.
- Traffic volume estimates should represent the average volume over the entire roadway length. This value will typically be less than the highest traffic volume (e.g., that found at the roadway entrance).
- Regions should provide the estimate using the same county listing submission method currently in use to report traffic count results. Traffic volume estimates based on trip

generation theory should have the date the estimate was developed and the letter "M" placed next to the value indicating whether it is a "manual" estimate.

- The Central Office records the technique creation date and estimates in a database as manual estimates, and publishes them with an identifier indicating the same.

- In future count years, the county listings provided to the regions to support traffic count collection and local secondary roadway volume reporting to the Central Office will include information that identifies the past estimate as manual, along with the date of the estimate. Regions decide the count cycles for updating manual estimates.

SELECTION OF TRAFFIC LINKS

VDOT developed criteria and guidance to evaluate sites for the trip generation method. District staff reviews each candidate site using recent aerial images to determine development and roadway connectivity. If VDOT staff can make a determination using aerial photos, VDOT recommends using the trip generation method only for traffic links that meet the following criteria:

- Land use is limited to single-family detached housing (ITE Trip Generation Code 210). For other land uses, it may not be possible to determine the number of dwelling units (or other independent variables) from an aerial photo. In the case of higher-density residential, this limitation also eliminates the need to judge which trip generation code to use, which may also be difficult to determine from an aerial photo. The majority of cul-de-sacs in the Northern Region consist of single-family homes.

- No alternative means of motor vehicle access is available, even by private streets or driveways.

- Unusual land uses are nearby that might cause traffic volumes to differ significantly from the trip generation rates. For example, a Metrorail station may induce more bicycle and pedestrian trips and fewer vehicle trips, or it may induce more vehicular trips if it attracts on-street parking.

- Occasionally, a private street diverges from a VDOT-maintained cul-de-sac. Consideration of these cul-de-sacs for the trip generation method is dependent on meeting all the criteria above, even though the private streets may lead to additional development, as long as the combined length of the public and private streets are less than the 0.5-mile threshold.

District staff retains the flexibility to conduct an actual traffic count on any link that exhibits unusual traffic conditions that do not meet the criteria defined above.

TRAFFIC VOLUME ESTIMATION

VDOT provides its staff with a description of the trip generation method along with estimation examples. According to VDOT, a simple method of computing traffic volumes for cul-de-sacs is to multiply the total number of households on the cul-de-sac by the trip generation rate. However, this would approximate the volume at the point where the cul-de-sac intersects the connecting roadway. The volume on a cul-de-sac is highest at this point since all trips from the cul-de-sac must pass it. The volume becomes lower toward the bulb because households along the stem typically travel away from the bulb. To capture this trend, the trip generation method estimates the average volume per weekday along the cul-de-sac as follows:

$$v = \frac{\sum_{n=1}^{H}(g_n \times d_n)}{L} \qquad (1)$$

Where:

v = number of trips per weekday using a cul-de-sac, averaged according to the length of the cul-de-sac.

H = households with driveways on the cul-de-sac.

g_n = number of trips per weekday generated by the n^{th} household.

d_n = portion of the length of each trip to and from the n^{th} household that uses the cul-de-sac, taken as the distance along the cul-de-sac between the n^{th} household's driveway and the end of the stem.

L = length of the cul-de-sac.

Because VDOT uses this process for only one land use type, it considers the same g value for every household. VDOT extracts this value from the ITE *Trip Generation Manual*. For single-family detached housing (Code 210), g = 9.57 trips per weekday per dwelling unit, according to the 8^{th} edition of the manual. VDOT rounds this rate to 10 trips per weekday for computational ease.

VDOT makes a further distinction between "bulb households," with driveways in the bulb of the cul-de-sac, and "stem households," with driveways in the stem. Trips to and from bulb households typically use the cul-de-sac for approximately its entire length, particularly when considering additional maneuvering in the bulb. Stem household trips typically use the cul-de-sac only from their driveways to the connecting road. Equation (1) simplified as follows:

$$v = g \times \left(H_b + H_s \times \frac{d}{L}\right) \qquad (2)$$

Where:

g = 10 trips per weekday per household.

