Advanced Traffic Engineering

TE-504A/TE-504

Lecture-4

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DTEM

Traffic Volume

Traffic volume studies are conducted to collect data on the number of vehicles and /or pedestrians that pass a point on a highway facility during a specified time period.

This time period varies from as little as 15 minutes to as much as a year depending on the anticipated use of the data.

The data collected also may be put into subclasses which may include directional movement, occupancy rates, vehicle classification, and pedestrian age.

Traffic Volume

Traffic volume studies are usually conducted when certain volume characteristics are needed, some of which follow:

1. Average Annual Daily Traffic (AADT) is the average of 24-hour counts collected every day of the year. AADTs are used in several traffic and transportation analyses for:

a. Estimation of highway user revenue.

b. Computation of crash rates in terms of number of crashes per 100 million vehicle miles.

c. Establishment of traffic volume trends.

d. Evaluation of the economic feasibility of highway projects.

e. Development of freeway and major arterial street systems.

f. Development of improvement and maintenance programs.

Traffic Volume

2. Average Daily Traffic (ADT) is the average of 24-hour counts collected over a number of days greater than one but less than a year.

ADTs may be used for:

a. Planning of highway activities

b. Measurement of current demand

c. Evaluation of existing traffic flow

Traffic Volume

3. Peak Hour Volume (PHV) is the maximum number of vehicles that pass a point on a highway during a period of 60 consecutive minutes.

PHVs are used for:

a. Functional classification of highways

b. Design of the geometric characteristics of a highway, for example, number of lanes, intersection signalization, or channelization

c. Capacity analysis

d. Development of programs related to traffic operations, for example, one-way street systems or traffic routing

e. Development of parking regulations

Traffic Volume

4. Vehicle Classification (VC) records volume with respect to the type of vehicles for example, passenger cars, two-axle trucks, or three-axle trucks.

VC is used in:

a. Design of geometric characteristics, with particular reference to turning-radii requirements, maximum grades, lane widths, and so forth

b. Capacity analyses, with respect to passenger-car equivalents of trucks

c. Adjustment of traffic counts obtained by machines

d. Structural design of highway pavements, bridges, and so forth

Traffic Volume

5. Vehicle Miles of Travel (VMT) is a measure of travel along a section of a road. It is the product of the traffic volume (that is, average weekday volume or ADT) and the length of roadway in miles to which the volume is applicable.

VMTs are used mainly as a base for allocating resources for maintenance and improvement of highways

Methods of Conducting Volume Counts

Traffic volume counts are conducted using two basic methods: <u>manual and automatic.</u>

Manual Method:

Manual counting involves one or more persons recording observed vehicles using a counter. With this type of counter, both the turning movements at the intersection and the types of vehicles can be recorded.

Note that in general, the inclusion of pickups and light trucks with four tyres in the category of passenger cars does not create any significant deficiencies in the data collected, since the performance characteristics of these vehicles are similar to those of passenger cars.

In some instances, however, a more detailed breakdown of commercial vehicles may be required which would necessitate the collection of data according to number of axles and /or weight.

However, the degree of truck classification usually depends on the anticipated use of the data collected.

Methods of Conducting Volume Counts

The main disadvantages of the manual count method are as under:

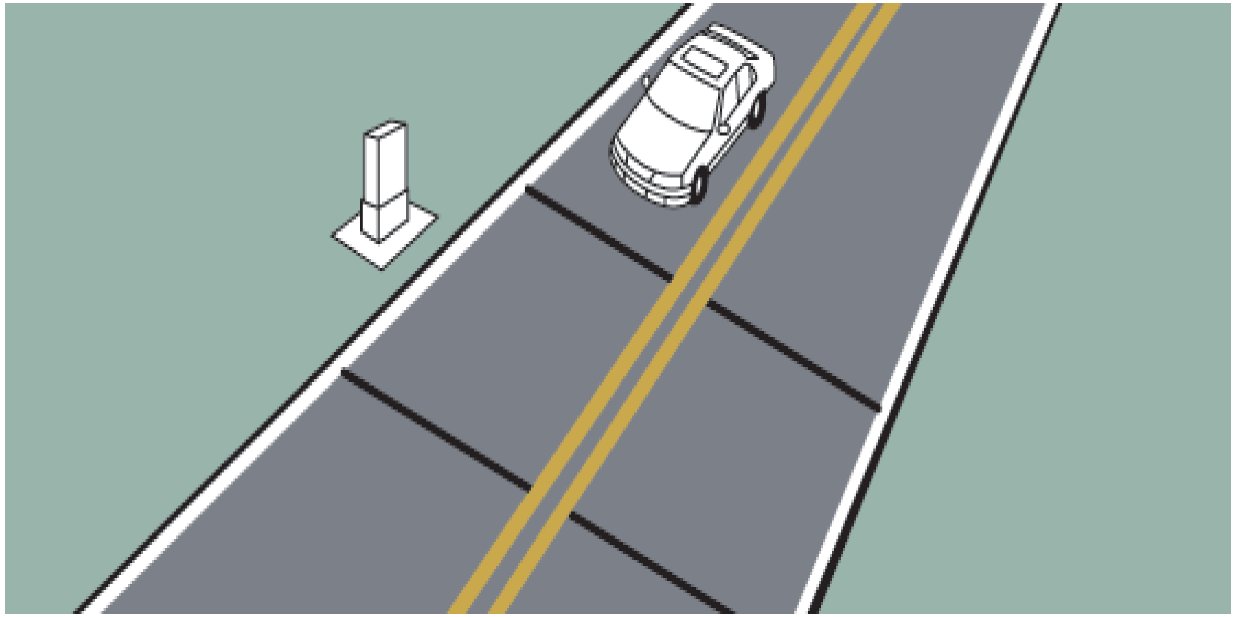
1. **It is labour intensive and therefore can be expensive,**
2. **It is subject to the limitations of human factors, and**
3. **It cannot be used for long periods of counting**

