A Method of Estimating Traffic Behavior on All Routes in a Metropolitan County

THOMAS C. MURANYI, Chicago Area Transportation Study

• WITH the constantly increasing demands for traffic information needed in the every day work of traffic and highway-engineering, thousands of road stations have been established for traffic counting. However, it is believed that in various Western European countries and the United States, there is essentially more valuable information hidden in these counts than is evaluated and placed at the disposal of traffic experts. This statement refers particularly to studies where the detailed geometric design of single road sections or junctions is not the problem to be solved, but rather development of an entire road network.

It seems to be obvious that the source of information about traffic behavior should be the traffic inventory regardless of the purpose of the study—estimating the present traffic demands or forecasting future traffic.

Despite the significant progress in synthetically simulating traffic on extended networks of large study areas, better knowledge of prevailing traffic conditions still remains part of the framework for long-range transportation studies. Evidence from comprehensive assignment analyses proves, furthermore, that a theoretical trip distribution on the network can match the requirements of the planner only when the real traffic behavior is taken into consideration.

It is well known that the main source of knowledge concerning the very variable traffic pattern within one year is the permanent counts and the repeated monthly sample counts at the so-called "key" stations. Moreover, these counts contain all the elements characterizing the traffic behavior. The problem is that by means of factors obtained from a relatively low number of stations, it is impossible to characterize all the important traffic fluctuations present in a large network. Perhaps these adjustment factors are good enough to convert one-day counts into annual average traffic volume (ADT). However, an average sometimes is far from being sufficient. The ADT of two routes can be absolutely identical. But some of the main problems, especially for traffic and highway engineers, originate in the fact that the traffic pattern of these routes, described with the ADT, can be completely different within twelve months. If the traffic character of one of these routes is a typical working day traffic, the traffic volume can be expected to be steady throughout the whole year. Meanwhile, heavy weekend traffic or important recreational traffic of the summer months can produce peak daily volumes, which are two to five times higher than the ADT.

It is most desirable for planners and engineers to know the locations of routes, within the study areas, with unusual traffic patterns. In other words, to know the traffic character of the different roads of the network. This paper gives criteria for classifying routes by traffic characters into types. The allocating of road sections to these different types is an objective grouping based on a few machine counts. A counting and evaluating procedure with built-in statistical control was developed. The method develops factors for each of these route types. The factors, with statistically estimated accuracy, reproduce synthetically all-important details of the traffic and their peak for the entire network.

The method shown is that used in the Lake County Transportation Study (Illinois). Estimating traffic behavior on Lake County roads was accomplished in a manner similar to that used in a comprehensive traffic research conducted by the author in Hungary, Austria, The Netherlands, Switzerland and Western Germany. The characteristics of

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traffic observed in Europe, when compared with the results of analysis of traffic on Illinois highways, demonstrate a large area of agreement between human behavior in Europe and in this country. This also proves, indirectly, the objective criteria used by the classification of the network to produce factors which characterize the traffic behavior of roads with sufficient accuracy in the large field of traffic engineering and planning activity.

METHOD OF CLASSIFYING ROUTE TYPES

It is generally known that route by route, the pattern of daily traffic volume during the twelve months of the year is essentially different. Figures 1 and 2 show four characteristic relative volume trends from Lake County. Without knowing the traffic character of a route, it is impossible to convert sample counts accurately to ADT, or to determine other traffic characteristics. A classification of route types by traffic character is necessary. Results of comprehensive traffic analyses show that a usable parameter for classification can be the ratio of recreational traffic to the total traffic. The recreational traffic has two important ingredients, and they are: the vacational traffic of the average weekday and the weekend traffic. This kind of information can be obtained by simple machine counts instead of roadside interview. The vacational traffic on an average weekday of the summer months can be expressed by the ratio of the average weekday traffic in August to the average weekday traffic in May and June; that is,

$$\psi = \frac{V_8}{\frac{1}{2}(V_5 + V_6)} \tag{1}$$

in which

V_8 = the daily average weekday traffic in August;
V_5 = the daily average weekday traffic in May; and
V_6 = the daily average weekday traffic in June.

The classification of routes by the various values of the factor means that sample counts of each route segment within the same route type can be converted with a single adjustment factor to ADT. This adjustment factor by route type is the arithmetic mean of ψ factors derived from counts on control stations by the same route type. The standard error of this arithmetic mean is the systematic error of this factor, which influences the accuracy of ADT estimates.

The practical consideration regarding the accuracy in ADT estimates led to the establishment of three characteristic categories of vacational traffic:

1. Routes with a high percentage of vacational traffic, $\psi > 1.2$;
2. Routes with a medium percentage of vacational traffic, $1.1 \leq \psi \leq 1.2$; and
3. Routes with a low percentage of vacational traffic, $\psi < 1.1$.

The weekend traffic can be characterized simply with the ratio of the average traffic of the week V_i to the average Sunday traffic of the summer half year v_7:

$$\frac{V_i}{v_7} = b_7 \tag{2}$$

in which

$V_i = \frac{1}{7}(5\, v_W + v_6 + v_7)$;
v_7 = traffic volume on Sunday;
v_6 = traffic volume on Saturday;
v_W = traffic volume on average weekday; and
b_7 = daily factor for Sunday.

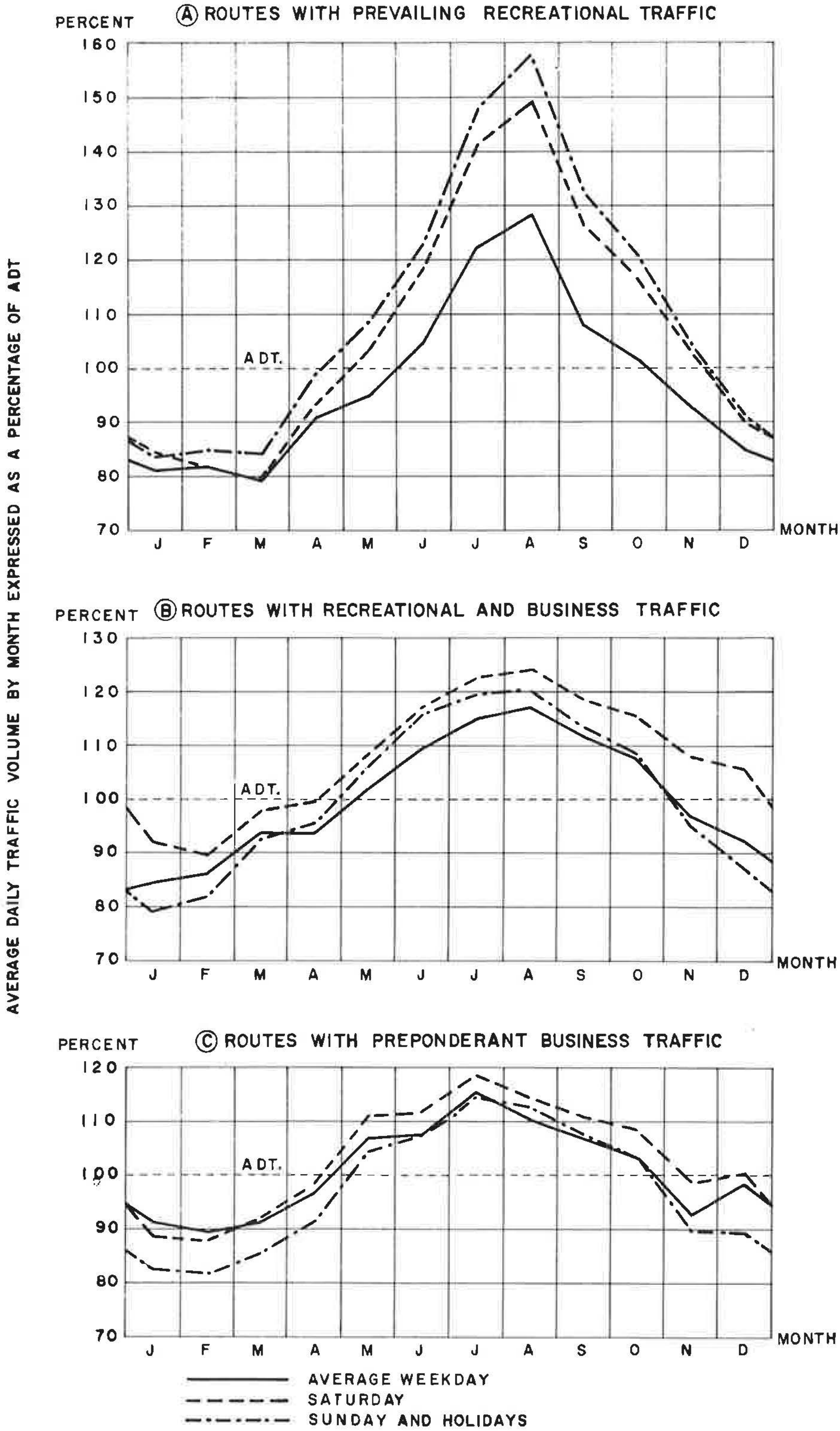

Figure 1. Relative traffic volume trends by route type on rural roads in Lake County (key stations, 1960, 1961).

