havior with geography or land use, or with travel cost as it is affected by regional fuel price. The information reported on travel alternatives is inadequate for determining the impact of public transportation on VMT, and the absence of locational information makes it impossible to externally supply this information. Finally, because of loose reporting of trip details, it is costly, if not impossible, to perform fine-grained analysis of behavior by trip purpose, local versus intercity travel, and other factors that influence travel choice. The more conventional sources of VMT data, including the FHWA Highway Statistics, were virtually useless for deterministic modeling.

The experience with commercial VMT was positive in terms of models with strong statistical characteristics and credible forecasts. The decision to use TIUS was an important step in the process, and the techniques used to factor the TIUS data were perhaps the major innovation of the project. With the separation of personal and commercial truck, the separation of intrastate and long-distance truck, and the reallocation of VMT to the state of occurrence, TIUS became a current and effective data source for modeling commercial VMT. The commercial VMT models presented here, however, are still very limited in terms of their capability to examine policy effects.

ACKNOWLEDGMENT

The work described in this paper was conducted under contract to the Office of the Secretary of Transportation (OST), U.S. Department of Transportation (14), and was completed in January 1981. I acknowledge the assistance of Helen Doo and Edward Wiener of OST for their support of the work as technical monitors, model consultant Charles Lave of the University of California at Irvine, and research assistant Dieter Klinger of COMSIS Corporation.

REFERENCES

1. R.M. Mellman. Aggregate Auto Travel Forecasting: State of the Art and Suggestions for Future Research. Transportation Systems Center, U.S. Department of Transportation, Cambridge, MA, Dec. 1976.
2. 1977 Nationwide Personal Transportation Survey. U.S. Bureau of the Census, 1978.
3. Highway Statistics. FHWA, 1977.
4. Highway Inventory and Performance Study. FHWA, 1976.
5. National Transportation Study. Office of the Secretary, U.S. Department of Transportation, April 1972.
6. L.M. Rudman. Vehicle Kilometers Traveled: Evaluation of Existing Data Sources. TRB, Transportation Research Record 726, 1979, pp. 19-28.
7. U.S. Bureau of the Census. Truck Inventory and Use Survey. U.S. Department of Transportation, 1977.
8. OBERS Series E Economic Projections. Water Resources Council, U.S. Department of Commerce, Special Early Release, 1979.
9. City and County Data Book 1977. Bureau of the Census, U.S. Department of Commerce, 1977.
10. Regional Transportation Energy Conservation Data Book. Oak Ridge National Laboratory, Oak Ridge, TN, Sept. 1978.
11. National Transportation Trends and Choices to the Year 2000. U.S. Department of Transportation, Jan. 1977.
12. OBERS Projections of Regional Economic Activity in the U.S. Water Resources Council, U.S. Department of Commerce, Vol. 4, 1972.
13. System Design Concepts, Inc., and Jack Faucett Associates, Inc. Recommended VMT Forecasts. U.S. Department of Transportation, Dec. 28, 1979.
14. COMSIS Corporation. Development of a National VMT Forecasting Model: Phase II. Office of the Secretary of Transportation, U.S. Department of Transportation, Jan. 1981.

Improved Method of Grouping Provincewide Permanent Traffic Counters

SATISH C. SHARMA AND AL WERNER

An improved method of grouping provincewide permanent traffic counters on the basis of their seasonal variation in traffic flows is proposed. The method uses two standard procedures: (a) hierarchical grouping, which is one of a variety of clustering techniques, and (b) Scheffe's S-method of multiple group comparisons. The proposed method has several advantages over existing grouping methods, which are largely subjective and manual in nature. The new method is simple, objective, computer-oriented, and statistically credible. In addition, application of the method to Alberta's traffic-counter data indicates that the method is rational for such considerations as trip purpose and trip-length distribution. It is believed that this technique can lead highway agencies to a better understanding of the functional classification of their road systems and help them to develop improved seasonal expansion procedures for estimating average annual daily traffic from sample traffic counts. Finally, the new method has implications for a standard functional classification of roads on a provincial and national basis. It is hoped that such a classification can lead to an overall consistency in the planning and design of roads for both safety and economy purposes.

From past traffic-counting experience, it is known that volume at a given roadway location varies from hour to hour, day to day, and month to month throughout the year. Such a variation in traffic volume is important to many users of traffic data. The average annual daily traffic (AADT) volume is perhaps the most common measure of traffic data used by transportation planners and engineers. It is primarily the AADT and certain other traffic peaking characteristics, such as peak-hour factor, that are used in planning and designing roadway facilities.