Methods of Conducting Volume Counts

Automatic Method

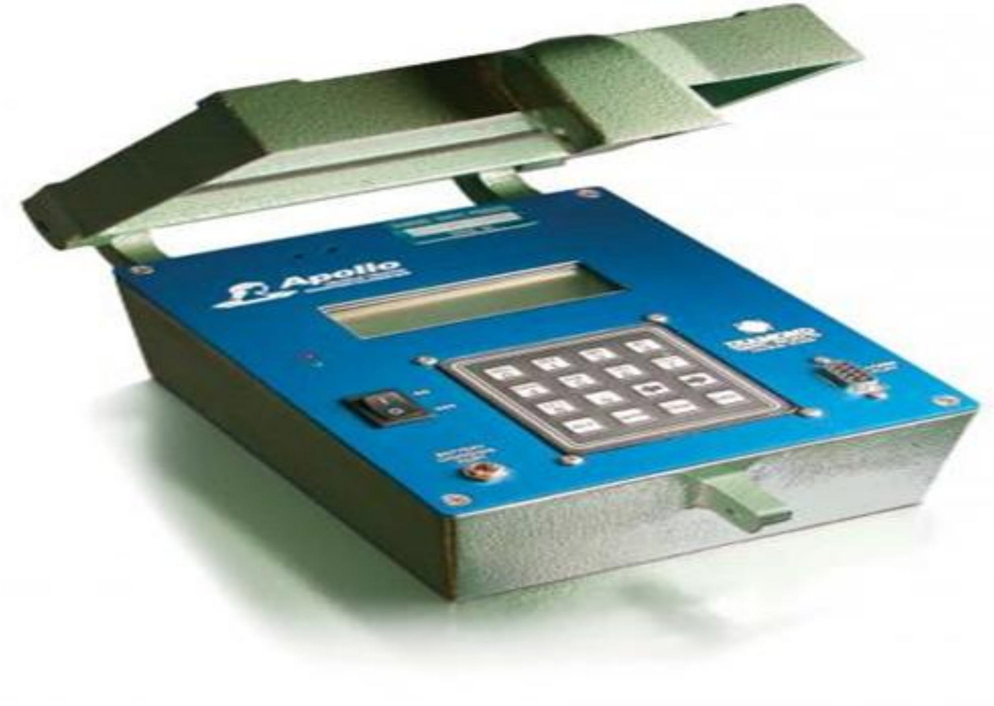
Automatic counters can be classified into two general categories: those that require the laying of detectors (surface or subsurface), and those that do not require the laying of detectors.

Automatic counters that require the laying of surface detectors (such as pneumatic road tubes) or subsurface detectors (non invasive, such as magnetic or electric contact devices) on the road, detect the passing vehicle and transmit the information to a recorder, which is connected to the detector at the side of the road.