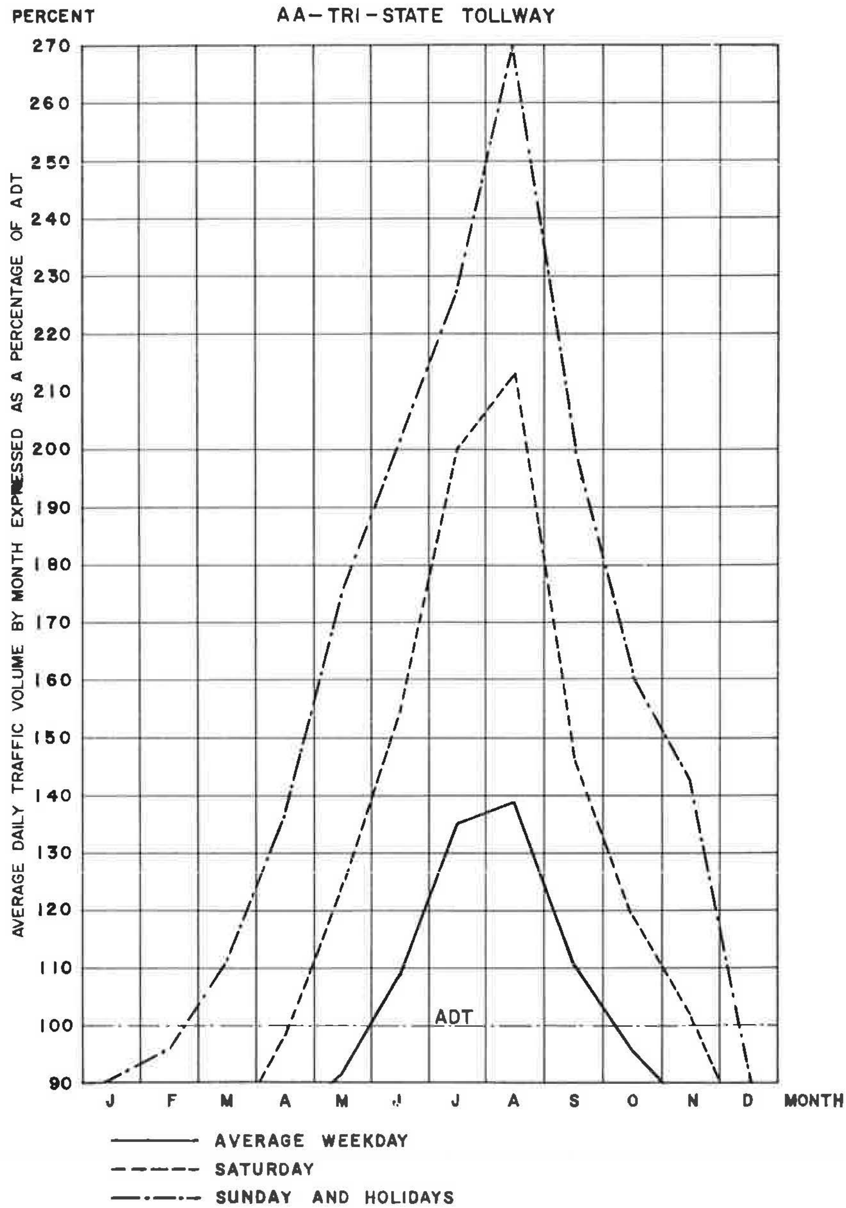

Figure 2. Relative traffic volume trend on Tri-State Tollway (Interstate 94) in Lake County (toll plazas no. 31 and 32, 1960-1961).

To characterize the different intensities of Sunday traffic, the routes can be grouped also in three categories.

1. Routes with relative high Sunday traffic are routes on which the traffic volume of an average Sunday of the summer half year is more than 10 percent higher than the traffic volume of the average weekday: $b_7 < 0.9$.

2. Routes with relative medium Sunday traffic are routes on which the average Sunday traffic of the summer half year is within 10 percent of the traffic on the average weekday: $0.9 \leq b_7 \leq 1.1$.

3. Routes with relative low Sunday traffic are routes on which the average Sunday traffic of the summer half year is more than 10 percent less than the traffic on an average weekday: $b_7 > 1.1$.

Grouping the routes by the combination of 3 types of vacational traffic and 3 types of Sunday traffic would result in 9 route types. Handling of 9 route types in practice is difficult, and also not necessary; therefore, only 4 route types were established where the different intensities of vacational and Sunday traffic were referred to as recreational traffic.

The final classification of the network is as follows:

1. Routes with prevailing recreational traffic (Route Type A) are routes with a high percentage of vacational traffic on an average weekday, regardless of the intensity of Sunday traffic: $\psi > 1.2$; b_7, any value.

2. Routes with recreational and business traffic (Route Type B) are either routes with a medium percentage of vacational traffic on an average weekday regardless of the intensity of Sunday traffic: $1.1 \leq \psi \leq 1.2$; b_7, any value—or with a low percentage of vacational traffic on an average weekday, but with high Sunday traffic; $\psi < 1.1$; $b_7 < 0.9$.

3. Routes with preponderant business traffic (Route Type C) are those with a low percentage of vacational traffic on an average weekday and with low Sunday traffic: $\psi < 1.1$; $b_7 > 1.1$.

4. The Tri-State Tollway represents a separate route type where a very high percentage of vacational trips ($\psi \sim 1.4$) on the average weekday of the summer half year combines with extra heavy and steady Sunday traffic throughout the whole year. Traffic on Sundays during the entire year is heavier than traffic on the average weekday (Table 1). The average Sunday traffic during the summer months is 55 percent higher than the traffic on the average weekday. The tollway (Route Type AA) is a recreational route.

Figure 3 shows the four different route types in the Lake County area. The factors necessary for these classifications were determined from counts of key stations (Table 2) and from counts taken on each of the crossing points of the cordon and screenline. Thirteen additional key stations were established to complete the counts necessary to classify the network by route type and to determine the traffic patterns on these route types.

ADT ESTIMATES BY ROUTE TYPES

After grouping the routes of the network into route types, the factors which characterize the changes of daily, weekly, and monthly traffic patterns can be determined.

Dealing with the ADT estimate problem, the various traffic flows during the weekend by route type is the first important factor which must be considered.

Table 1 shows the traffic on Sundays and Table 3 the traffic on Saturdays, by route type throughout the year. Traffic volume is expressed as a percentage of average weekly traffic. In the weekend traffic of recreational routes (Types AA and A) the

TABLE 1

TRAFFIC ON SUNDAYS BY MONTH AND BY ROUTE TYPE AS PERCENTAGE OF AVERAGE DAY OF WEEK[a]

Route Type	Month											
	J	F	M	A	M	J	J	A	S	O	N	D
AA	137	139	145	149	162	169	143	162	154	147	149	114
A	102	103	105	107	111	112	114	115	115	112	109	104
B	93	94	98	101	103	104	103	102	101	99	97	93
C	92	93	95	97	91	101	102	103	102	101	99	93

[a]Derived from Table 2.

