Urban Traffic Volume Patterns in Tennessee

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Fifty-five continuous-count traffic recorders at 51 locations were installed in Tennessee cities since 1954. The recommendations of the Highway Research Board Committee on Urban Volume Characteristics were used as guides for the selection of locations for these recorders. The 1956 data at 30 locations in 13 cities were analyzed in studies for machine counts. Also, 1955 data at 33 locations were used in the analysis for manual counts.

• AN EXTENSIVE PROGRAM of studies of urban traffic volumes was inaugurated in Tennessee in 1954, since which 55 continuous-count traffic recording machines were located on 51 street sections in 23 cities. In the selection of locations for these installations, the state has followed in general the recommendations developed by the Highway Research Board Committee on Urban Volume Characteristics. These committee suggestions as interpreted by code for Tennessee are given in Appendix A. The designations of the urban continuous-count stations according to this classification are given in Appendix B.

Data for one complete year of operations, 1956, were available for 30 locations scattered throughout 13 cities. Table 1 shows the distribution of these stations by the cities. It is noted that these cities vary in population from 514 in Decaturville to over 400,000 in Memphis (Appendix B).

For the purpose of statistical analysis three tabulating cards were developed: No. 21 (Fig. 1); No. 31 (Fig. 2); and the general card, the code sheet (Fig. 3).

To determine the actual annual average daily number of vehicles (ADT) at a particular point on the road or street would require continuous counting for 365 days. On the other extreme, a qualified person could make an estimate without counting, just from general knowledge of the situation. The latter method usually would not be considered acceptable because of the suspected lack of accuracy. Because the exact determination is seldom possible, it becomes axiomatic that the ADT's are estimates based on sampling, and the cost of obtaining these estimates must be related to their accuracy. The problem, therefore, is to find means of measuring the accuracy of ADT estimates obtained by various methods of sampling traffic volumes. The measures used in the Tennessee studies make use of the configuration of similar patterns of repetition in the mass movement of the people and the concepts of probability of these repetitions.

At this time only a few basic analyses were made to aid in the evaluation of existing procedures of sampling traffic volumes, and to provide essential measures in the development of new traffic-counting schedules. The present, as well as other possible schedules, was presumed to be based on the assumption that a sample weekday count is representative of the average weekday volume of traffic during the month of the sample count. Therefore, this basic assumption was evaluated and the size of the standard error was estimated. The standard error is a measure of the dispersion of all possible estimates which are based on samples of a given size about their averages. Although the mathematics of probability do not require the knowledge of the true values in these studies, the true (or practically true) values are available at the continuous-count recorders and are therefore used as the basis for measurement of

TABLE 1

RATIOS OF ADT TO AVERAGE DAY OF THE MONTH, 1956; URBAN STATIONS IN TENNESSEE

Location	Station No.	January Ratio	January d[1]	February Ratio	February d[1]	March Ratio	March d[1]	April Ratio	April d[1]	May Ratio	May d[1]	June Ratio	June d[1]	July Ratio	July d[1]	August Ratio	August d[1]	September Ratio	September d[1]	October Ratio	October d[1]	November Ratio	November d[1]	December Ratio	December d[1]
Nashville	500	1.10	−1	1.02	−4	1.01	−1	0.97	−3	0.97	0	0.99	+3	0.96	−1	0.98	+2	1.02	+4	1.01	+2	1.02	+2	0.97	−2
	501	1.11	0	0.99	−7	0.99	−3	1.01	+1	0.96	−1	1.05	+9	1.02	+5	1.02	+6	1.01	+3	0.97	−2	0.97	−3	0.93	−6
	502	—[2]		—[2]		1.01	−1	0.95	−5	0.97	0	0.94	−2	0.88	−9	0.87	−9	1.00	+2	1.03	+4	1.05	+5	0.99	0
	503	1.22	+11	1.06	0	0.99	−3	0.95	−5	0.95	−2	0.94	−2	0.98	+1	0.98	+2	0.98	0	0.99	0	1.01	+1	1.00	+1
	504	1.07	−4	1.04	−2	1.03	+1	1.00	0	0.99	+2	1.01	+5	1.03	+6	0.95	−1	0.94	−4	0.95	−4	1.01	+1	1.00	+1
	505	1.09	−2	1.04	−2	1.03	+1	1.03	+3	0.97	0	0.93	−3	0.94	−3	0.94	−2	0.99	+1	1.05	+6	1.03	+3	1.00	+1
Memphis	506	1.09	−2	1.13	+7	1.06	+4	1.05	+5	0.95	−2	0.91	−5	0.90	−7	0.87	−9	0.87	−11	0.87	−12	0.91	−9	1.02	+3
	507	1.00	−11	1.06	0	1.05	+3	1.02	+2	1.00	+3	0.92	−4	0.93	−4	0.98	+2	1.00	+2	1.01	+2	1.01	+1	1.04	+5
	508	1.05	−6	1.07	+1	1.02	0	0.97	−3	0.95	−2	0.97	+1	0.99	+2	0.98	+2	—[2]		0.97	−2	0.98	−2	0.93	−6
	509	1.02	−9	0.96	−10	0.98	−4	0.94	−6	0.93	−4	0.94	−2	1.08	+11	1.05	+9	1.05	+7	1.04	+5	1.05	+5	—[2]	
	510	1.08	−3	1.03	−3	1.00	−2	1.03	+3	1.02	+5	0.99	+3	1.01	+4	0.96	+3	0.96	−2	0.97	−2	0.97	−3	0.95	−4
	511	1.19	+8	1.06	0	1.05	+3	1.11	+11	0.96	−1	0.92	−4	0.95	−2	0.89	−7	0.89	−9	0.99	0	0.95	−5	1.13	+14
Knoxville	512	1.07	−4	1.05	−1	1.03	+1	1.01	+1	1.03	+6	1.05	+9	0.86	−11	1.00	+4	1.02	+4	0.93	−6	0.96	−4	1.04	+5
	513	1.24	+13	1.15	+9	1.11	+9	1.04	+4	0.95	−2	0.90	−6	0.91	−6	0.88	−8	0.99	+1	0.99	0	0.96	−4	1.00	+1
	515	1.11	0	1.04	−2	0.96	−6	0.98	−2	0.98	+1	0.94	−2	0.93	−4	0.94	−2	1.02	+4	1.03	+4	1.08	+8	1.03	+4
Johnson City	517	1.15	+4	1.05	−1	1.02	0	1.00	0	0.96	−1	0.98	+2	0.96	−1	0.94	−2	0.96	−2	0.98	−1	1.02	+2	1.00	+1
	518	1.28	+17	1.11	+5	1.05	+3	0.98	−2	0.95	−2	0.95	−1	0.93	−4	0.80	−16	0.86	−12	0.99	0	—[2]		1.05	+6
Morristown	519	1.09	−2	1.08	+2	1.03	+1	1.01	+1	0.98	+1	0.95	−1	0.95	−2	0.94	−2	0.97	−1	1.00	+1	1.01	+1	1.03	+4
	520	1.13	+2	1.14	+8	1.10	+8	1.03	+3	1.00	+3	0.97	+1	1.06	+9	0.99	+3	1.01	+3	0.89	−10	0.85	−15	0.93	−6
Crossville	521	1.21	+10	1.16	+10	1.08	+6	1.05	+5	0.96	−1	0.86	−10	0.88	−9	0.84	−12	0.91	−7	1.01	+2	1.11	+11	1.11	+12
Rockwood	522	1.03	−8	1.02	−4	1.00	−2	1.00	0	0.99	+2	0.94	−2	1.00	+3	0.98	+2	0.99	+1	1.03	+4	1.05	+5	0.98	−1
McMinnville	523	1.13	+2	1.10	+4	1.03	+1	1.03	+3	1.00	+3	1.03	+7	0.97	0	0.97	+1	0.99	+1	0.96	−3	0.94	−6	0.91	−8
Columbia	524	1.08	−3	1.01	−5	0.97	−5	1.00	0	0.96	−1	1.04	+8	1.07	+10	1.04	+8	0.94	−4	0.97	−2	0.97	−3	0.98	−1
	525	1.12	+1	1.06	0	1.00	−2	1.00	0	0.96	−1	0.99	+3	0.99	+2	0.97	+1	0.95	−3	0.98	−1	0.99	−1	1.01	+2
Jackson	526	1.03	−8	0.99	−7	0.95	−7	0.97	−3	1.01	+4	1.01	+5	1.00	+3	—[2]		0.99	+1	0.99	0	1.00	0	0.96	−3
	527	1.05	−6	1.03	−3	1.01	−1	0.98	−2	0.97	0	0.99	+3	1.04	+7	1.03	+7	0.99	+1	0.97	−2	0.98	−2	0.97	−2
Dyersburg	528	1.09	−2	1.02	−4	0.97	−5	1.00	0	0.97	0	0.94	−2	0.94	−3	0.96	0	1.00	+2	1.03	+4	1.07	+7	1.03	+4
	529	1.07	−4	0.97	−9	0.93	−9	0.96	−4	0.88	−9	0.89	−7	1.06	+9	1.05	+9	1.00	+2	1.06	+7	1.11	+11	1.11	+12
Dresden	530	1.15	+4	1.10	+4	0.93	−9	0.93	−7	0.99	+2	0.98	+2	0.98	+1	1.00	+4	1.02	+4	1.09	+10	1.05	+5	0.86	−13
Decaturville	532	1.17	+6	1.10	+4	1.14	+12	1.12	+12	0.95	−2	0.97	+1	0.94	−3	0.90	−6	1.04	+6	1.00	+1	0.94	−6	0.86	−13
Mean Monthly Ratio		1.11		1.06		1.02		1.00		0.97		0.96		0.97		0.96		0.98		0.99		1.00		0.99	
$\Sigma d(+) = +716$			+78		+54		+53		+54		+32		+62		+73		+65		+49		+52		+68		+76
$\Sigma d(-) = -700$			−75		−64		−60		−42		−31		−53		−69		−76		−55		−47		−63		−65
Net d = +16																									
Σd^2 = (Total)			1305		756		719		564		245		649		990		1111		634		615		947		1181