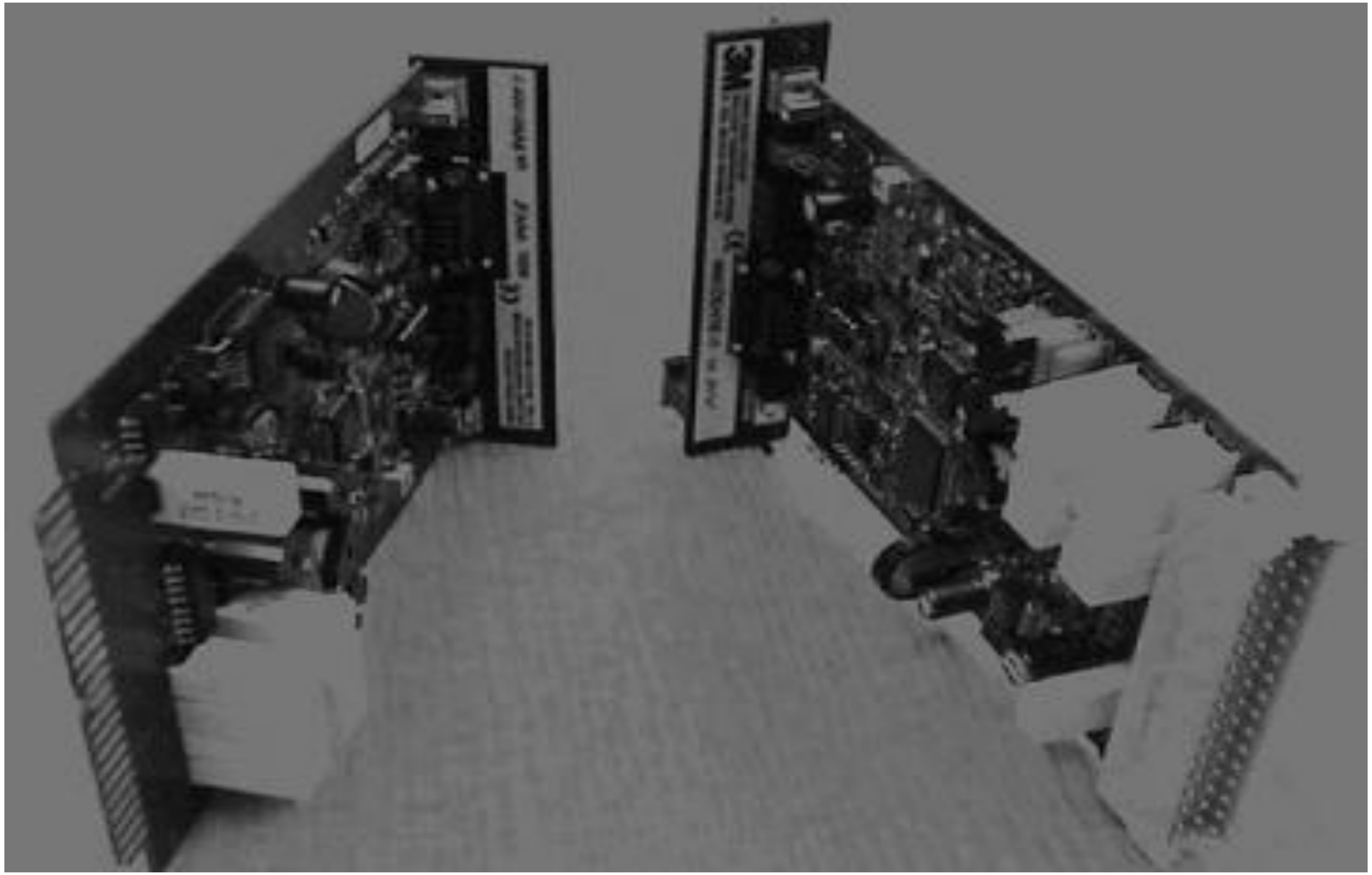
Methods of Conducting Volume Counts

Apollo Counter/Classifier which is particularly suitable for cities and counties. It is capable of obtaining per-vehicle or volume data. The data collected can be downloaded to the Centurion-CC software for Windows and a variety of reports obtained. Data collected can be verified in the field using a four-line LCD display. It can collect data on up to four lanes. It has a standard memory of 512k, but options of 4.5 MB and 8.5 MB are available. In addition to its internal battery, an optional solar panel is available.



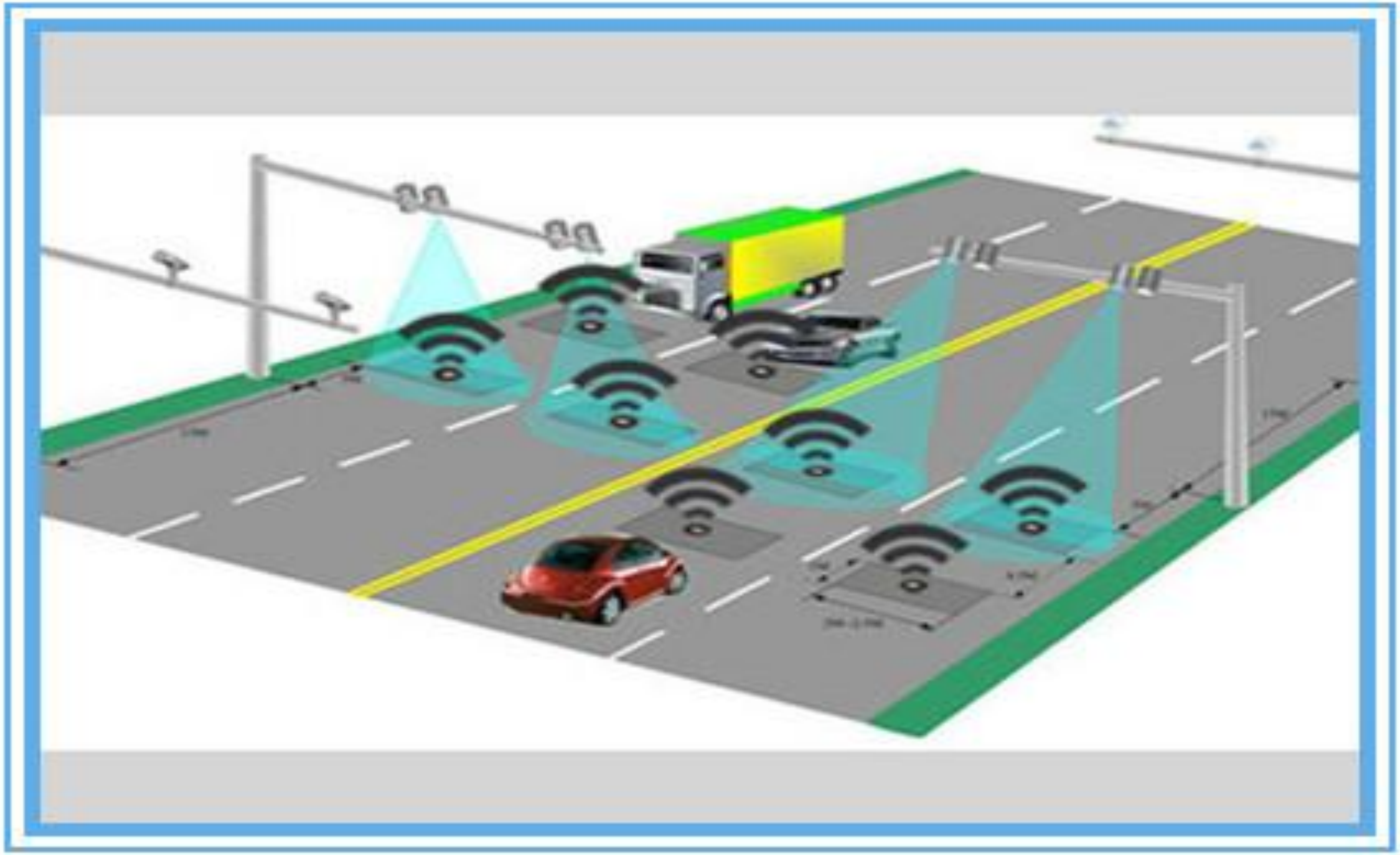
Methods of Conducting Volume Counts 3M Canoga C900 Series Vehicle Detectors