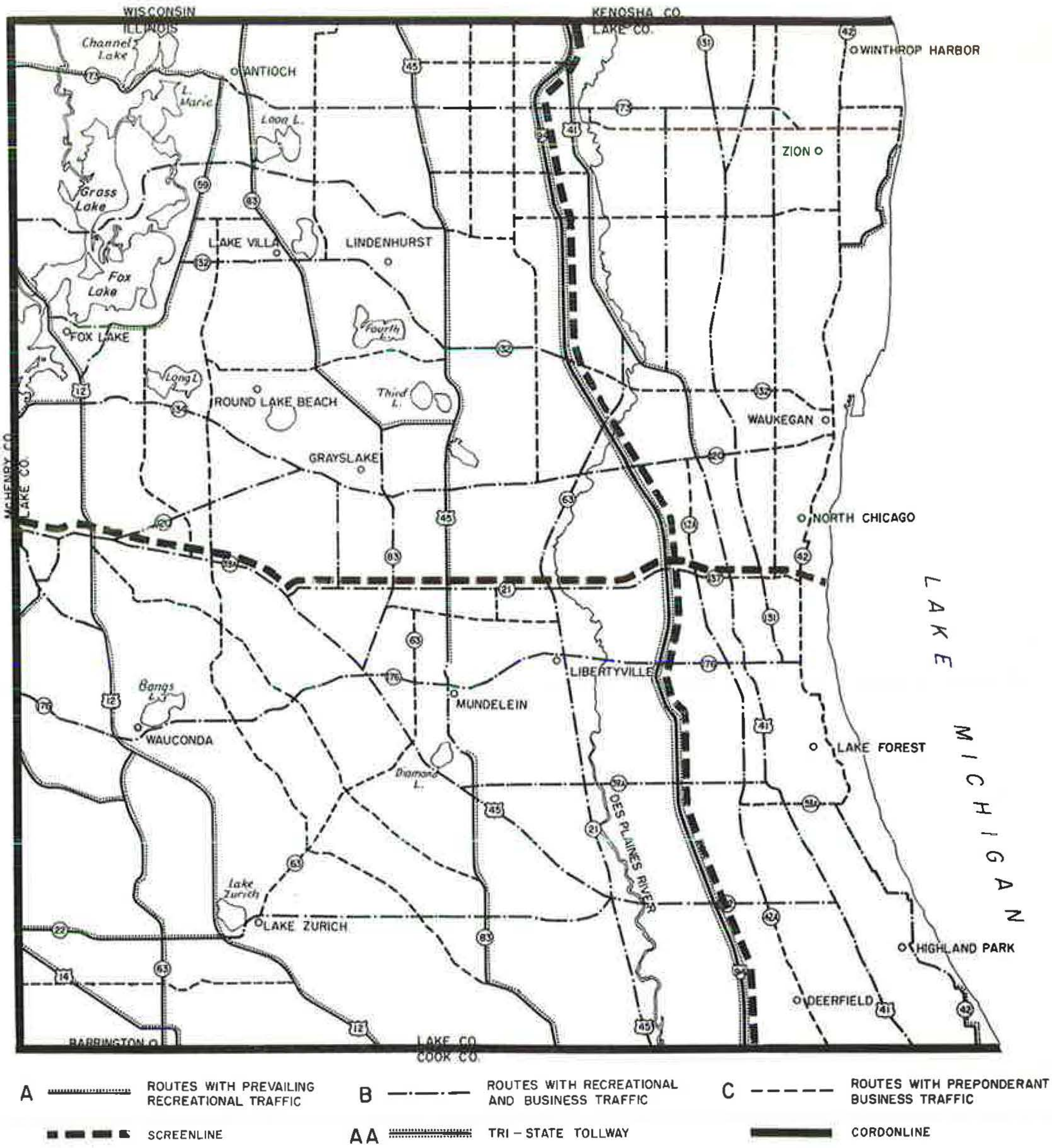

Figure 3. Spatial distribution of recreation routes in Lake County.

traffic of Sundays is dominant. For the importance of the weekend traffic on routes with recreational and business traffic (Type B) and on routes with preponderant business traffic (Type C), the traffic on Saturdays is characteristic. The characteristics of the weekend traffic, by route type, can be expressed as daily factors for Sundays (b_7), daily factors for Saturdays (b_6), and daily factors for average weekdays (b_W). Figure 4 shows the average values of these factors by route type for each month. Another characteristic for the changes in traffic patterns by route type is described as the monthly factor (c_i) given in Table 4. This factor yields as a product with the average day of the month the ADT. From a single sample count taken on an average weekday for any month of the year v_i, the traffic volume of the average day of the month is $b_W v_i$; and the annual average of the daily traffic ADT (V_o) is

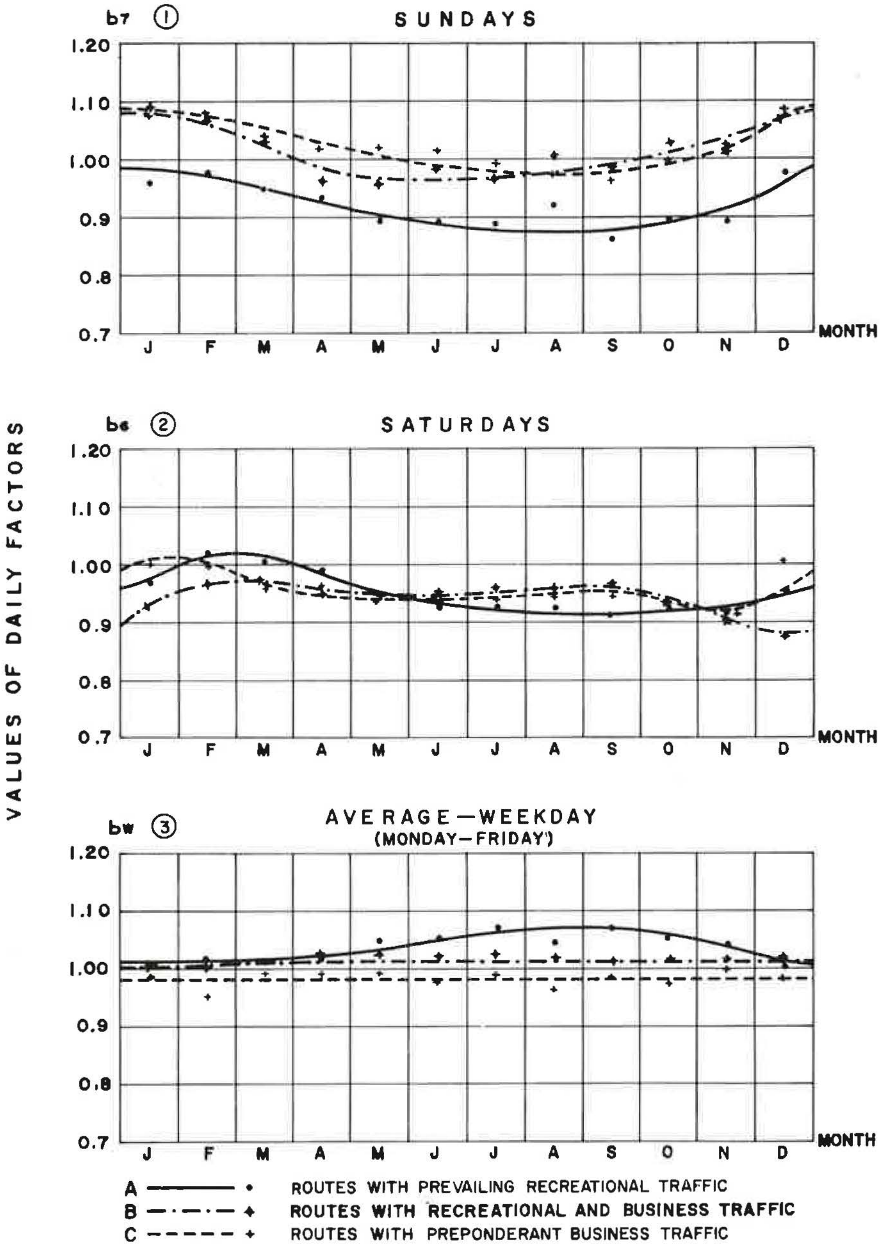

Figure 4. Seasonal fluctuation of daily factors by route type.