[1] $d = (X_1 - X)\ 100$, where X_1 is the ratio of the station's annual ADT to the average day of the month and X is the mean monthly ratio for all stations.
[2] Unacceptable values.

$$S = \sqrt{\frac{1}{N-1}\left(\Sigma d^2 - \frac{1}{N}\,\Sigma d^2\right)} = \sqrt{\frac{1}{354-1}\left(9{,}716 - \frac{1}{354}\,16^2\right)} = \pm 5.2$$

N = Number of observations = 354.

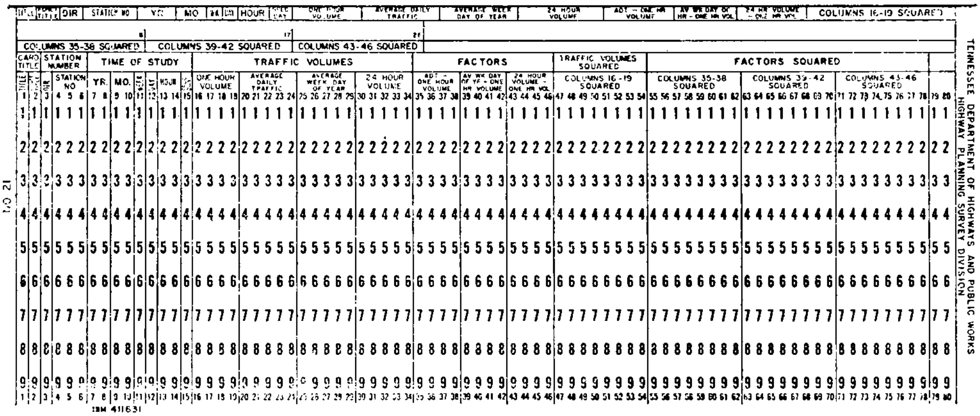

Figure 1.

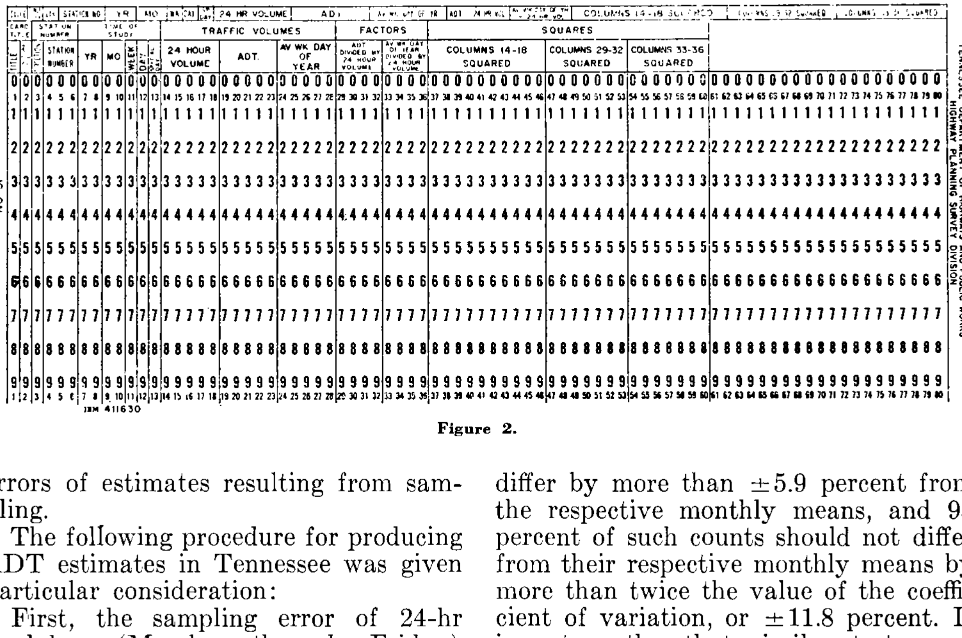

Figure 2.

errors of estimates resulting from sampling.

The following procedure for producing ADT estimates in Tennessee was given particular consideration:

First, the sampling error of 24-hr weekday (Monday through Friday) counts, which were distributed throughout all months of the year, was computed for the six stations in Memphis, as shown in Table 2. The mean coefficient of variation of ±5.9 percent means that when the traffic volume for a 24-hr period on a given weekday was compared with the average 24-hr weekday traffic during that month at that point, then, based on a normal distribution, it could be expected that approximately two-thirds of such 24-hr weekday counts would not differ by more than ±5.9 percent from the respective monthly means, and 95 percent of such counts should not differ from their respective monthly means by more than twice the value of the coefficient of variation, or ±11.8 percent. It is noteworthy that similar tests conducted by the Bureau of Public Roads on the 1954 data at 12 stations in St. Louis, Mo., resulted in standard deviation of ±5.4 percent; and for 1954-1955 data, except the period December through March, at 10 stations in Detroit, Mich., the standard deviation was ±6.3 percent.

If the truest adjustment ratio of ADT to average weekday of the month (namely, the ratio derived from the same station from which the sample was taken) were applied to the sample to estimate the ADT, the measure of error in such ADT estimates would still be expressed by the coefficient of variation of ±5.9 percent. Inasmuch as the mean ratio value of the various tests based on annual ADT is unity, the coefficient of variation is equal to the standard deviation. The significance of the measure of standard deviation in these cases is prac-

STATE OF TENNESSEE
DEPARTMENT OF HIGHWAYS AND PUBLIC WORKS
HIGHWAY PLANNING SURVEY DIVISION
CODING SHEET FOR AUTOMATIC TRAFFIC RECORDER DATA

	Card Column Number	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Station Number	1-2-3-4							
Day Of Week	5	7	1	2	3	4	5	6
Month Of Count	6 - 7							
Day Of Month	8 - 9							
Year	10 - 11							
Traffic Volume 6 A.M. - 7 A.M.	12 - 15							
7 - 8	16 - 19							
8 - 9	20 - 23							
9 - 10	24 - 27							
10 - 11	28 - 31							
11 - 12 Noon	32 - 35							
12 Noon - 1 P.M.	36 - 39							
1 - 2	40 - 43							
2 - 3	44 - 47							
3 - 4	48 - 51							
4 - 5	52 - 55							
5 - 6	56 - 59							
6 - 7	60 - 63							
7 - 8	64 - 67							
8 - 9	68 - 71							
Total 24 Hour Volume	72 - 76							
Peak Hour Volume	77 - 80							

Figure 3.