These use an inductive loop to identify the presence of individual vehicles and determine speed, length, occupancy, and obtain vehicle counts. They are designed to use either standard inductive loops or 3M's Non-Invasive Micro loop Model 702 Probes. These probes are considered to be non-invasive as they can be installed 18 to 24 in. below the road surface in 3 in. plastic conduits. They convert changes in the vertical component of the earth's magnetic field due to vehicles moving over them to changes in inductance. The vehicle detector then detects the change in inductance which signals the presence of a vehicle. Advantages of these loops include that once installed, they leave the road surface intact, they bypass the effect of poor surface conditions, and have lower life cycle costs.



Methods of Conducting Volume Counts
Traffic Detection Sensor

Traffic Detection Sensor, manufactured by OSI Laser Scan, emits two scanning laser beams to create a 3D image of each vehicle that passes through the field of the beams, thereby classifying the vehicle. The speed of the vehicle is determined from the difference in times the vehicle breaks the first and second beams.



Types of Volume Counts

Different types of traffic counts are carried out, depending on the anticipated use of the data to be collected.

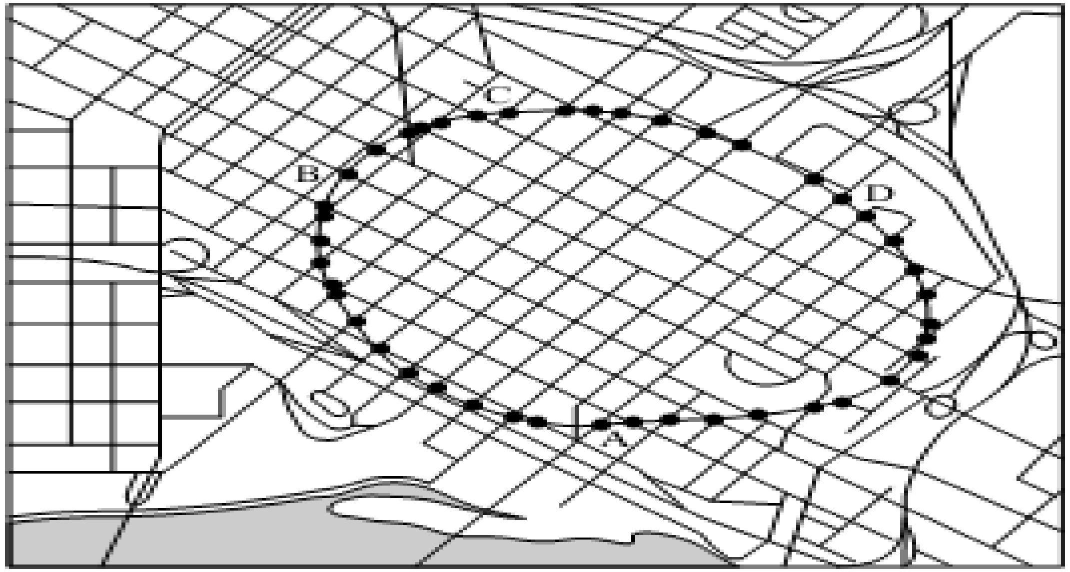
Cordon Counts:

When information is required on vehicle accumulation within an area such as the central business district (CBD) of a city, particularly during a specific time, a cordon count is undertaken. The area for which the data are required is cordoned off by an imaginary closed loop; the area enclosed within this loop is defined as the cordon area.

Types of Volume Counts

Cordon Counts:

Figure shows such an area where the CBD of a city is enclosed by the imaginary loop ABCDA. The intersection of each street crossing the cordon line is taken as a count station; volume counts of vehicles and /or persons entering and leaving the cordon area are taken. The information obtained from such a count is useful for planning parking facilities, updating and evaluating traffic operational techniques, and making long-range plans for freeway and arterial street systems.



Types of Volume Counts

In screen line counts, the study area is divided into large sections by running imaginary lines, known as screen lines, across it. In some cases, natural and manmade barriers, such as rivers or railway tracks, are used as screen lines. Traffic counts are then taken at each point where a road crosses the screen line. It is usual for the screen lines to be designed or chosen such that they are not crossed more than once by the same street. Collection of data at these screen-line stations at regular intervals facilitates the detection of variations in the traffic volume and traffic flow direction due to changes in the land-use pattern of the area.

Types of Volume Counts

Intersection counts are taken to determine vehicle classifications, through movements, and turning movements at intersections. These data are used mainly in determining phase lengths and cycle times for signalized intersections, in the design of channelization at intersections, and in the general design of improvements to intersections.