$$V_o = (b_w c_i) v_i \tag{3}$$

Further simplification can be made in practice by computing the product $\varkappa_i$ of the two factors shown above in advance. The values of these $\varkappa$-factors are given in Figure 5 for each route type. These factors give the relations between the traffic volume of an arbitrarily chosen average v_i and V_o.

$$V_o = \varkappa_i v_i \tag{4}$$

TABLE 2

ANALYZED KEY STATIONS

(Counts Taken by Illinois Division of Highways, 1960 and 1961)

Station	County	On Route	Location	ψ	Sunday's Traffic as % of avg. Day of the Week	Route Type by Traffic Character
Plaza 31	Lake	Tri-State Tollway[a]	State line	1.43	155	Route Type AA
Plaza 32	Lake	Tri-State Tollway[a]	Lake-Cook line	1.37	155	
2	Lake	Ill. 59 + US 12	S of Ill. 134	1.36	178	
6Z	Lake	US 41	NW of Ill. 63	1.24	122	Route Type A
6BZ	Lake	US 45	S of Ill. 173	1.29	118	
75	Cook	US 12	NW of Ill. 83	1.23	139	
75BX	Cook	US 14	SE of Ill. 53	1.41	102	
75C	Cook	Ill. 62	SE of Ill. 53	1.30	94	
3	McHenry	US 14	SE of Ill. 47	1.32	88	
3BZ	Cook	Ill. 59	N of Ill. 72	1.21	128	
1	Lake	Ill. 176	W of Ill. 42A	1.12	87	Route Type B
1A	Lake	Ill. 42A	N of Ill. 176	1.14	102	
1CX	Lake	US 45	Deerfield Rd.	1.14	118	
2A	Lake	Ill. 134	E of Ill. 59 and US 12	1.11	118	
2B	Lake	Ill. 59A	SE of Ill. 120	1.12	119	
6AZ	Lake	US 41	NW of Ill. 63	1.08	111	
6CZ	Lake	Ill. 120	E of Ill. 131	1.14	82	
1BM	Lake	Edens Expwy.	Cook-Lane	1.10	118	
74	Cook	Ill. 21	SE of Ill. 58	1.09	110	
74B	Cook	Green Bay Rd.	NW of Church St.	1.12	77	
4C	Kane	Ill. 25	SE of S. Elgin	1.07	114	
3R	McHenry	Ch. 25	S of Ill. 120	1.19	123	
3CZ	McHenry	Ill. 31	N of Ill. 176	0.92	122	
1B	Lake	Ill. 42	S of Zion	1.08	93	Route Type C
1R	Lake	Ch. 27	S of Zion	1.05	100	
2C	Lake	Ill. 63	NE of Fairfield	1.08	108	
2R	Lake	Ch. 32	SE of US 12	1.06	108	
73A	Cook	Touhy Ave.	E of US 41	1.01	90	
74C	Cook	Ill. 68	W of Ill. 42A	1.10	106	
75A	Cook	Ill. 83	N of US 42	0.92	104	

[a]Counts taken by Illinois State Toll Highway Commission.

TABLE 3

TRAFFIC ON SATURDAYS BY MONTH AND BY ROUTE TYPE AS PERCENT OF AVERAGE DAY OF WEEK[a]

Route Type	Month											
	J	F	M	A	M	J	J	A	S	O	N	D
AA	104	103	106	106	115	118	125	125	113	108	106	98
A	103	99	99	102	105	108	108	109	110	109	108	105
B	108	103	103	105	105	105	105	105	105	106	110	114
C	99	100	103	104	105	105	105	105	105	106	109	104

[a]Derived from Table 2.

The accuracy of ADT's obtained by means of these $\varkappa$-factors was checked empirically. The accuracy of the ADT's also differ on the route types from which the sample counts were taken (Table 5). This shows that more counts are necessary on routes with prevailing recreational traffic than on routes with preponderant business traffic, if the same level of accuracy in ADT estimates is required.

Table 6 shows the accuracy of converted ADT's by month. June proves to be the best month for sample counts, not only in Lake County, but also in west European countries.

The average errors of ADT estimates are not sufficient information if higher accuracy is wanted. Figure 6 shows the frequency distribution of errors in ADT estimates, by route type. Single machine counts taken on routes with prevailing recreational traffic cannot always be converted to a reliable ADT, because the traffic of recreational routes is not as steady as the traffic on business routes. Increasing the number of machine counts by station eliminates the maximum errors (Fig. 7).

The assignment analysis requires very accurate ADT data on cordon and screenline stations. The total number of vehicles crossing these lines may be compared with the assignment results; therefore, the ADT on routes with heavy traffic must be reliable. Figure 8 shows the accuracy of the converted ADT's values is essentially higher on routes with traffic greater than 500 vehicles per 24 hours than on routes with less than 500 vehicles. In the Lake County study, the ADT value of vehicles that cross the cordon and screenline (Fig. 3) is 269,258 vehicles per 24 hours. The ADT estimates obtained with these $\varkappa$-factors from a single sample count were

TABLE 4

MONTHLY FACTORS (c_i) BY ROUTE TYPE[a]

Month	Route Type			
	AA	A	B	C
Jan.	1.50	1.22	1.17	1.12
Feb.	1.45	1.22	1.15	1.14
Mar.	1.32	1.25	1.06	1.12
Apr.	1.09	1.09	1.06	1.06
May	0.92	1.02	0.97	0.95
June	0.76	0.91	0.90	0.94
July	0.63	0.77	0.86	0.89
Aug.	0.59	0.73	0.85	0.92
Sept.	0.77	0.87	0.89	0.95
Oct.	0.91	0.93	0.92	0.98
Nov.	1.04	1.04	1.02	1.10
Dec.	1.24	1.15	1.07	1.04

[a]Derived from Table 2.

TABLE 5

ACCURACY OF ADT ESTIMATES BY ROUTE TYPE[a]

Route Type	Deviations from Actual ADT as Percent of ADT		
	n[b] = 1	n = 2	n = 3
A	± 10.0	± 8.5	± 8.3
B	± 7.5	± 6.6	± 6.8
C	± 4.8	± 3.2	± 2.7
All Routes	± 7.5	± 6.2	± 6.1

[a]ADT obtained by $\varkappa$-factors in Figure 4.
[b]n = number of machine counts taken on an average weekday during the summer half year.

ADT obtained from single machine counts in May = 267,218 vehicles per 24-hour; June = 273,087; July = 266,375; and August = 270,140.

The average value of these deviations from the actual ADT is less than ± 1 percent.

An interesting comparison was made between ADT's obtained from these factors by route type and ADT's derived from a constant factor (ρ) which can be applied for all route types of the area. This so-called ρ-factor was derived by the author in western Europe and was previously presented (1). The value of this factor in Europe was ρ = 0.31 (see Table 9) and in the Lake County network it was found to be the same. With this single factor, counts of all kinds of route types can be converted to ADT using