TABLE 2

SAMPLING ERROR OF SAMPLES OF 24-HR DURATION ON WEEKDAYS (MONDAY-FRIDAY) 1955, URBAN, MEMPHIS

Station No. and Item	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
506												
Number of weekdays	12	19	18	24	21	20	20	17	19	22	21	22
Avg. weekday volume	17,668	18,703	20,402	21,684	22,061	23,836	24,378	24,174	23,712	24,115	22,297	22,831
Coeff. of variation	10.8	3.3	3.9	3.9	3.1	2.4	2.8	3.2	8.4	2.7	3.5	8.8
507												
Number of weekdays	17	20	16	10	20	8	24	20	19	22	19	24
Avg. weekday volume	9,172	9,049	9,660	10,203	11,429	10,695	10,608	10,221	10,606	12,331	11,714	11,475
Coeff. of variation	4.8	4.5	3.8	5.3	12.6	3.9	4.6	4.7	4.4	7.9	4.2	6.2
508												
Number of weekdays	10	17	16	22	20	11	24	15	19	25	19	24
Avg. weekday volume	15,014	11,777	12,355	12,478	12,607	13,009	12,694	12,643	13,339	12,506	13,198	13,040
Coeff. of variation	20.7	3.8	3.6	5.6	7.2	4.3	3.9	3.6	7.1	11.2	5.6	6.4
509												
Number of weekdays	16	20	16	20	14	16	24	17	15	23	16	20
Avg. weekday volume	18,095	17,984	18,222	18,188	18,772	19,366	18,741	18,585	19,475	22,731	23,292	23,550
Coeff. of variation	2.2	4.7	3.6	6.7	10.8	3.5	3.7	4.2	14.4	1.7	4.3	8.0
510												
Number of weekdays	19	20	14	23	20	20	24	19	12	23	19	24
Avg. weekday volume	8,385	7,527	7,903	7,942	7,559	7,383	8,173	7,598	7,962	7,242	7,232	7,280
Coeff. of variation	1.8	5.1	4.9	4.2	4.9	3.8	10.6	5.9	4.4	7.2	2.6	7.3
511												
Number of weekdays	15	18	18	23	13	12	18	20	16	14	13	24
Avg. weekday volume	29,575	24,549	25,333	27,038	25,106	27,775	27,375	25,410	25,578	28,721	26,624	25,940
Coeff. of variation	8.9	4.6	4.2	4.0	8.5	7.9	9.8	5.9	11.7	5.6	10.0	7.9

Mean coefficient of variation $= \frac{426.2}{72} = \pm 5.9.$

tically synonymous with that of the coefficient of variation. Thus, this ±5.9 percent measure of the sampling error is the minimum that can be expected in the distribution of errors in ADT estimates in this particular study. That is, when these estimates are based on adjustment ratios computed in terms of ADT to average weekday of the month from any other source, it generally can be expected that the error in ADT estimates will be greater than the sampling error of the sample.

Next, the 24-hr weekday counts are adjusted to the ADT by application of appropriate factors. These factors are obtained from a group of stations having similar patterns of monthly variations of traffic volumes. They should be in terms of ratios of ADT to the average weekday traffic of the respective months. Because the factors are based on group values, the resulting group mean values are characterized by differences between the individual station data and the group mean data. Thus, factors are another source of error contributing to the error in the ADT estimates.

The material readily available did not permit evaluation of the error in such factors. However, a reasonable approximation was available in terms of the ratios of ADT to the average daily volume for each month for the 30 stations in 13 Tennessee cities. These ratios permitted measurement of monthly variations and comparisons of these variations among stations (Table 1). It is noted that the overwhelming majority of the monthly ratios vary from the respective means of the 30 stations by ±10 percent or less, and the standard deviation of these differences is ±5.2 percent.

By comparison with the spread of seasonal variation usually encountered on rural roads, the extremely narrow range observed in this study and the implications of these observations as regards traffic survey costs were given special attention in the analysis.

Experience with rural traffic counts (*1*) indicates that when monthly factors fall within the ±10 percent range of the group mean, the effect of added amount of error to the sampling error of the 24-hr sample in the estimates of ADT is very small. Thus, it appeared that single monthly expansion factors that are the means of the 30 stations could be used in Tennessee for the expansion of 24-hr weekday sample counts so that the resulting errors in ADT estimates would not be much larger than that expressed by the standard deviation of ±5.9 percent. The χ^2 test on these data (standard deviation ±5.2 percent) showed a probability level between 5 percent and 1 percent, $(0.05 > P > 0.01)$. Considering "good fit" within the range from 5 percent to 95 percent, the goodness of fit was not quite acceptable. The normal distribution is applicable only when chance forces are in operation. In this instance the normal distribution of the observed values is borderline, indicating the possibility of forces or heterogeneous populations causing results not due to chance alone. The computation of χ^2 is given in Table 3 and the values are presented graphically in Figure 4. The tend-

TABLE 3

CHI-SQUARE GOODNESS OF FIT TEST DEVIATIONS OF INDIVIDUAL RATIOS OF ADT FROM AVERAGE RATIO OF THE MONTH; $N = 354$, $S = \pm 5.24$

Class Interval	x	x/s	Cumulative Frequency, Theoretical	Theoretical f_t	Observed f_o	Cumulative Frequency, Observed	$f_o - f_t$	$(f_o - f_t)^2$	$\frac{(f_o - f_t)^2}{f_t}$
0.00-1.99	2.00	0.38	104.8	104.8	88	88	16.8	282.24	2.69
2.00-3.99	4.00	0.76	195.7	90.9	109	197	18.1	327.61	3.60
4.00-5.99	6.00	1.15	265.4	69.7	63	260	6.7	44.89	0.64
6.00-7.99	8.00	1.53	309.4	44.0	36	296	8.0	64.00	1.45
8.00-9.99	10.00	1.91	334.1	24.7	29	325	4.3	18.49	0.75
10.00-11.99	12.00	2.29	346.2	12.1	15	340	2.9	8.41	0.70
12.00-13.99	14.00	2.67	351.3	5.1	10	350	4.9	24.01	4.71
14.00-15.99	16.00	3.05	353.2	1.9	2	352			
16.00-17.99	18.00	3.44	353.8	0.6 }2.7	2 }4	354	1.3	1.69	0.63
18.00 and over	—	—	354.0	0.2	0	354			

Degrees of freedom = 8 − 2 = 6; $0.05 > P > .01$. $\chi^2 = 15.17$

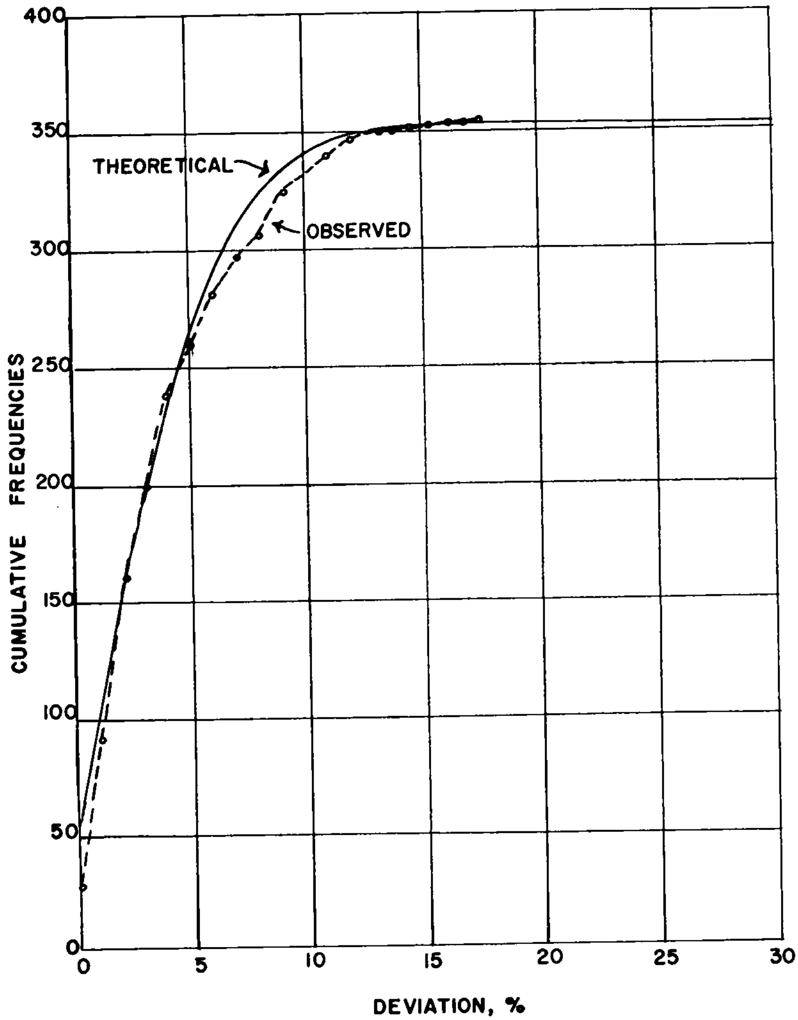

Figure 4. Cumulative frequencies of deviation of factors (ratios of ADT to average day of month) from monthly means.

ency for the traffic observations to concentrate bimodally on either side of the mean contributes to the low χ^2 probability level.