Types of Volume Counts

Volume counts of pedestrians are made at locations such as subway stations, mid-blocks, and crosswalks. The counts are usually taken at these locations when the evaluation of existing or proposed pedestrian facilities is to be undertaken. Such facilities may include pedestrian overpasses or underpasses

Types of Volume Counts

Periodic Volume Counts

In order to obtain certain traffic volume data, such as AADT, it is necessary to obtain data continuously. However, it is not feasible to collect continuous data on all roads because of the cost involved. To make reasonable estimates of annual traffic volume characteristics on an area-wide basis, different types of periodic counts, with count durations ranging from 15 minutes to continuous, are conducted; the data from these different periodic counts are used to determine values that are then employed in the estimation of annual traffic characteristics. The periodic counts usually conducted are continuous, control, or coverage counts.

Types of Volume Counts

Periodic Volume Counts-Continuous Counts

These counts are taken continuously using mechanical or electronic counters. Stations at which continuous counts are taken are known as permanent count stations. In selecting permanent count stations, the highways with in the study area must first be properly classified. Each class should consist of highway links with similar traffic patterns and characteristics. A highway link is defined for traffic count purposes as a homogeneous section that has the same traffic characteristics, such as AADT and daily, weekly, and seasonal variations in traffic volumes at each point. Broad classification systems for major roads may include freeways, express-ways, and major arterials. For minor roads, classifications may include residential, commercial, and industrial streets.

Types of Volume Counts

Periodic Volume Counts-Control Counts

These counts are taken at stations known as control-count stations, which are strategically located so that representative samples of traffic volume can be taken on each type of highway or street in an area-wide traffic counting program. The data obtained from control counts are used to determine seasonal and monthly variations of traffic characteristics so that expansion factors can be determined.

These expansion factors are used to determine year-round average values from short counts.

Types of Volume Counts

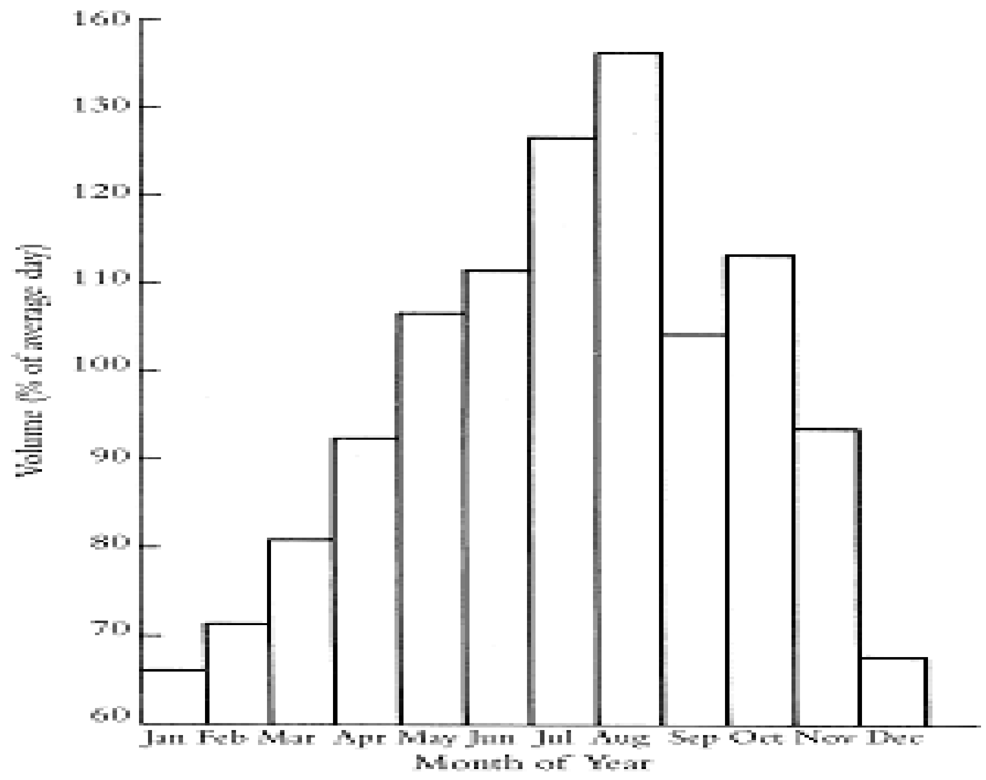
Periodic Volume Counts-Coverage Counts

These counts are used to estimate ADT, using expansion factors developed from control counts. The study area is usually divided into zones that have similar traffic characteristics. At least one coverage count station is located in each zone. A 24-hour non-directional weekday count is taken at least once every four years at each coverage station. The data indicate changes in area-wide traffic characteristics