$$V_0 = \rho\ (V_5 + V_6 + V_7) = 0.31\ (V_5 + V_6 + V_7) \qquad (5)$$

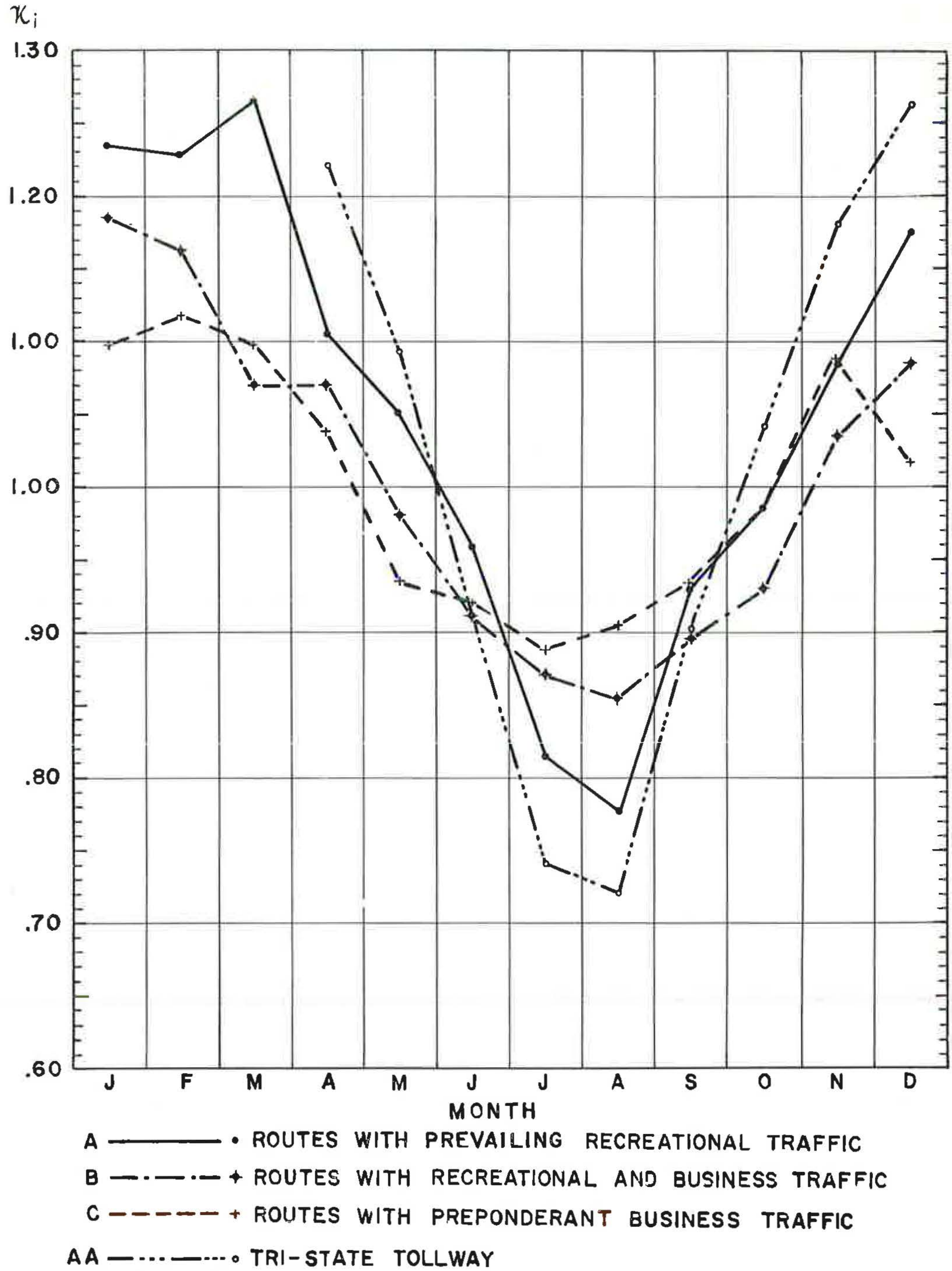

Figure 5. κ_i-factors by route type.

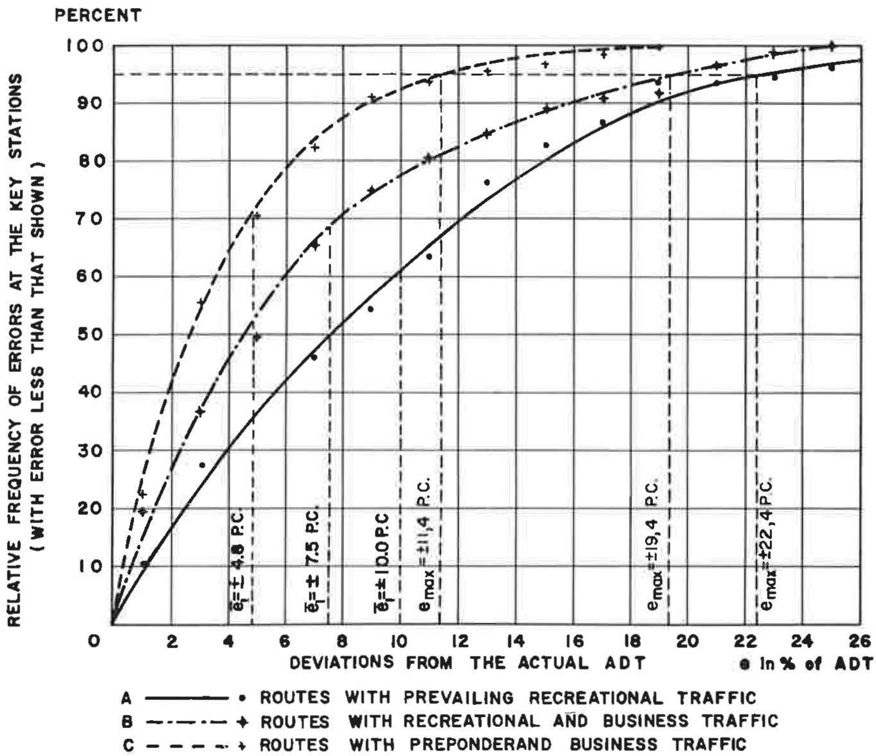

Figure 6. Accuracy of ADT estimates on Lake County's rural highway system (ADT obtained by means of κ_i-factors, n = 1).

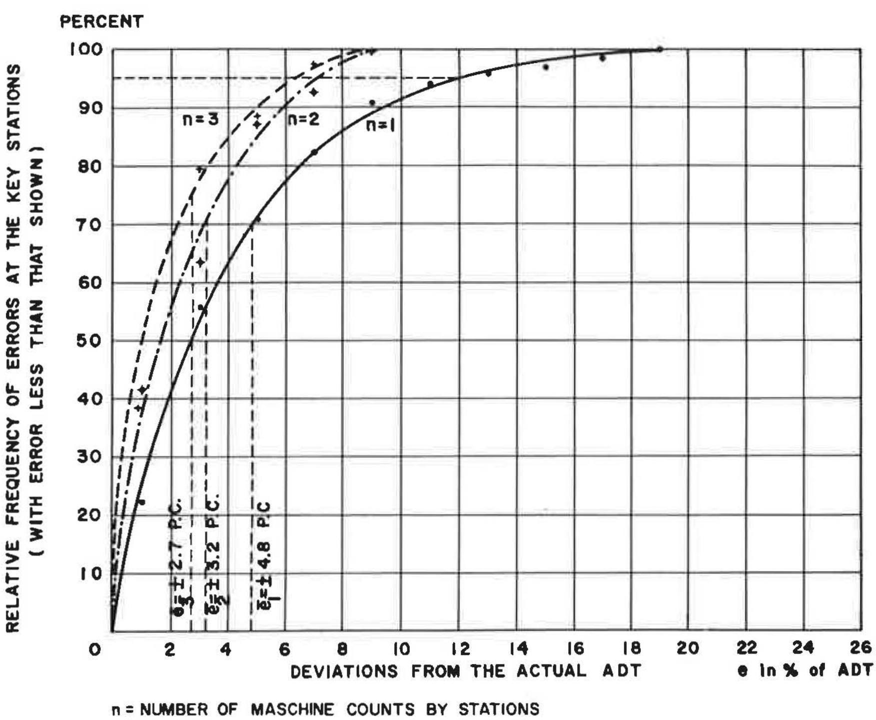

Figure 7. Frequency distributions of errors in ADT estimates, Route Type C.

in which V_5 = the traffic volume on an average weekday in May; V_6 = that in June; and V_7 that in July. Using this 0.31 factor to estimate ADT's on cordon and screenlines, the result was 270,708 vehicles per 24 hour, which was only ½ percent different from the 269,258 for actual ADT. Figure 9 shows the frequency distribution of ADT values as derived.

The classification of the network, by route type, has three advantages compared to the other procedures:

1. It enables a simple ADT estimate on all route types of an area; and also gives the number of sample counts, by route type, which is necessary to match the different accuracy needs of the assignment procedure.

2. For transportation planning purposes, this method gives the necessary information about peaks and frequency of these peaks, which are quite different by route type.

3. The result of the assignment procedure in the traffic forecast is the allocated ADT value of all trips by links. Knowing the actual traffic character on all routes in a metropolitan area, it is easier to estimate the relative traffic volume of design hours by different routes, for the future. Having the land-use data for the planning and horizon years, it is easier to find relations between traffic characteristics of the present and future network than to estimate the value of an adjustment factor on a master control station for the future.