Three random samples of 6, 5, and 4 stations were taken from the 30-station data; the respective standard deviations, S, were ± 5.93, ± 4.70, and ± 2.53. The F-test related the variance, S^2, of each of the three random samples to the variance of the 30-station data and expressed the probability level of the relationship. The test showed that the 5- and 6-station random samples yielded stable results, whereas for the 4-station random sample the variations are so much greater as to be unreliable. The formula for the F-test is:

$$F = \frac{S_1^2}{S_2^2} \tag{1}$$

where

S_1^2 = the larger variance; and

S_2^2 = the smaller variance.

Another test for conformity, the T-test, related the significance of the difference in the monthly means of each of the three random samples to the monthly means of the 30-station data, but here the differences were not significant for all three. The formula for the T-test is:

$$T = \frac{\bar{X}_1 - \bar{X}_2}{S_{(\bar{X}_1 - \bar{X}_2)}} \qquad (2)$$

where

$$S_{(\bar{x}_1 - \bar{x}_2)} = \sqrt{\frac{(N_1+N_2)(\Sigma d_1^2 + \Sigma d_2^2)}{N_1 N_2 [(N_1-1)+(N_2-1)]}} \qquad (3)$$

$\bar{X}_1$ = monthly mean of sample having N_1 observations per month;

$\bar{X}_2$ = monthly mean of sample having N_2 observations per month;

Σd_1^2 = sum of the squares of the deviations of N_1 observations from the monthly mean; and

Σd_2^2 = sum of the squares of the deviations of N_2 observations from the monthly mean.

A χ^2 test on each of the three random samples conformed with normal curve requirements. Random samples are not always representative, inasmuch as such samples are subject to the law of chance. In this particular instance, the use of the 4-station random sample would appear to be the least satisfactory.

It was mentioned previously that the Tennessee 30-station data could have had a heterogeneous population. The following method was used to divide the original data into population groups having similar characteristics; in this case, pattern conformity:

1. An array of the 30 stations based on their ratio values was set up for each month of the year (Table 4).

TABLE 4

FREQUENCY DISTRIBUTION OF STATIONS BY VALUE OF RATIO OF ADT TO AVERAGE DAY FOR EACH MONTH AND THE LOCATION OF EACH QUARTILE POINT[1]

Ratio	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1.28	1											
1.24	1											
1.22	1											
1.21	1											
1.19	1											
1.17	1											
1.16		1										
1.15	2—Q3	1										
1.14		1	1									
1.13	2	1										1
1.12	1			1								
1.11	2	1	1	1							2	2
1.10	1	3—Q3	1									
1.09	4—Q2									1		
1.08	2	1	1								1	
1.07	3—Q1	1					2				1	
1.06		4	1				2			1		
1.05	2	2—Q2	3—Q3	2		2		2	1	1	4—Q3	1
1.04		3		1		1	1	1	1	1		2
1.03	2	2	5	4—Q3	1	1	1	1		4—Q3	1	3—Q3
1.02	1	3—Q1	2—Q2	1	1		1	1	4		2	1
1.01		1	3	3	1	2	1—Q3		2—Q3	3	4—Q2	1
1.00	1		3	6—Q2	3		2	2	4	2	1	5—Q2
0.99		2	2—Q1		3—Q3	4—Q3	2	2—Q3	6—Q2	5—Q2	1	1
0.98			1	3	2	2	2	5	1	2	2	2
0.97		1	2	3—Q1	5—Q2	3	1—Q2	2 —Q2	1	5—Q1	3—Q1	2
0.96		1	1	1	6	—Q2	2	1	2—Q1	1	2	1—Q1
0.95			1	2	6—Q1	2	2	1	1	1	1	1
0.94				1		6—Q1	3	4—Q1	2		2	
0.93			2	1	1	1	3—Q1			1		3
0.92						2						
0.91						1	1		1		1	1
0.90						1	1	1				
0.89						1		1	1	1		
0.88					1		2	1				
0.87								2	1	1		
0.86						1	1		1			2
0.85											1	
0.84								1				
0.80								1				

[1] Q_1, Q_2, and Q_3 show quartile points for each month.

2. The median and quartile values for each month were determined.
3. As shown in Table 5, arbitrary values were assigned to the quartile position of each station for each month, thereby setting up a configurative pattern for each station's relationship to all other stations.
4. The stations were grouped according to individual patterns, as follows:

> *Group I.* A relatively small amplitude of deviations from the monthly medians.
> *Group II.* Tending to deviate greatly from the monthly median values for the first 6 months of the year.
> *Group III.* Tending to deviate greatly from the monthly median values for the last 6 months of the year.
> *Group IV.* Having monthly values occurring within the interquartile range for more than 9 months of the year. In a normal distribution the interquartile range is the 50 percent probability level, as contrasted with the standard deviation of 68 percent. In the Tennessee data this range was approximately ±5 percent and this group consists of 12 of the 30 stations.
> *Group V.* A station having monthly values closest to the monthly mean or median of all stations was selected. Using the monthly mean or median values of this station (No. 519) as a control, all stations having values falling within ±10 percent of the control values were included in Group V. Although this method does not necessarily sepa-

TABLE 5

QUARTILE POSITION BY MONTH FOR EACH STATION IN RELATION TO ALL STATIONS[1]

Station	Group	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
500	III, IV, V	3	Q_1	2	Q_1	Q_2	Q_3	2	3	4	3	3	2
501	I, V	3	1	Q_1	3	2	4	4	4	Q_3	Q_1	Q_1	1
502	III, IV, V	—	—	2	1	Q_2	Q_1	1	1	3	Q_3	Q_3	2
503	I, IV	4	3	Q_1	1	Q_1	Q_1	3	3	2	Q_2	Q_2	Q_2
504	II, V	Q_1	2	3	Q_2	Q_3	4	4	2	1	1	Q_2	Q_2
505	I, IV, V	Q_2	2	3	Q_3	Q_2	1	2	Q_1	Q_2	4	3	Q_2
506	II	Q_2	4	4	4	Q_2	1	1	1	1	1	1	3
507	I, V	1	3	Q_3	3	Q_2	1	Q_1	3	3	3	Q_2	4
508	I, IV, V	1	3	Q_2	Q_1	Q_1	3	3	3	—	Q_1	2	1
509	III	1	1	1	1	1	Q_1	4	4	4	4	Q_3	—
510	II, IV, V	2	2	2	Q_3	4	Q_3	Q_3	Q_3	Q_1	Q_1	Q_1	1
511	II, V	4	3	Q_3	4	2	1	2	1	1	Q_2	1	4
512	I, V	Q_1	Q_2	3	3	4	4	1	4	4	1	1	4
513	II	4	4	4	4	Q_1	1	1	1	Q_2	Q_2	1	Q_2
515	I, IV, V	3	2	1	2	3	Q_1	Q_1	Q_1	Q_1	Q_3	4	Q_3
517	I, IV, V	Q_3	Q_2	Q_2	Q_2	2	3	2	Q_1	4	2	3	Q_2
518	II	4	4	Q_3	2	Q_1	2	Q_1	1	1	Q_2	—	4
519	I, IV, V	2	3	3	3	3	2	2	Q_1	2	3	Q_2	Q_3
520	II	3	4	4	Q_3	4	3	4	Q_3	Q_3	1	1	1
521	II	4	4	4	4	2	1	1	1	1	3	4	4
522	III, IV, V	1	Q_1	2	Q_2	Q_3	Q_1	3	3	Q_2	Q_3	Q_3	2
523	II	3	Q_3	3	Q_3	4	4	Q_2	Q_2	Q_2	1	1	1
524	I	2	1	1	Q_2	2	4	4	4	1	Q_1	Q_1	2
525	I, IV, V	3	3	2	Q_2	2	Q_3	3	Q_2	1	2	2	3
526	I, V	1	1	1	Q_1	4	4	3	—	Q_2	Q_2	2	Q_1
527	I, V	1	2	2	2	Q_2	Q_3	4	4	Q_3	Q_1	2	2
528	III, IV, V	2	Q_1	1	Q_2	Q_2	Q_1	2	2	3	Q_3	4	Q_3
529	III	Q_1	1	1	1	1	1	4	4	3	4	4	4
530	III	Q_3	Q_3	1	1	Q_3	3	3	4	4	4	Q_3	1
532	II	4	Q_3	4	4	Q_1	3	2	1	4	3	1	1

[1] 1 = ratio value $< Q_1$;
2 = ratio value $> Q_1 < Q_2$;
3 = ratio value $> Q_2 < Q_3$;
4 = ratio value $> Q_4$.

rate populations from a heterogeneous group, it does eliminate extreme values and trouble spots which probably should have been originally eliminated for one reason or another.