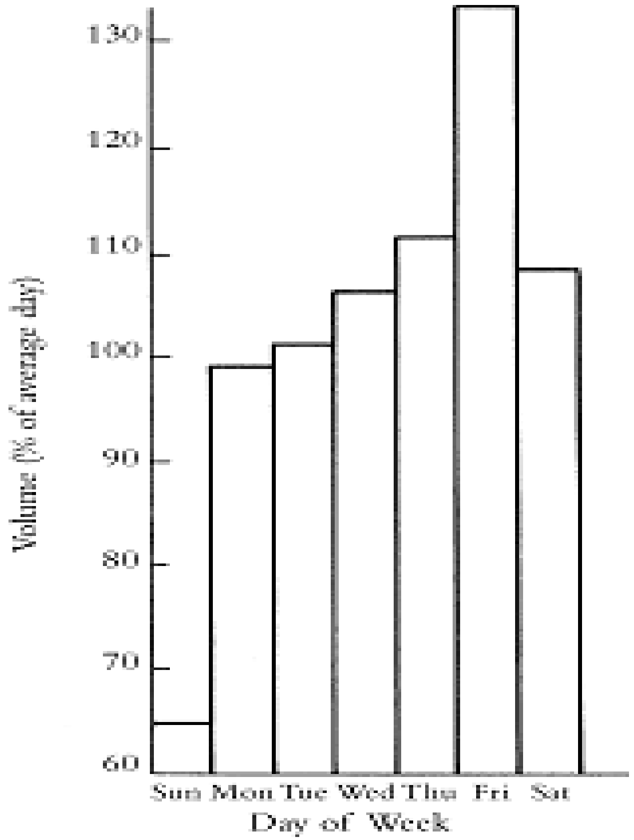
Traffic Volume Characteristics

A continuous count of traffic at a section of a road will show that traffic volume varies from hour to hour, from day to day, and from month to month. However, the regular observation of traffic volumes over the years has identified certain characteristics showing that although traffic volume at a section of a road varies from time to time, this variation is repetitive and rhythmic. These characteristics of traffic volumes are usually taken into consideration when traffic counts are being planned so that volumes collected at a particular time or place can be related to volumes collected at other times and places. Knowledge of these characteristics also can be used to estimate the accuracy of traffic counts.

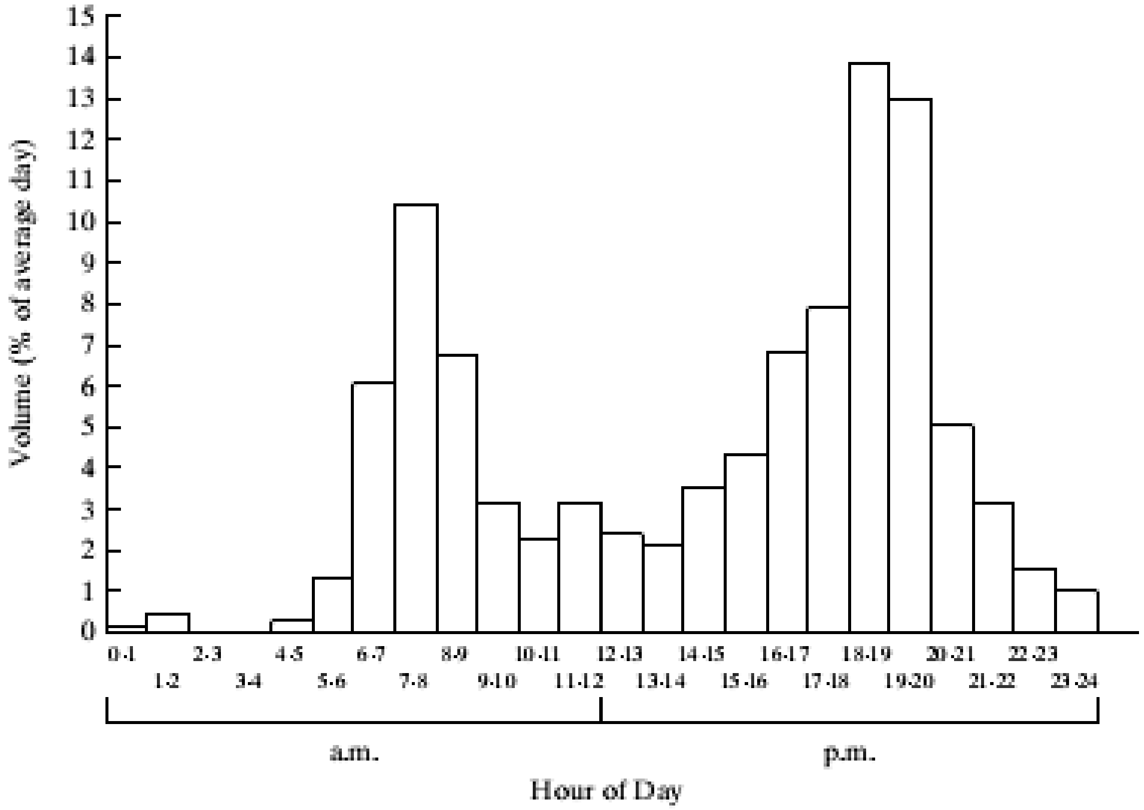
Monthly Traffic Variation



Daily Traffic Variation



Hourly Traffic Variation



Traffic Volume Data for a Highway Section

PHV	430
ADT	5375
Vehicle Classification (VC)	
Passenger cars	70%
Two-axle trucks	20%
Three-axle trucks	8%
Other trucks	2%

Determination of Number of Count Stations

The minimum sample size depends on the precision level desired. The commonly used precision level for volume counts is 95–5. When the sample size is less than 30 and the selection of counting stations is random, a distribution known as the student's t distribution may be used to determine the sample size for each class of highway links.

The student's t distribution is unbounded (with a mean of zero) and has a variance that depends on the scale parameter, commonly referred to as the degrees of freedom (v).