TABLE 6

ACCURACY[a] OF ADT ESTIMATES BY MONTH[b]

n = 1 Machine Count	Route Type			All Route Types
	A	B	C	
May	± 9.4	± 7.9	± 5.0	± 7.6
June	± 7.4	± 5.0	± 4.2	± 5.5
July	± 10.0	± 8.2	± 4.1	± 7.6
Aug.	± 8.0	± 7.1	± 5.1	± 6.8
Sept.	± 12.8	± 9.8	± 5.6	± 9.6
Oct.	± 12.3	± 7.4	± 4.8	± 8.2
Avg. summer half year	± 10.0	± 7.5	± 4.8	± 7.5

[a]Deviation from the actual ADT given as a percentage of ADT.
[b]ADT obtained by κ-factors in Figure 4.

ESTIMATE OF TRAFFIC FOR PEAK HOURS OF THE YEAR

Table 7 gives the relative traffic volume by hours of the day by route type. The relative traffic of Sundays is the highest on the Tollway, but the relative traffic of Saturdays and average weekdays is the highest on routes with preponderant business traffic.

Figure 10 shows the different characteristics in the daily pattern of the peaks between the tollways and 2-lane routes with prevailing recreational traffic. Having the previously described daily and monthly factors by route type and the peak values given in Table 7, the characteristic peak-hour pattern for each route type for the entire year can be computed.

The daily traffic values expressed as a percent of ADT shown in Figures 1 and 2 were computed from the following:

Traffic on Sundays:

$$i_7 = \frac{100}{b_7 c_i} \qquad (6)$$

Traffic on Saturdays:

$$i_6 = \frac{100}{b_6 c_i} \qquad (7)$$

Traffic on average weekday:

$$i_w = \frac{100}{\kappa_i} \qquad (8)$$

In the second column of Table 8, the daily traffic volumes as a percent of ADT are computed for the Tri-State Tollway (shown also in Fig. 2).

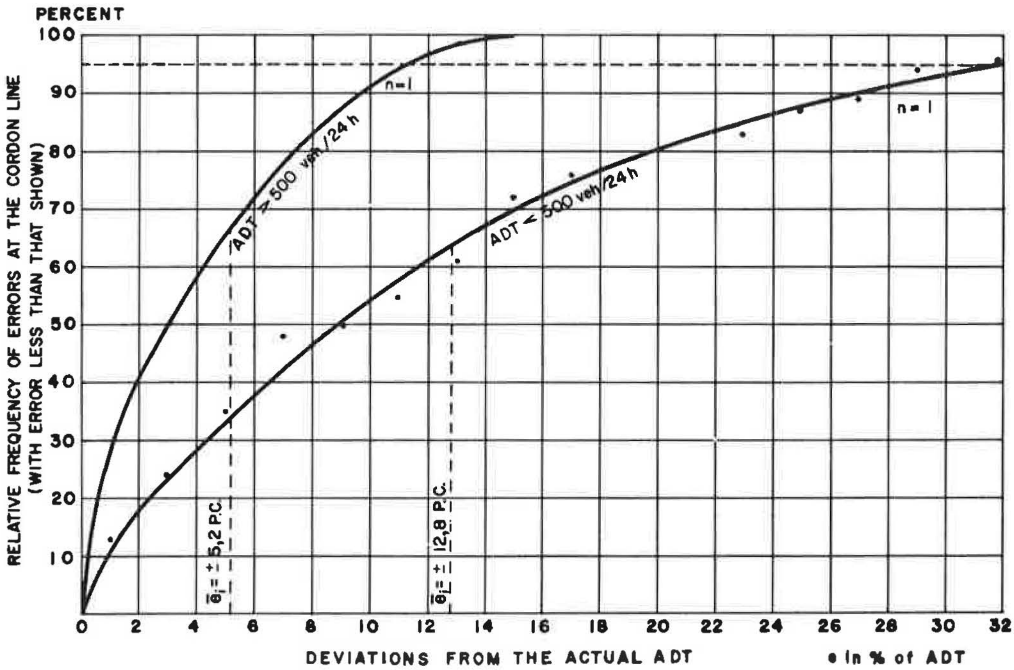

Figure 8. Accuracy of ADT estimates of arterial and local roads.

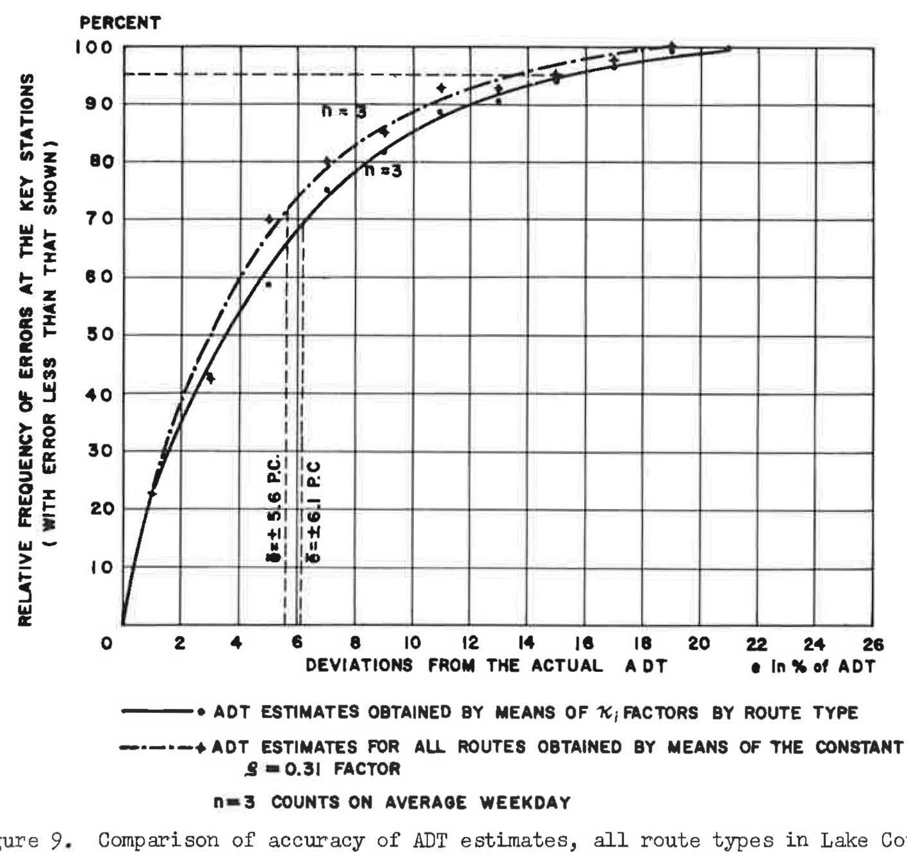

Figure 9. Comparison of accuracy of ADT estimates, all route types in Lake County.

TABLE 7

AVERAGE RELATIVE HOURLY TRAFFIC VOLUME[a] OF THE DAY BY ROUTE TYPE

Route Type	Highest Traffic Volume of Day as Percent of Daily Total							
	1st	2nd	3rd	4th	5th	6th	7th	8th
(a) Sundays and Holidays								
AA	11.5	9.8	8.9	8.2	7.6	6.6	6.0	5.4
A	9.1	8.8	8.4	8.2	7.6	7.2	6.8	6.4
B	9.1	8.6	8.1	7.8	7.6	7.1	6.7	6.5
C	9.1	8.5	8.2	7.9	7.7	7.3	7.0	6.7
(b) Saturdays								
AA	7.4	7.0	6.6	6.3	6.1	5.8	5.6	5.5
A	7.1	6.5	6.2	6.0	5.8	5.7	5.5	5.3
B	7.6	7.3	7.0	6.8	6.6	6.4	6.2	5.9
C	8.1	7.5	7.2	6.9	6.7	6.5	6.2	5.9
(c) Average Weekdays								
AA	9.7	8.7	7.8	6.9	6.4	5.9	5.6	5.3
A	9.6	8.6	7.9	7.8	7.2	7.1	6.8	6.7
B	9.6	8.7	7.9	7.2	6.5	6.2	6.0	5.8
C	10.6	9.5	8.6	7.6	6.8	6.3	5.9	5.5

[a]Counts taken during the summer half year of 1960 and 1961.