To test whether Groups I through V belong to significantly different populations, the groups were checked against each other by the use of the F- and T-tests. The results showed that Groups I, II, and III were distinct populations; Groups I and IV were not significantly different, inasmuch as their selection was based more or less on the frequency of monthly central tendency. Group IV is a mixed population, but it can be used when the least variance from the mean is desired. Group V is also a mixed population, tending to resemble Groups I and IV; it serves to eliminate undesirable extreme values due to error or forces incompatible with the remainder of the data. The separate populations can be broken down into subpopulations; however, there is danger in accepting the manifestations of a small group of individual stations which may not be truly representative of the whole population group.

The χ^2 test was applied to all five groups with satisfactory results for all except Groups III and V, indicating that these two groups still had heterogeneous populations and could be further divided into more populations.

Another test supplementing the χ^2 "goodness of fit" test to the normal curve was also made, namely, Fisher's g_1 and g_2 statistics. For each sample, these are based on the first through the fourth moments of the deviations of the observations from the mean of a frequency distribution where the X-axis is the class interval of the monthly value of the ratio of each station's annual ADT to the average day of the month, and the Y-axis is the frequency of occurrence. Just as the first and second moments about the mean are measures of the average deviation from the mean and the standard deviation, respectively, so are the first through the third moments used to obtain a measure of asymmetry (g_1) and the first through the fourth moments a measure of the kurtosis, flatness, and/or peakedness (g_2) as compared with the normal curve. The statistics g_1 and g_2 are calculated from the k-statistics, which are in turn derived from the sum of the powers, from the second through the fourth, of the deviations from the mean of a frequency distribution.

$$g_1 = \frac{k_3}{\sqrt{k_2{}^3}} \tag{4}$$

$$g_2 = \frac{k_4}{k_2{}^2} \tag{5}$$

In converting the values of g_1 and g_2 to "t" values, which show the probability levels and significance of the sample in relation to the normal curve, the following formulas were used:

$$t_{g1} = \frac{g_1}{\sqrt{S^2_{g2}}} \tag{6}$$

where

$$S^2_{g1} \text{ (variance of } g_1\text{)} = \frac{6N(N-1)}{(N-2)(N+1)(N+3)} \tag{7}$$

and N is the number of observations in samples.

$$t_{g2} = \frac{g_2}{\sqrt{S^2_{g2}}} \tag{8}$$

where

$$S^2_{g2} \text{ (variance of } g_2\text{)} = \frac{24N(N-1)^2}{(N-3)(N-2)(N+3)(N+5)} \tag{9}$$

An interesting sidelight on the value of g_2 is its use in determining the minimum size of a sample to be taken from a larger sample or population when the value of g_2 of the larger sample is known. The following formulas are used:

$$B_2 = g_2 + 3 \tag{10}$$

$$n \text{ (size of sample)} = \frac{B_2 - 1}{4V^2} \tag{11}$$

where V is the desired coefficient of variation for the standard deviation. In the Tennessee 30-station data, $g_2 = 0.4477$, and assuming the desired coefficient of variation, V, of the standard deviation is also equal to 10 percent, applying Eq. 10, $B_2 = 0.4477 + 3.000 = 3.4477$; and n (size of sample) $= \frac{3.4477-1}{4(0.10)^2} = 61.2$ months.

Because each station reports for 12 months, the minimum sample required is $\frac{61.2}{12}$ or 5 stations. However, this sample of 61.2 months is a random sample distributed over all stations and not clustered in five stations. This cluster effect has not yet been investigated, but because of its possible effect the number of stations may have to be raised to 6 or 7.

It has been observed that when the χ^2 test for "goodness of fit" showed weakness, the g_1 and g_2 tests tended to substantiate this weakness.

The results of the various tests for the selected groups are summarized in Table 6.

The following conclusions were reached regarding the observations on the 30-station Tennessee data:

1. The range of deviations of the monthly ratios from the respective means of the 30 urban traffic stations is predominantly ±10 percent. The standard deviation for the Tennessee urban stations was ±5.2 percent. Subsequent studies for urban stations in St. Louis, Mo., and Detroit, Mich., showed standard deviations of approximately ±6.0 percent. It appears that the confidence limits could be set so that a range lower than ±10 percent could be achieved if populations could be identified in urban areas. These heterogeneous populations can be separated on the basis of parameters showing similar configurative patterns or selected maximum ranges of deviation.

2. The "goodness of fit" tests as applied to the Gaussian or normal curve can be used to detect heterogeneous populations. These tests include the χ^2, and Fisher's g_1 and g_2 statistics.

3. Samples may be taken from heterogeneous populations, and with the proper statistical safeguards that they are representative of the original population they will give satisfactory results. The statistical safeguards are the F- and T-tests.

4. The 30 stations mean monthly adjustment factors could be satisfactorily used. Furthermore, practically the same factors could be obtained from the data for 6 or 7 stations randomly selected.

5. The tests indicate the possibility of refinements in the accuracy of adjustments for monthly variations. Such refinements would require identification of populations, which is a costly operation. Even if this were accomplished, the study of Nashville described later would indicate that the improvement in the accuracy of estimates of ADT when based on 24-hr weekday samples could hardly be expected to reduce the value of standard deviation by more than 1 percent.

NASHVILLE AND MEMPHIS STUDIES

From the data of 6 stations located in Nashville, 63 random samples of 24-hr duration were selected (Table 7). These were adjusted to the ADT estimates by application of the 6 stations monthly means of ratios of ADT's to the respective average weekday traffic volumes (Table 8). The differences (errors) of these estimates from their respective true values were expressed by the standard deviation of ±6.7 percent. Recalling that the sampling error of the 24-hr samples was measured by the standard deviation of ±5.9 percent for Memphis, the effect of factorization on the final error is small indeed. Further, to test the practical meaning of the previously discussed significance of the observed ±10 percent range of variation in the monthly characteristics of the variations among stations, it was assumed that no monthly adjustment ratios were available from Nashville stations. Instead, the monthly mean ratios from the six stations located in Memphis (Table 8) were used for estimating the ADT's in Nashville using the same 63 samples. The standard deviation resulting from this procedure was ±7.2 percent. The difference between 7.2 percent and 6.7 percent could hardly