H_b = number of bulb households.

H_s = number of stem households.

The ratio *d*/*L* is a dimensionless constant since both *d* and *L* are expressed in units of length. It represents the average fraction of the cul-de-sac used by trips to and from stem households. Stem household driveways are assumed to be distributed uniformly along the length of the cul-de-sac, so *d*/*L* = 0.5. VDOT further simplifies Equation (2) as follows:

$$v = 10 \times (H_b + 0.5H_s) \quad (3)$$

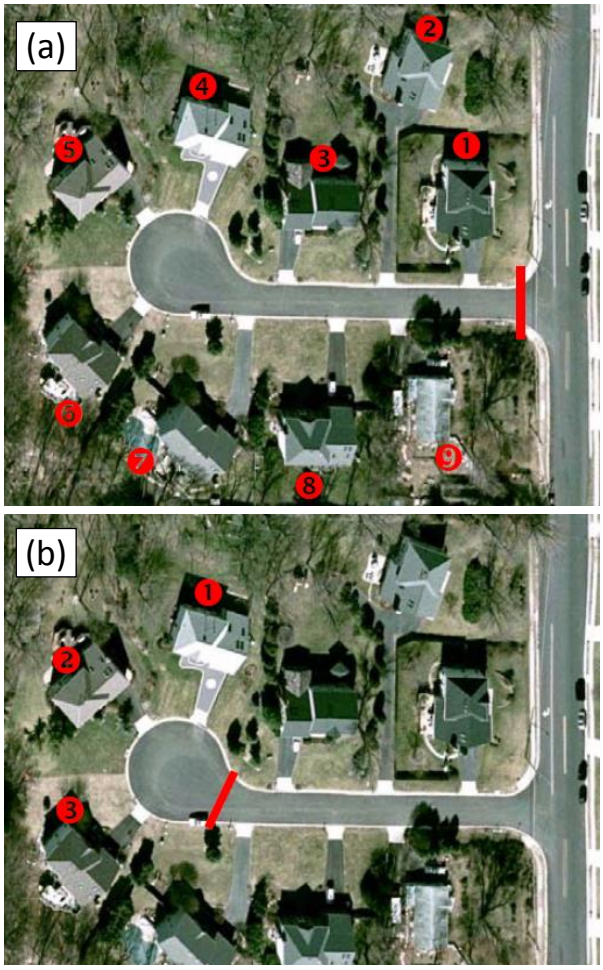
Although it is possible to compute a traffic volume estimate without differentiating between bulb and stem households, VDOT does not do so because it wants to produce estimates that are more accurate. Most cul-de-sacs do not have driveways distributed uniformly along their length. Site plans often distribute driveways more densely in the bulb of the cul-de-sac than along the stem. Likewise, connecting roadways often serve households at the corner of a cul-de-sac resulting in fewer driveways.

VDOT established the following five steps for estimating traffic volumes for eligible traffic links.

Step 1: Draw an imaginary line at the entrance of the cul-de-sac, where it joins the connecting road, and count the number of houses whose primary driveway can only be reached by traveling across the line. For example, on the traffic link shown in Figure 1a, there are nine houses.

Step 2: Draw another imaginary line between the bulb and the stem of the cul-de-sac and count the number of houses whose primary

Figure 1. Examples: (a) Step 1; (b) Step 2.



Source: Process for implementing the trip generation method as an alternative to secondary local counts, VDOT Northern Region (Rev. 12/2009).

driveway can only be reached by traveling across this line. For example, on the cul-de-sac shown in Figure 1b, there are three houses.

Step 3: Add the results of Steps 1 and 2, and multiply the sum by 5. The calculation in this step is based on Equation (3). For example, from the first two figures, the result is $(9 + 3) \times 5 = 60$.

Step 4: Report the result of Step 3 as the number of trips per day on a spreadsheet provided by the Central Office. Use the letter "M" to indicate that the value resulted from a "manual" estimate rather than a physical count. Also, report the date the estimate was prepared.