TABLE 8

TRAFFIC VOLUME OF THE PEAK HOURS AS PERCENT OF ADT TRI-STATE TOLLWAY

Month	Daily Traffic (% of ADT)	1st	2nd	3rd	4th	5th	6th	7th	8th	Frequency of Peak Hours by Year
		Highest Peak-Hour of Day								
		Average Relative Hourly Traffic Volume								
		0.115	0.098	0.089	0.082	0.076	0.066	0.060	0.054	
(a) Sundays and Holidays										
April	137	15.7	13.4	12.2	11.2	10.4	9.0	8.2	7.4	5
May	176	20.3	17.2	15.7	14.4	13.4	11.6	10.6	9.7	5
June	222	25.4	21.8	19.7	18.2	16.8	14.6	13.3	12.0	4
July	227	26.0	22.2	20.2	18.6	17.2	15.0	13.6	12.2	5
Aug.	270	31.0	26.5	24.1	22.2	20.5	17.8	16.2	14.6	5
Sept.	200	23.0	19.6	17.8	16.4	15.2	13.2	12.0	10.8	6
Oct.	161	18.4	15.7	14.3	13.2	12.2	10.6	9.6	8.7	4
Nov.	143	16.4	14.0	12.7	11.7	10.8	9.4	8.6	7.7	5
(b) Saturdays										
		0.074	0.070	0.066	0.063	0.061	0.058	0.056	0.055	f
May	125	9.2	8.8	8.2	7.9	7.6	7.2	7.0	6.9	4
June	154	11.4	10.8	10.2	9.7	9.4	8.9	8.6	8.5	5
July	200	14.8	14.0	13.2	12.6	12.2	11.6	11.2	11.0	4
Aug.	213	15.9	15.0	14.2	13.6	13.1	12.5	12.0	11.8	4
Sept.	147	10.9	10.3	9.7	9.2	8.9	8.5	8.2	8.1	5
(c) Average Weekdays										
July	135	0.097	0.087	0.078	0.069	0.064	0.059	0.056	0.053	f
July	135	13.1	11.8	10.5	9.3	8.7	8.0	7.6	7.2	22
Aug.	139	13.5	12.1	10.8	9.6	8.9	8.2	7.8	7.4	22

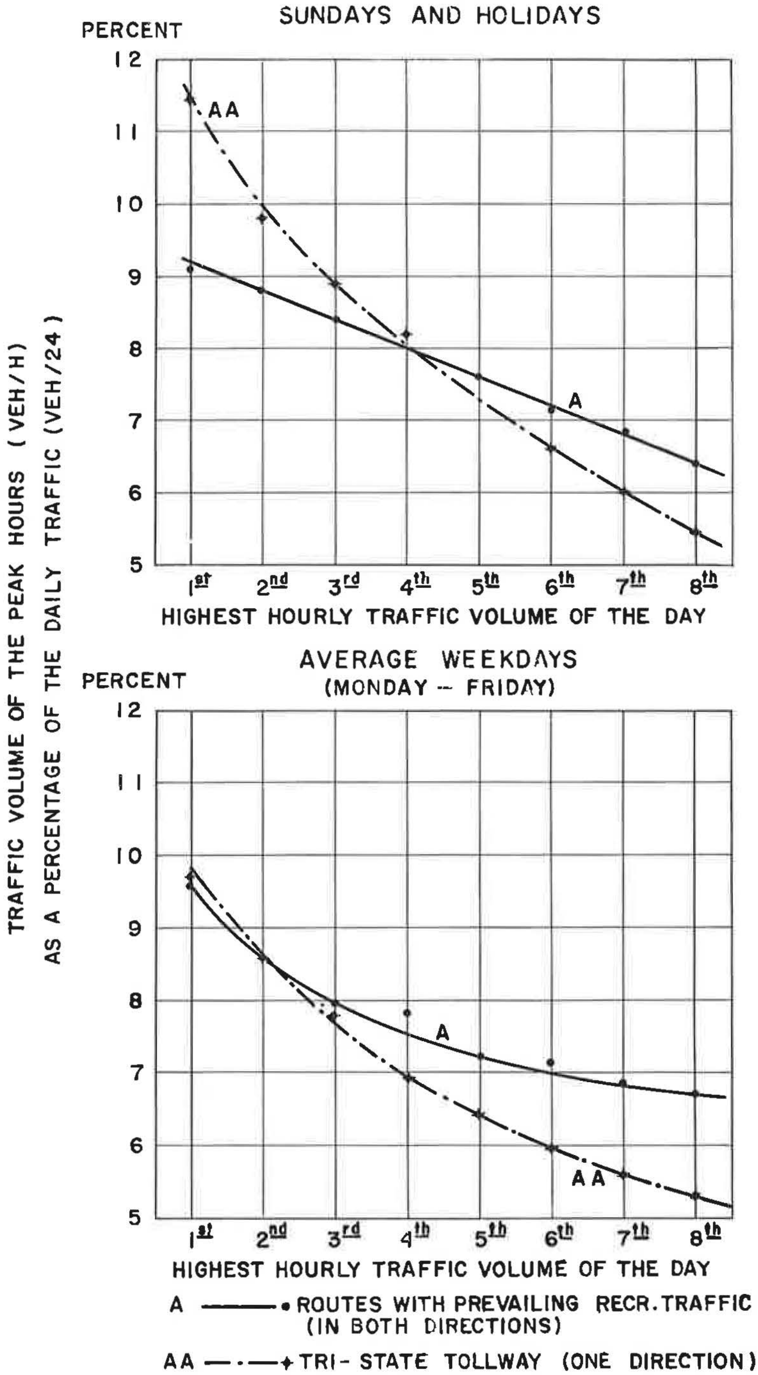

Figure 10. Average relative hourly traffic volumes of the day.

From the average relative hourly traffic volume of the day (δ_i) and the i_7, i_6 and i_W values, the relation between traffic volume of the peak hours and the ADT (ω_i) can be computed for any day as a percentage of ADT.

Sunday peak hours:

$$\omega_7 = \delta_7 \, i_7 \tag{9}$$

Saturday peak hours:

$$\omega_6 = \delta_6 \, i_6 \tag{10}$$

Average weekday peak hours:

$$\omega_W = \delta_W \, i_W \tag{11}$$

Knowing the volume of ADT V_0 and the route type, the peak hour V_{max} for any day of the year can be computed:

$$V_{max} = \omega_i \, V_0 \tag{12}$$

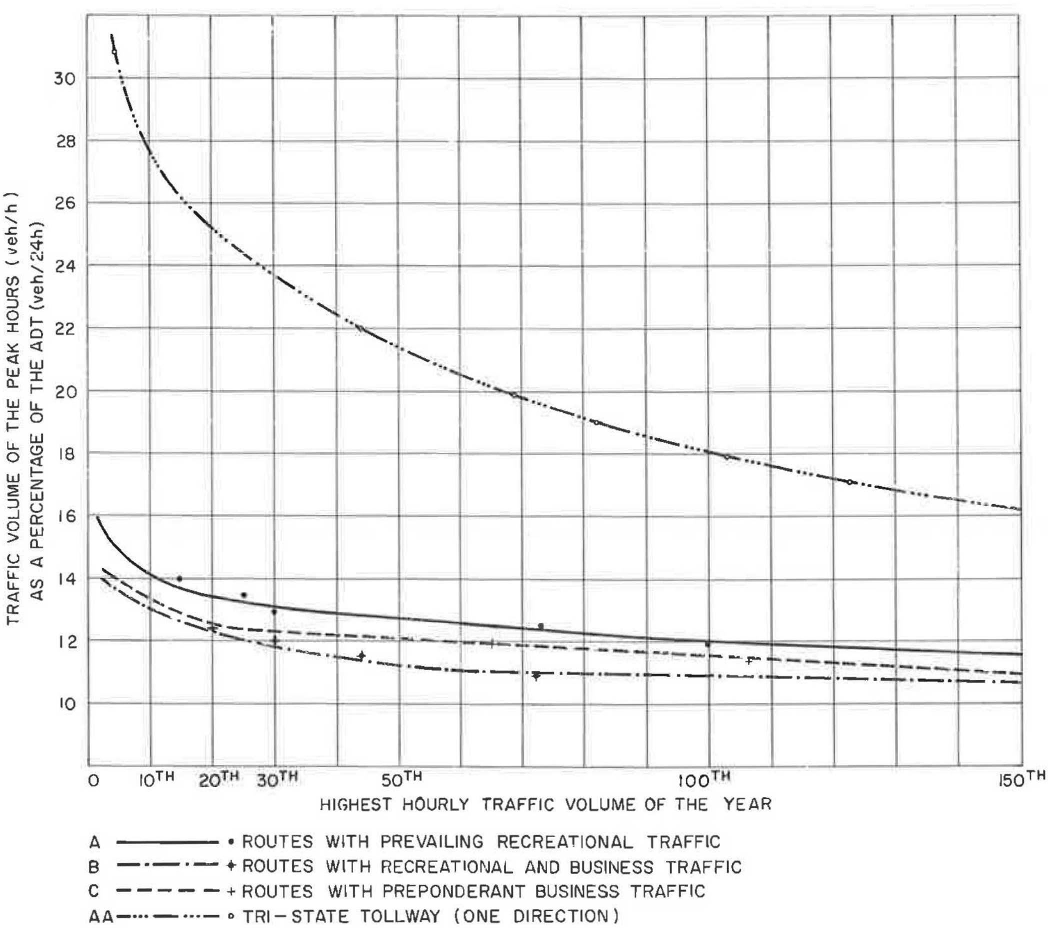

Figure 11. Relation between traffic flow of peak hours and annual average daily traffic.

Computations for Figure 11 were similar to those in Table 8. These diagrams are the basis for selecting the relative traffic volumes of design hours by route types for a given metropolitan area.

COMPARISON BETWEEN TRAFFIC PATTERNS BY ROUTE TYPE IN LAKE COUNTY AND IN EUROPE

Table 9 gives characteristics in traffic patterns by route type in five European countries and in Lake County. These similarities demonstrate, not only the large area of agreement between human behavior in Europe and in this country, but also prove indirectly the objective criteria used by classification of the network to be correct. The factors which characterize the traffic behavior of these routes can be used with sufficient accuracy in the large field of traffic engineering.

SUMMARY

Classifying Route Types by Traffic Character

A usable parameter for classification is the ratio of recreational traffic to the total traffic of summer months. The recreational traffic can be estimated from (a) the vacational traffic of the average weekday; and (b) from the average weekend traffic. The parameter can be obtained for each road section of the network by simple machine counts in May, June and August.

Route Types by Traffic Character in a Metropolitan County

There are four route types by traffic character on the rural roads in Lake County, Illinois: (a) recreational (Route Type AA); (b) prevailing recreational traffic (Route Type A); (c) recreational and business traffic (Route Type B); (d) preponderant business traffic (Route Type C).

The traffic behavior on these routes in Illinois is very similar to the traffic behavior of equivalent types in Europe. A fifth route type found in certain parts of Europe—the mountain roads in the Alps—is, of course, not represented. Within these types, classification of all rural roads in Europe or Illinois could be made satisfactorily.

No conclusions concerning urban route classification were drawn, because traffic counts in the urban part of Lake County have not yet been completed. A brief analysis of preliminary data from Lake County and treatment of Chicago counts suggest that the overwhelming proportions of urban roads can be classified as Route Type C. Only a few exceptions, such as Lake Shore Drive or Edens Expressway in Chicago, could be found, where, despite the heavy weekday use, Sunday traffic exceeded weekday traffic.

TABLE 9

COMPARISON OF TRAFFIC BEHAVIOR BY ROUTE TYPE AND LOCATION

Location	Route Type A					Route Type B					Route Type C				
	κ_5	κ_6	κ_7	κ_8	δ	κ_5	κ_6	κ_7	κ_8	δ	κ_5	κ_6	κ_7	κ_8	δ
Austria	1.00	0.95	0.84	0.71	0.31	0.96	0.93	0.86	0.88	0.31	0.96	0.93	0.88	0.94	0.31
Hungary	0.99	0.92	0.79	0.74	0.30	—	—	—	—*	—	—*	—	—	—	—
Netherlands	1.00	0.93	0.83	0.73	0.30	0.98	0.92	0.88	0.83	0.31	0.92	0.89	0.88	0.89	0.30
Switzerland	1.11	1.02	0.87	0.74	0.33	0.93	0.98	0.92	0.86	0.31	—*	—	—	—	—
W. Germany	0.97	0.85	0.78	0.72	0.29	0.92	0.88	0.83	0.79	0.29	0.94	0.89	0.89	0.88	0.30
European avg.	1.02	0.93	0.82	0.73	0.30	0.95	0.93	0.87	0.84	0.31	0.94	0.90	0.89	0.90	0.30
Lake County	1.05	0.96	0.82	0.78	0.31	0.98	0.91	0.81	0.86	0.31	0.94	0.92	0.87	0.91	0.30

*No information.

Determining Factors to Characterize Traffic Behavior

After grouping the permanent counting stations and key stations into route types, the following factors of these groups can be determined:

1. $\varkappa$-factors by route type and by month (Fig. 5). These factors yield, as products with the daily traffic volume of an average weekday, the ADT.

2. Daily factors by route type and by month (Fig. 4). These factors (b_7, b_6 and b_ω) yield (as products with the daily traffic volume on Sundays, or as products with the daily traffic volume on Saturdays, or as products with the daily traffic volume of the weekdays) the traffic of average day of the week.

3. δ_i-factors by route type (Fig. 10). These factors show the relative traffic volume by hours of the day. The factors should be computed for Sundays, for Saturdays, and for the traffic on the average weekday of the summer months (Table 7).

After grouping all routes of the network into route types (Fig. 3), the $\varkappa_i$-factors of these route types can convert one day counts to ADT.

For all routes in a metropolitan county, characterized with their ADT volume, by means of $\varkappa_i$-factors and b_ω, b_6, or b_7 factors the daily traffic volumes can be computed for any day of the year (Figs. 1 and 2).

The average relative hourly traffic volumes of the day—δ_i factor (Table 7)—yields as a product with the daily traffic volumes (expressed as a percent of ADT and called i_ω, i_6 and i_7 factors) all the peaks throughout the whole year. Not only the peaks of the weekdays, but also the Saturday and Sunday traffic peaks can be computed (Table 8 and Fig. 11).

Having as results of the assignment procedure the traffic forecast (the ADT values on all routes in a metropolitan area), and knowing the route types of the network, it is easier to estimate the relative traffic volume of design hours for the future.

Accuracy of ADT Estimates Differs by Route Types

A single machine count taken on an average weekday during the summer half year, after converting with $\varkappa_i$-factors to ADT shows ± 5 percent deviations from the actual ADT, if the counts were taken on a route with preponderant business traffic. The probable error of ADT estimates is ± 10 percent if the count was taken on a route with prevailing recreational traffic.

The accuracy of the converted ADT value is considerably higher on routes with traffic greater than 500 vehicles per 24 hours than on routes with less than 500 vehicles per 24 hours (Fig. 7).

As the accuracy of ADT has an effect on the accuracy of the derived peak hours and other traffic characteristics, the number of sample counts should be adjusted by route type to any required accuracy.

CONCLUSION

The research briefly outlined in this paper is a pilot study as a part of the Lake County Area Transportation Study. Lake County, which is part of the Chicago Metropolitan Area, has an area of 468 sq mi and contains nearly 250,000 people. The objectives of the study are to develop a comprehensive and detailed highway plan for the county down to and including the roads at the county level. Lake County, especially its northwestern part with its many lakes, is a typical recreational area attracting, during the summer months, a very heavy weekend traffic from nearby Chicago. The study area lies between Chicago, Wisconsin and other states with significant vacational opportunities, which results in a heavy vacational traffic, not only on the weekends, but also on the average weekday of the peak season.

It is important for planners to know the recreational routes of the area. It is well known that the presence of weekend and vacational traffic results in heavy peaks (Fig. 2). Therefore, the knowledge of traffic behavior on all routes in a metropolitan county is important for traffic engineers, too, for it helps them to estimate the appropriate relative traffic volume of design hours by different routes.

REFERENCE

1. Muranyi, Thomas, "Estimating Traffic Volumes by Systematic Sampling." HRB Bull. 281, 16-47 (1961).