TABLE 6

SUMMARY OF VARIOUS TESTS FOR SELECTED STATION GROUPS

Station Sample or Group	Test or Statistic					
	Std. Dev.	F-Test on Variance	T-Test on Means	χ^2 Test [3]	g-Criteria Prob. Levels t_{g1} [4]	g-Criteria Prob. Levels t_{g2} [4]
All 30 stations —	± 5.24			$0.05 > P > 0.01$	$P > 0.90$	$0.10 > P > 0.05$
Compared with: 6-station random sample		1.28				
5-station random sample		1.24				
4-station random sample		4.29 [1]				
Group I		2.12 [1]				
Group II		1.09	[2]			
Group III		1.49 [1]	[2]			
Group IV		3.20 [1]				
Group V		2.05 [1]				
6-Station random sample —	± 5.93			$0.70 > P > 0.50$	$P > 0.90$	$0.70 > P > 0.60$
Compared with: 5-station random sample		1.59				
4-station random sample		5.49 [1]				
Group I		2.71 [1]				
Group II		1.18				
Group III		1.91 [1]				
Group IV		4.10 [1]				
Group V		2.70 [1]				
5-Station random sample —	± 4.70			$0.30 > P > 0.20$	$0.80 > P > 0.70$	$0.30 > P > 0.20$
Compared with: 4-station random sample		3.45 [1]				
Group I		1.70 [1]				
Group II		1.35				
Group III		1.20	[2]			
Group IV		2.57 [1]				
Group V		1.65 [1]				
4-Station random sample —	± 2.53			$0.90 > P > 0.80$	$0.20 > P > 0.10$	$0.50 > P > 0.40$
Compared with: Group I		2.03 [1]				
Group II		4.66 [1]				
Group III		2.88 [1]	[2]			
Group IV		1.34				
Group V		2.09 [1]				
Group I (13 stations) —	± 3.60			$P = 0.10$	$0.30 > P > 0.20$	$0.10 > P > 0.05$
Compared with: Group II		2.30 [1]	[2]			
Group III		1.42 [1]	[2]			
Group IV		1.51 [1]				
Group V		1.03				
Group II (10 stations) —	± 5.46			$0.90 > P > 0.80$	$0.60 > P > 0.50$	$P > 0.90$
Compared with: Group III		1.62 [1]	[2]			
Group IV		3.47 [1]	[2]			
Group V		2.22 [1]	[2]			
Group III (7 stations) —	± 4.29			$0.02 > P > 0.01$	$0.50 > P > 0.40$	$0.02 > P > 0.01$
Compared with: Group IV		2.14 [1]	[2]			
Group V		1.37 [1]	[2]			
Group IV (12 stations) —	± 2.93			$0.20 > P > 0.10$	$0.90 > P > 0.80$	$P > 0.001$
Compared with: Group V		1.56 [1]				
Group V (18 stations) —	± 3.66			$0.05 > P > 0.02$	$0.50 > P > 0.40$	$0.01 > P > 0.001$

[1] Significant at 5 percent level.
[2] Difference in means highly significant at 5 percent level.
[3] Acceptable probability level between the 0.95 and 0.05 range.
[4] P values of less than 0.05 considered significantly different from a normal fit.

TABLE 7

ERRORS IN ADT ESTIMATES OF NASHVILLE TRAFFIC, 1956, BASED ON 24-HOUR WEEKDAY SAMPLES EXPANDED BY MEAN FACTORS

Month	24-Hr Weekday Volume	Using Mean Nashville Factor				Using Mean Memphis Factor			
				Error				Error	
		Factor	Est. ADT	Vol.	%	Factor	Est. ADT	Vol.	%
(a) Station 500, ADT 26,635									
Jan.	24,821	1.09	27,055	420	1.6	1.06	26,310	−325	−1.2
Feb.	25,528	1.02	26,038	−597	−2.2	1.03	26,294	−341	−1.3
Mar.	25,727	0.98	25,212	−1,423	−5.3	1.01	25,984	−651	−2.4
Apr.	27,727	0.95	26,341	−294	−1.1	1.01	28,004	1,369	5.1
May	29,876	0.92	27,486	851	3.2	0.96	28,681	2,046	7.7
June	30,435	0.93	28,305	1,670	6.3	0.93	28,304	1,669	6.3
July	27,407	0.93	25,489	−1,146	−4.3	0.96	26,311	−324	−1.2
Aug.	—	0.92	—	—	—	0.94	—	—	—
Sept.	—	0.95	—	—	—	0.95	—	—	—
Oct.	25,680	0.95	24,396	−2,239	−8.4	0.96	24,653	1,982	−7.4
Nov.	24,853	0.97	24,107	−2,529	−9.5	0.96	23,859	2,776	−10.4
Dec.	—	0.94	—	—	—	0.95	—	—	—
(b) Station 501 ADT 576									
Jan.	458	1.09	499	−77	−13.3	1.06	485	91	−15.8
Feb.	594	1.02	606	30	5.2	1.03	612	36	6.3
Mar.	668	0.98	655	79	13.7	1.01	675	99	17.2
Apr.	548	0.95	521	−55	9.5	1.01	553	−23	−4.0
May	602	0.92	554	−22	−3.8	0.96	578	2	0.3
June	565	0.93	525	−51	−8.9	0.93	525	−51	−8.9
July	605	0.93	563	−13	−2.3	0.96	581	5	0.9
Aug.	530	0.92	488	−88	−15.3	0.94	498	−78	−13.5
Sept.	531	0.95	504	−72	−12.5	0.95	504	−72	−12.5
Oct.	561	0.95	533	−42	−7.3	0.96	539	−37	−6.4
Nov.	573	0.97	556	−20	−3.5	0.96	550	−26	−4.5
Dec.	633	0.94	595	19	3.3	0.95	601	25	4.3
(c) Station 502, ADT 4,868									
Jan.	4,456	1.09	4,857	−411	−8.4	1.06	4,723	−145	−3.0
Feb.	4,489	1.02	4,579	−289	−5.9	1.03	4,624	−244	−5.0
Mar.	5,285	0.98	5,179	311	6.4	1.01	5,338	470	9.7
Apr.	5,736	0.95	5,449	581	11.9	1.01	5,793	925	19.0
May	5,515	0.92	5,074	206	4.2	0.96	5,294	426	8.8
June	5,844	0.93	5,435	567	11.6	0.93	5,435	567	11.6
July	5,928	0.93	5,513	645	13.2	0.96	5,691	823	16.9
Aug.	—	0.92	—	—	—	0.94	—	—	—
Sept.	5,099	0.95	4,844	−24	−0.5	0.95	4,844	−24	−0.5
Oct.	5,140	0.95	4,883	15	0.3	0.96	4,934	66	1.4
Nov.	5,267	0.97	5,109	241	4.9	0.96	5,056	188	3.9
Dec.	—	0.94	—	—	—	0.95	—	—	—
(d) Station 503, ADT 7,615									
Jan.	7,436	1.09	8,105	490	6.4	1.06	7,882	267	3.5
Feb.	7,834	1.02	7,991	376	4.9	1.03	8,069	454	6.0
Mar.	7,967	0.98	7,808	193	2.5	1.01	8,047	432	5.7
Apr.	8,219	0.95	7,808	193	2.5	1.01	8,301	686	9.0
May	8,641	0.92	7,950	335	4.4	0.96	8,295	680	8.9
June	8,010	0.93	7,449	−166	−2.2	0.93	7,449	−166	−2.2
July	8,295	0.93	7,714	99	1.3	0.96	7,963	348	4.6
Aug.	8,453	0.92	7,777	162	2.1	0.94	7,946	331	4.3
Sept.	8,363	0.95	7,945	330	4.3	0.95	7,945	330	4.3
Oct.	7,861	0.95	7,468	−147	−1.9	0.96	7,547	−68	−0.9
Nov.	8,023	0.97	7,782	167	2.2	0.96	7,702	87	1.1
Dec.	7,980	0.94	7,501	−114	−1.5	0.95	7,581	−34	−0.4
(e) Station 504, ADT 7,863									
Jan.	8,061	1.09	8,786	923	11.7	1.06	8,545	682	8.7
Feb.	—	1.02	—	—	—	1.03	—	—	—
Mar.	8,226	0.98	8,061	198	2.5	1.01	8,308	445	5.7
Apr.	8,734	0.95	8,297	434	5.5	1.01	8,821	958	12.2
May	8,281	0.92	7,619	−244	−3.1	0.96	7,950	87	1.1
June	8,822	0.93	8,204	341	4.3	0.93	8,204	341	4.3
July	7,936	0.93	7,380	−483	−6.1	0.96	7,618	−245	−3.1
Aug.	8,540	0.92	7,857	−6	−0.1	0.94	8,028	165	2.1
Sept.	—	0.95	—	—	—	0.95	—	—	—
Oct.	8,772	0.95	8,333	470	6.0	0.96	8,421	558	7.1
Nov.	8,400	0.97	8,148	285	3.6	0.96	8,064	201	2.6
Dec.	8,601	0.94	8,085	222	2.8	0.95	8,171	308	3.9