Step 5: Periodically send the spreadsheet back to CO-TED to import it into the traffic monitoring system. This occurs at least once per year. The results are reported in annual publications.

VDOT provides its staff with additional aerial photos (Figure 2) and estimation examples to highlight differences between links that have different roadway and geometric characteristics.

Figure 2. Examples: (a) Fariba Drive; (b) Pine Knot Drive.

Source: Process for implementing the trip generation method as an alternative to secondary local counts, VDOT Northern Region (Rev. 12/2009).

The first three steps of the traffic volume estimation process result in the following:

Figure 2a:
Step 1: 17 houses.
Step 2: 4 houses.
Step 3: (17 + 4) x 5 = 105 trips per day.

Figure 2b:
Step 1: 38 houses.
Step 2: 17 houses.
Step 3: (38 + 17) x 5 = 275 trips per day.

Figure 2a shows a simple case of a traffic link that consists of a bulb and a stem. In Figure 2b, the cul-de-sac has two private-street connections through the bulb, taken into consideration in Step 2, and two connections along the stem. Distribution of the connections along the stem is relatively uniform along the cul-de-sac's length, so the trip generation computation is valid.

COST AND OTHER CONSIDERATIONS

In general, the cost to generate traffic volume estimates is significantly lower than collecting field data. Some Districts apply the trip generation method in-house, while others hire a temporary service contractor. As of February 2016, a typical hourly rate of these contractors ranged between $20 and $30 per hour. Depending on the complexity and the number of the houses along a roadway link, VDOT staff or its contractors spend between 15-30 minutes to generate a traffic volume estimate for one link.

Most contractors are responsible for both conducting counts in the field using portable traffic equipment and generating traffic volume estimates using the trip generation method. Some Districts ask their contractor(s) not to rely heavily on aerial photos, but visit the roadway links of interest and collect necessary information and data in the field. To save time and reduce travel costs, contractors try to do both (i.e., conduct short-duration counts and visit eligible links that are close to the counts) in one trip. Other Districts allow their contractor(s) to apply the trip generation method at the office and ask them to visit the field in case the aerial photos are old, trees cover driveways and houses, and there is significant construction activity in the examined area.

LESSONS LEARNED

VDOT is innovative, creative, and proactive when it comes to implementing new strategies. This practice is part of VDOT's culture and accompanies its strategy of incorporating user needs and ideas into the development of new business practices and methods. VDOT's lessons learned from using trip generation estimates can be beneficial to other agencies. The most important lessons learned pertaining to this practice are summarized below.

- The use of trip generation estimates has minimized the need to carry out traffic counts on qualified links by yielding time and cost savings for the department.
- It is cheaper to use state resources and labor than to hire contractors in most cases.
- Keys to successful application of the trip generation method include a clear implementation plan and specific assignment of roles and responsibilities to different parties within the agency.
- Developing requirements and guidelines can be a time-consuming process, but the benefits realized outweigh the development effort.
- Developing systematic instructions and providing illustrated examples facilitated the implementation process and helped VDOT staff easily understand how to apply the trip generation method.
- Providing information regarding the trip generation theory and explaining how formulas can be simplified can help region and district staff better understand the basic principles of this method and make appropriate assumptions.
- Having people with a strong background in data collection and traffic volume estimation helps with development of the guidelines.
- Agencies should inform managers and executives on cost savings and other benefits achieved through adopting more-efficient procedures.
- Staff must be willing to change existing business practices and learn how to use new methods.
- Having the right people in the room helps with decision-making.
- Agencies should consider the needs and preferences of all region and district staff. This helps secure buy-in and support across the board during and after the implementation phase.

- Agencies should estimate the cost for generating traffic volume estimates, compare it to the cost for conducting and processing short-duration counts, and relate it to the hidden cost of not having data on secondary local roads.
- If aerial photos are old, the quality of the photos is low, trees cover houses and driveways or there is significant construction activity in the examined area, it is better to visit the examined link(s) and gather necessary data and information in the field than from aerial images.

Because of the positive experience and feedback received with this effort, VDOT will continue to promote the use of the trip generation method.

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