Determination of Number of Count Stations

The degrees of freedom (v) is a function of the sample size; v=N-1 for the student's t distribution. The variance of the student's t distribution is v/(v-2), which indicates that as v approaches infinity, the variance approaches 1. The probabilities (confidence levels) for the student's t distribution for different degrees of freedom are given in Table A.1.

Table A.1 Level of Significance for One-Tailed Test

	.250	.100	.050	.025	.010	.005	.0025	.0005
	Level of Significance for a Two-Tailed Test							
Degrees of Freedom	.500	.200	.100	.050	.020	.010	.005	.001
1.	1.000	3.078	6.314	12.706	31.821	63.657	27.321	536.627
2.	.816	1.886	2.920	4.303	6.965	9.925	14.089	31.599
3.	.765	1.638	2.353	3.182	4.541	5.841	7.453	12.924
4.	.741	1.533	2.132	2.776	3.747	4.604	5.598	8.610
5.	.727	1.476	2.015	2.571	3.365	4.032	4.773	6.869
6.	.718	1.440	1.943	2.447	3.143	3.707	4.317	5.959
7.	.711	1.415	1.895	2.365	2.998	3.499	4.029	5.408
8.	.706	1.397	1.860	2.306	2.896	3.355	3.833	5.041
9.	.703	1.383	1.833	2.262	2.821	3.250	3.690	4.781
10.	.700	1.372	1.812	2.228	2.764	3.169	3.581	4.587
11.	.697	1.363	1.796	2.201	2.718	3.106	3.497	4.437
12.	.695	1.356	1.782	2.179	2.681	3.055	3.428	4.318
13.	.694	1.350	1.771	2.160	2.650	3.012	3.372	4.221
14.	.692	1.345	1.761	2.145	2.624	2.977	3.326	4.140
15.	.691	1.341	1.753	2.131	2.602	2.947	3.286	4.073
16.	.690	1.337	1.746	2.120	2.583	2.921	3.252	4.015
17.	.689	1.333	1.740	2.110	2.567	2.898	3.222	3.965
18.	.688	1.330	1.734	2.101	2.552	2.878	3.197	3.922
19.	.688	1.328	1.729	2.093	2.539	2.861	3.174	3.883
20.	.687	1.325	1.725	2.086	2.528	2.845	3.153	3.850
21.	.686	1.323	1.721	2.080	2.518	2.831	3.135	3.819

Degrees of Freedom	.250	.100	.050	.025	.010	.005	.0025	.0005
	Level of Significance for a Two-Tailed Test							
	.500	.200	.100	.050	.020	.010	.005	.001
22.	.686	1.321	1.717	2.074	2.508	2.819	3.119	3.792
23.	.685	1.319	1.714	2.069	2.500	2.807	3.104	3.768
24.	.685	1.318	1.711	2.064	2.492	2.797	3.091	3.745
25.	.684	1.316	1.708	2.062	2.485	2.787	3.078	3.725
26.	.684	1.315	1.706	2.056	2.479	2.779	3.067	3.707
27.	.684	1.314	1.703	2.052	2.473	2.771	3.057	3.690
28.	.683	1.313	1.701	2.048	2.467	2.763	3.047	3.674
29.	.683	1.311	1.699	2.045	2.462	2.756	3.038	3.659
30.	.683	1.310	1.697	2.042	2.457	2.750	3.030	3.646
35.	.682	1.306	1.690	2.030	2.438	2.724	2.996	3.591
40.	.681	1.303	1.684	2.021	2.423	2.704	2.971	3.551
45.	.680	1.301	1.679	2.014	2.412	2.690	2.952	3.520
50.	.679	1.299	1.676	2.009	2.403	2.678	2.937	3.496
55.	.679	1.297	1.673	2.004	2.396	2.668	2.925	3.476
60.	.679	1.296	1.671	2.000	2.390	2.660	2.915	3.460
65.	.678	1.295	1.669	1.997	2.385	2.654	2.906	3.447
70.	.678	1.294	1.667	1.994	2.381	2.648	2.899	3.435
80.	.678	1.292	1.664	1.990	2.374	2.639	2.887	3.416
90.	.677	1.291	1.662	1.987	2.368	2.632	2.878	3.402
100.	.677	1.290	1.660	1.984	2.364	2.626	2.871	3.390
125.	.676	1.288	1.657	1.979	2.357	2.616	2.858	3.370
150.	.676	1.287	1.655	1.976	2.351	2.609	2.849	3.357
200.	.676	1.286	1.653	1.972	2.345	2.601	2.839	3.340
∞	.6745	1.2816	1.6448	1.9600	2.3267	2.5758	2.8070	3.2905

Determination of Number of Count Stations

Assuming that the sampling locations are randomly selected, the minimum sample number is given as

$$n = \frac{t^2_{\alpha/2,N-1}(S^2/d^2)}{1 + (1/N)(t^2_{\alpha/2,N-1})(S^2/d^2)}$$

where

- **N=minimum number of count locations required**
- **t=value of the student's t distribution with (1-a/2) confidence level (N-1 degrees of freedom)**
- **N=Total number of links (population) from which a sample is to be selected**
- **a=significance level**
- **S=estimate of the spatial standard deviation of the link volumes**
- **d=allowable range of error**

Problem

To determine a representative value for the ADT on 100 highway links that have similar volume characteristics, it was decided to collect 24-hour volume counts on a sample of these links. Estimates of mean and standard deviation of the link volumes for the type of highways in which these links are located are 32,500 and 5500, respectively. Determine the minimum number of stations at which volume counts should be taken if a 95 –5 precision level is required with a 10 percent allowable error.