TABLE 7—Continued

Month	24-Hr Weekday Volume	Using Mean Nashville Factor				Using Mean Memphis Factor			
		Factor	Est. ADT	Error Vol.	Error %	Factor	Est. ADT	Error Vol.	Error %
(*f*) Station 505, ADT 17,439									
Jan.	17,869	1.09	19,477	2,038	11.7	1.06	18,941	1,502	8.6
Feb.	—	1.02	—	—	—	1.03	—	—	—
Mar.	17,420	0.98	17,072	−367	−2.1	1.01	17,594	155	0.9
Apr.	17,061	0.95	16,208	−1,231	−7.1	1.01	17,232	−207	−1.2
May	18,993	0.92	17,474	35	0.2	0.96	18,233	794	4.6
June	19,157	0.93	17,816	377	2.2	0.93	17,816	377	2.2
July	—	0.93	—	—	—	0.96	—	—	—
Aug.	18,274	0.92	16,812	−627	−3.6	0.94	17,178	−261	−1.5
Sept.	17,998	0.95	17,098	−341	−2.0	0.95	17,098	−341	−2.0
Oct.	18,810	0.95	17,869	430	2.5	0.96	18,058	619	3.5
Nov.	17,883	0.97	17,346	−93	−0.5	0.96	17,168	−271	−1.6
Dec.	19,789	0.94	18,602	1,163	6.7	0.95	18,800	1,361	7.8

$$\text{Standard deviation (Nashville)} = S = \frac{\sqrt{\Sigma(\text{percent error})^2}}{N-1} = \frac{\sqrt{2{,}786.54}}{63-1} = \pm 6.7 \text{ percent}$$

$$\text{Standard deviation (Memphis)} = S = \frac{\sqrt{\Sigma(\text{percent error})^2}}{N-1} = \frac{\sqrt{3{,}255.18}}{63-1} = \pm 7.2 \text{ percent}$$

$$N = 63$$

be considered of practical significance, yet it implies the complete absence of need for Nashville data for the adjustment of samples. At least for this purpose, the six stations in Nashville could be considered unnecessary. Furthermore, the identification of possible different populations, as previously discussed, could not have had any appreciable practical effect on the accuracy of ADT estimates based on 24-hr weekday samples, as the error could not be expected to fall below the ±5.9 percent standard deviation of sampling.

A comparison of the same 63 24-hr weekday sample counts directly with the ADT's disclosed that the differences between the sample traffic volumes and the respective ADT's were measured by a standard deviation of ±8.7 percent. Considering that the corresponding minimum possible measure was ±5.9 percent, and the best results upon factorization (by Nashville factors) was 6.7 percent, a significant conclusion is derived: if on a 68 percent confidence limit, errors of 9 percent or less would be acceptable as satisfactorily accurate, a 24-hr weekday traffic count may be assumed to represent the ADT's. Similar tests on Detroit and St. Louis appear to bear out this conclusion with qualifications, as follows:

1. The months of January, July, August, and December show a high degree of dispersion for the test observations,

TABLE 8

COMPUTATION OF MEAN FACTORS (RATIO OF ADT TO AVERAGE WEEKDAY), 1956

Month	Nashville Sta. 500	Sta. 501	Sta. 502	Sta. 503	Sta. 504	Sta. 505	Mean	Memphis Sta. 506	Sta. 507	Sta. 508	Sta. 509	Sta. 510	Sta. 511	Mean
Jan.	1.09	1.12	1.14	1.15	1.10	1.03	1.09	1.12	0.95	1.05	0.99	1.07	1.17	1.06
Feb.	1.02	1.00	1.11	1.00	0.98	0.98	1.02	1.16	0.99	1.06	0.93	1.01	1.04	1.03
Mar.	1.01	1.01	0.94	0.94	0.97	0.98	0.98	1.10	0.99	1.02	0.95	0.98	1.04	1.01
Apr.	0.96	1.00	0.88	0.91	0.94	0.98	0.95	1.11	0.97	0.97	0.91	1.01	1.10	1.01
May	0.97	0.95	0.89	0.89	0.93	0.91	0.92	1.01	0.96	0.95	0.90	0.99	0.95	0.96
June	0.94	1.04	0.88	0.89	0.94	0.89	0.93	0.95	0.87	0.97	0.90	0.96	0.90	0.93
July	0.94	1.01	0.84	0.92	0.96	0.90	0.93	0.94	0.88	0.98	1.03	0.97	0.93	0.96
Aug.	0.96	1.01	0.82	0.92	0.88	0.90	0.92	0.90	0.93	0.97	1.00	0.95	0.87	0.94
Sept.	1.01	1.00	0.93	0.93	0.88	0.94	0.95	0.91	0.97	0.98	1.01	0.94	0.88	0.95
Oct.	1.00	0.95	0.94	0.93	0.88	0.99	0.95	0.90	0.97	0.96	0.99	0.95	0.96	0.96
Nov.	1.02	0.97	0.96	0.96	0.94	0.98	0.97	0.95	0.95	0.97	1.01	0.93	0.92	0.96
Dec.	0.95	0.91	0.92	0.96	0.94	0.95	0.94	0.99	0.99	0.92	0.95	0.92	0.95	0.95
ADT	26,635	576	4,868	7,615	7,863	17,439	—	23,671	10,394	12,282	21,254	7,058	27,903	—

hence are not representative months of the year.

2. There are low-volume roads in urban areas which will also show a high degree of dispersion and may not be reliable.

3. The average weekday count is generally higher than the respective annual ADT, the average difference for the year being about +5 percent of the ADT. When seasonal variation is considered, the average range of the 24-hr weekday count is about 95 to 110 percent of the ADT. In Tennessee, because the factors are already available, the adjustments for monthly variations will be made.

FOUR-HOUR WEEKDAY COUNTS

Manual counts of 4-hr duration on weekdays are also used in Tennessee cities for the purpose of estimating ADT. The evaluation of the conversion of weekday 24-hr counts to estimates of ADT already has been discussed. Utilizing an electronic computer, a population study was made on the 1955 data of 33 urban continuous-count recorders for the purpose of determining and evaluating the procedure for the expansion of these 4-hr samples into estimates of traffic during 24 hr on weekdays.

Table 9 shows the mean expansion

TABLE 9

FACTORS FOR THE EXPANSION OF 4-HR URBAN COUNTS TO 24-HR COUNTS ON WEEKDAYS AND THE EVALUATION OF THE ACCURACY OF THESE FACTORS, TENNESSEE, 1955

Month	Number of Counts	Average Ratio of 24-Hr Traffic to 4-Hr Traffic			Number of Counts	Average Ratio of 24-Hr Traffic to 4-Hr Traffic		
		Ratio	Standard Dev.	Standard Error		Ratio	Standard Dev.	Standard Error
		(a) 6 AM — 10 AM				(b) 7 AM — 11 AM		
Jan.	262	4.54	0.85	0.05	262	4.10	0.64	0.04
Feb.	631	4.72	0.84	0.03	631	4.29	0.62	0.02
Mar.	719	4.52	0.73	0.03	719	4.26	0.55	0.02
Apr.	672	4.40	0.59	0.02	672	4.27	0.52	0.02
May	643	4.43	0.55	0.02	643	4.35	0.51	0.02
June	685	4.60	0.63	0.02	685	4.45	0.58	0.02
July	603	4.61	0.70	0.03	603	4.46	0.59	0.02
Aug.	736	4.57	0.67	0.02	736	4.46	0.61	0.02
Sept.	690	4.53	0.84	0.03	690	4.38	0.67	0.03
Oct.	633	4.34	0.66	0.03	633	4.18	0.57	0.02
Nov.	623	4.42	0.72	0.03	623	4.15	0.60	0.02
Dec.	414	4.50	0.73	0.04	414	4.19	0.60	0.03
Avg	—	4.50 [1]	0.71	—	—	4.31 [1]	0.59	—
		(c) 8 AM — NOON				(d) 11 AM — 3 PM		
Jan.	262	4.53	0.65	0.04	262	4.47	0.54	0.03
Feb.	631	4.50	0.66	0.03	631	4.26	0.62	0.02
Mar.	719	4.50	0.56	0.02	719	4.30	0.56	0.02
Apr.	672	4.53	0.51	0.02	672	4.39	0.55	0.02
May	643	4.60	0.52	0.02	643	4.50	0.58	0.02
June	685	4.54	0.53	0.02	685	4.33	0.52	0.02
July	603	4.59	0.52	0.02	603	4.47	0.51	0.02
Aug.	736	4.63	0.53	0.02	736	4.46	0.57	0.02
Sept.	690	4.57	0.58	0.02	690	4.51	0.62	0.02
Oct.	633	4.45	0.50	0.02	633	4.46	0.60	0.02
Nov.	623	4.39	0.57	0.02	623	4.34	0.60	0.02
Dec.	414	4.45	0.57	0.03	414	4.35	0.57	0.03
Avg	—	4.53 [1]	0.56	—	—	4.40 [1]	0.57	—
		(e) 12 NOON — 4 PM				(f) 1 PM — 5 PM		
Jan.	262	4.14	0.41	0.03	262	3.66	0.34	0.02
Feb.	631	3.93	0.48	0.02	631	3.57	0.36	0.01
Mar.	719	3.96	0.45	0.02	719	3.62	0.33	0.01
Apr.	672	4.08	0.42	0.02	672	3.71	0.10	0.00
May	643	4.18	0.48	0.02	643	3.79	0.34	0.01
June	685	4.16	0.42	0.02	685	3.85	0.10	0.00
July	603	4.30	0.45	0.02	603	3.94	0.36	0.01
Aug.	736	4.25	0.51	0.02	736	3.90	0.37	0.01
Sept.	690	4.21	0.52	0.02	690	3.87	0.39	0.01
Oct.	633	4.10	0.49	0.02	633	3.74	0.37	0.01
Nov.	623	4.00	0.47	0.02	623	3.65	0.34	0.01
Dec.	414	3.98	0.48	0.02	414	3.63	0.34	0.02
Avg	—	4.11 [1]	0.47	—	—	3.75 [1]	0.31	—

[1] Weighted average based on card count.

factors, the standard deviation, and the standard errors of the means of the expansion factors by months and by different 4-hr periods of traffic counts; notable are the great similarities of the mean monthly factors and the consistency of the standard deviation for various 4-hr periods. It is observed, however, that the greatest variations, average standard deviation ±0.71, occur during the period from 6 to 10 AM, being 15.8 percent of the mean factor of 4.5. The smallest variation is for the period from 1 to 5 PM, for which the average standard deviation is ±0.31 or ±8.3 percent of the mean factor of 3.75. These characteristics indicate that these estimates of 24-hr weekday volumes are accurate in terms of standard deviations of about ±12 to 13 percent, which may be considered satisfactory for practical purposes.

CONCLUSIONS

1. Traffic counts of 24-hr duration on weekdays may be assumed to represent the annual average daily traffic within certain limitations, some of which have been referred to in the St. Louis and Detroit studies. Although previous studies have indicated that this may result in an overestimate, the error of this assumption is within practical limits of acceptance.

2. Weekday traffic counts of 4-hr duration during the periods 6 to 10 AM, 7 to 11 AM, 8 AM to noon, 11 AM to 3 PM, noon to 4 PM, and 1 to 5 PM produce satisfactory estimates of 24-hr weekday traffic volumes when expanded by means of monthly average factors of 33 stations.

3. The monthly variations of traffic are very uniform throughout all 30 stations in 13 cities. The predominant majority of the ratios of ADT's to the daily averages by the months at individual stations fall within the ±10 percent range from their respective means of 30 stations.

Statistical analyses indicate the existence of several statistical populations in the factors of the monthly variations. However, indications were found that if the various populations were identified the possible refinement in accuracy of estimates of ADT's based on 24-hr samples would be too small to be practical.

REFERENCE

1. PETROFF, B. B. *Pub. Roads* (Dec. 1956).

APPENDIX A

CODES USED FOR THE DISTRIBUTION AND LOCATION OF CONTINUOUS-COUNT URBAN STATIONS BY CITY CHARACTERISTICS AND STREET CLASSIFICATION

A. Distribution by city characteristics:

I. By dominant economic base (as described on pages 37 and 48 of the 1950 Municipal Yearbook):

(a) Manufacturing and industrial, including diversified manufacturing, mining, and transportation.
(b) Retail, including diversified retail.
(c) Wholesale.
(d) Resort.
(e) Education.
(f) Government.
(g) Dormitory.

II. By population size (1950 census):

(a) 1,000,000 and over.
(b) 500,000-1,000,000.
(c) 250,000- 500,000.
(d) 100,000- 250,000.
(e) 50,000- 100,000.
(f) 25,000- 50,000.
(g) 10,000- 25,000.

B. Location by street classification:

I. By traffic function:

(a) Major or arterial streets:

1. Radials that are part of primary state highways.
2. Radials that are not part of primary state highways.
3. Crosstowns (or rings) connecting two or more major radials.

(b) Secondary streets:

1. Radials and crosstowns.
2. Local, commercial and industrial.
3. Local, residential.

II. By average over-all speed range in peak period:

(a) 5-15 mph.
(b) 15-25 mph.
(c) 25-35 mph.
(d) 35-45 mph.

APPENDIX B

URBAN CONTINUOUS COUNT STATIONS IN TENNESSEE

City	Pop.	Station No.	City Characteristics	City Street Classifications
Nashville	176,170	500	A-I(a)(b)(c)(e)(f) A-II(d)	B-I(a)1 B-II(c)
		501		B-I(b)3 B-II(b)
		502 [1]		B-I(a)1 B-II(c)
		503		B-I(b)1 B-II(c)
		504		B-I(a)2 B-II(b)
		505		B-I(a)2 B-II(c)
Memphis	407,439	506 [1]	A-I(a)(b)(c)(e) A-II(c)	B-I(a)1 B-II(c)
		507		B-I(b)2 B-II(a)
		508		B-I(b)1 B-II(b)
		509		B-I(a)2 B-II(c)
		510		B-I(b)3 B-II(b)
		511 [2]		B-I(a)3 B-II(c)
Knoxville	124,769	512	A-I(a)(b)(c)(e) A-II(d)	B-I(b)1 B-II(b)
		513		B-I(b)2 B-II(a)
		514		B-I(a)1 B-II(c)
		515		B-I(a)1 B-II(c)
		516		B-I(b)3 B-II(b)
		551 [1]		B-I(a)1 B-II(d)
Johnson City	28,337	517	A-I(b)(c)(e) A-II(f)	B-I(a)2 B-II(c)
		518		B-I(b)3 B-II(b)
Morristown	13,151	519	A-I(a)(b)(c) A-II(g)	B-I(b)2 B-II(a)
		520		B-I(a)1 B-II(c)
Crossville	2,291	521	A-I(b)(c) A-II less than 10,000	B-I(a)1 B-II(c)
Rockwood	4,272	522	A-I(a)(b)(c) A-II less than 10,000	B-I(b)1 B-II(a)
McMinnville	7,577	523	A-I(a)(b)(c) A-II less than 10,000	B-I(b)1 B-II(a)
Columbia	10,911	524	A-I(a)(b)(c) A-II(g)	B-I(b)1 B-II(b)
		525		B-I(a)1 B-II(c)
Jackson	33,354	526	A-I(a)(b)(c)(e) A-II(f)	B-I(a)1 B-II(c)
		527		B-I(a)3 B-II(b)
Dyersburg	12,063	528	A-I(b)(c) A-II(g)	B-I(b)1 B-II(a)
		529		B-I(b)1 B-II(b)
Dresden	1,509	530	A-I(b) A-II less than 10,000	B-I(a)1 B-II(c)
Waverly	2,410	531	A-I(b) A-II less than 10,000	B-I(b)3 B-II(b)
Decaturville	514	532	A-I(b) A-II less than 10,000	B-I(b)1 B-II(b)
Rogersville	2,670	533	A-I(b)(c) A-II less than 10,000	B-I(a)1 B-II(c)
Kingsport	19,609	534	A-I(a)(b)(c) A-II(g)	B-I(b)3 B-II(b)
		535		B-I(b)2 B-II(a)
Athens	10,103	536	A-I(b)(c) A-II(g)	B-I(b)3 B-II(b)
		537		B-I(b)1 B-II(b)
Chattanooga	131,041	538	A-I(a)(b)(c) A-II(d)	B-I(a)2 B-II(c)
		539		B-I(b)3 B-II(b)
		540		B-I(a)3 B-II(b)
		541 [2]		B-I(a)1 B-II(c)
		542		B-I(b)2 B-II(b)
Bolivar	2,429	543	A-I(b)(c) A-II less than 10,000	B-I(a)1 B-II(c)
Humboldt	7,426	544	A-I(b)(c) A-II less than 10,000	B-I(a)1 B-II(c)
		545		B-I(a)3 B-II(c)
Union City	7,665	546	A-I(b)(c) A-II less than 10,000	B-I(b)1 B-II(b)
		547		B-I(a)1 B-II(c)
Shelbyville	9,847	548	A-I(b)(c) A-II less than 10,000	B-I(a)1 B-II(c)
		549		B-I(a)2 B-II(c)
Lewisburg	5,312	550	A-I(b)(c) A-II less than 10,000	B-I(a)1 B-II(b)

[1] East and west. [2] North and south.