- **Establish the data.**

a=(100-95)=5 percent

S=5500

M=32,500

d=0.1 32,500=3250 (allowable range of error)

v=100-1=99

$t_{a/2,99}$ =1.984 (from Table A.1)

Solution

$$n = \frac{t^2_{\alpha/2,N-1}(S^2/d^2)}{1 + (1/N)(t^2_{\alpha/2,N-1})(S^2/d^2)}$$

$$= \frac{(1.984^2 \times 5500^2)/3250^2}{1+(\frac{1}{100})(1.984^2 \times 5500^2)/3250^2} = \frac{11.27}{1.11} = 10.1$$

Counts should be taken at a minimum of 11 stations. When sample sizes are greater than 30, the normal distribution is used instead of the student’s t distribution

Adjustment of Periodic Counts

Expansion factors, used to adjust periodic counts, are determined either from continuous count stations or from control count stations.

Expansion Factors from Continuous Count Stations. Hourly, daily, and monthly expansion factors can be determined using data obtained at continuous count stations.

- Hourly expansion factors (HEFs) are determined by the formula

$$\text{HEF} = \frac{\text{total volume for 24-hr period}}{\text{volume for particular hour}}$$

These factors are used to expand counts of durations shorter than 24 hour to 24-hour volumes by multiplying the hourly volume for each hour during the count period by the HEF for that hour and finding the mean of these products.

Adjustment of Periodic Counts

- Daily expansion factors (DEFs) are computed as

$$DEF = \frac{\text{average total volume for week}}{\text{average volume for particular day}}$$

These factors are used to determine weekly volumes from counts of 24-hour duration by multiplying the 24-hour volume by the DEF.

- Monthly expansion factors (MEFs) are computed as

$$MEF = \frac{AADT}{\text{ADT for particular month}}$$

The AADT for a given year may be obtained from the ADT for a given month by multiplying this volume by the MEF.

Table-1: Hourly Expansion Factors for a Rural Primary Road

Hour	*Volume*	*HEF*	*Hour*	*Volume*	*HEF*
6:00–7:00 a.m.	294	42.00	6:00–7:00 p.m.	743	16.62
7:00–8:00 a.m.	426	29.00	7:00–8:00 p.m.	706	17.49
8:00–9:00 a.m.	560	22.05	8:00–9:00 p.m.	606	20.38
9:00–10:00 a.m.	657	18.80	9:00–10:00 p.m.	489	25.26
10:00–11:00 a.m.	722	17.10	10:00–11:00 p.m.	396	31.19
11:00–12:00 p.m.	667	18.52	11:00–12:00 a.m.	360	34.31
12:00–1:00 p.m.	660	18.71	12:00–1:00 a.m.	241	51.24
1:00–2:00 p.m.	739	16.71	1:00–2:00 a.m.	150	82.33
2:00–3:00 p.m.	832	14.84	2:00–3:00 a.m.	100	123.50
3:00–4:00 p.m.	836	14.77	3:00–4:00 a.m.	90	137.22
4:00–5:00 p.m.	961	12.85	4:00–5:00 a.m.	86	143.60
5:00–6:00 p.m.	892	13.85	5:00–6:00 a.m.	137	90.14

Total daily volume = 12,350.

Table-2: Daily Expansion Factors for a Rural Primary Road

Day of Week	*Volume*	*DEF*
Sunday	7895	9.515
Monday	10,714	7.012
Tuesday	9722	7.727
Wednesday	11,413	6.582
Thursday	10,714	7.012
Friday	13,125	5.724
Saturday	11,539	6.510

Total weekly volume = 75,122.

Table-3: Monthly Expansion Factors for a Rural Primary Road

Month	*ADT*	*MEF*
January	1350	1.756
February	1200	1.975
March	1450	1.635
April	1600	1.481
May	1700	1.394
June	2500	0.948
July	4100	0.578
August	4550	0.521
September	3750	0.632
October	2500	0.948
November	2000	1.185
December	1750	1.354

Total yearly volume = 28,450.
Mean average daily volume = 2370.

Problem

A traffic engineer urgently needs to determine the AADT on a rural primary road that has the volume distribution characteristics shown in Tables 1, 2 and 3. She collected the data shown below on a Tuesday during the month of May. Determine the AADT of the road.

7:00 – 8:00 a.m.	**1400**
8:00 – 9:00 a.m.	**535**
9:00 –10:00 a.m.	**650**
10:00 –11:00 a.m.	**710**
11:00 –12 noon	**650**

Solution

Estimate the 24-hr volume for Tuesday using the factors given in above Table.

$$= \frac{1400\times29.0+535\times22.05+650\times18.80+710\times17.10+650\times18.52}{5} = 11{,}959$$

Adjust the 24-hr volume for Tuesday to an average volume for the week using the factors given in Table.

$$\text{Total 7-day volume} = 11{,}959\times7.727$$

$$\text{Average 24-hr volume} = \frac{11{,}959\times7.727}{7} = \mathbf{13{,}201}$$

Since the data were collected in May, use the factor shown for May in Table to obtain the AADT.

$$\text{AADT} = 13{,}201\times1.394 = 18{,}402$$