Several traffic-counting programs are undertaken by provincial and local roadway agencies to obtain values of AADT on road sections. The most commonly used programs are (a) continuous counting by permanent traffic counters (PTCs); (b) seasonal counting by portable counters, in which counts are taken a few times a year for periods from 48 h to 2 weeks in length; and (c) short-period counting, in which manual traffic counts are undertaken for less than a day.

Only PTCs provide true values of AADT under perfect operating conditions. However, installing and maintaining PTCs on every section of roadway would be prohibitively expensive. For this reason, the idea of expansion of a sample traffic count into an estimate of AADT has been universally accepted and used by the roadway authorities.

The usual method for estimating AADT from short-period traffic counts is that advocated by the Bureau of Public Roads (BPR) in its Guide for Traffic Volume Counting Manual (1). In general the BPR method involves (a) grouping together the PTC sites into similar patterns of monthly traffic variation, (b) determining average expansion factors for each group, (c) assigning road sections that do not have PTCs to one of these groups, and (d) applying the appropriate average expansion factor to short-period counts to produce an estimate of AADT. It is suggested that the BPR method be used only for roads that carry 500 or more vehicles/day.

The existing techniques of grouping the PTC sites into similar patterns of monthly traffic variation are manual and subjective in nature (1,2). This paper describes the development of an improved procedure that uses standard computational and statistical methods for objectively classifying the PTC sites. In addition, the proposed technique appears to be quite rational in relation to such considerations as trip purpose and trip-length distribution. It is believed that this technique could lead to the development of improved seasonal expansion procedures for practical use. In addition, this research has implications for a future standard classification of roads that would enable highway schemes to be designed on a nationally consistent basis for both safety and economy purposes.

STATE OF THE ART: GROUPING PTC'S INTO SIMILAR SEASONAL TRAFFIC PATTERNS

The most commonly used method of grouping PTCs into similar seasonal traffic patterns is that recommended by BPR (1). In this method, the counters are grouped on the basis of monthly traffic factors, which are defined as the ratio of AADT to the average weekday traffic for the month.

The BPR method uses a manual ranking system in which the PTCs are listed in ascending order of monthly factors. For each month a group of counters is determined so that the difference between the smallest and the largest factor does not exceed the range of 0.20 in the values of factors. In other words, the criterion of grouping is a subjectively and arbitrarily chosen value of ±0.10 from the assumed mean. The final grouping of counters in this method is supposed to be such that all or as many as possible of the same counters would fall into the same group for each of the months.

A recent study by the Transport and Road Research Laboratory (2) used a cluster analysis technique in an attempt to classify the seasonal variation of traffic flow at the 50-point PTC sites in Britain. From the results of the cluster analysis, the study found that it was difficult to decide what grouping of the sites was most appropriate. Because the cluster analysis grouping could not be regarded as conclusive, the study reconciled with a largely subjective method that was very similar to the BPR method.

The main problem with the BPR method and its variants is that the grouping of counters is manual and subjective in nature. In addition, there is no guarantee that the BPR method would provide an appropriate number of counter groups that could be rationalized on the basis of such considerations as trip-purpose and trip-length distribution.

Because of these weaknesses of the existing grouping methods, a large number of provincial highway agencies in Canada do not at this time have a standard and objective classification of their PTCs and roadways (3). Considerable subjective judgment is used in choosing a PTC pattern to estimate AADT from sample traffic volume counts. With such an input of subjective judgment, misclassification of individual road sections could result in substantial errors in the estimated AADT values.

The preceding argument suggests that more effort is needed to investigate the classification of provincial roads into groups of similar seasonal traffic variations. The central theme of this research is to develop a computer-oriented and objective method of grouping PTC sites that may lead to the improved and standard procedure of estimating AADT from sample traffic counts.

STUDY DATA

At the present time, Alberta Transportation uses approximately 50 permanent traffic counters throughout the province. These counters use inductive loop detectors for automatic traffic counting. All PTCs but one are located on the provincial primary highways; the one exception is located on a secondary or regional road. The locations of the counters have historically been selected mostly on a random basis of need and volume.

Considering the reliability of the available Alberta PTC data, a total of 45 counters were selected to be used in the analysis. For some of these counters, data were used from the year 1978. Due to the equipment failures in 1978, data for the other counters had to be taken from the year 1977. The PTC information for the years 1977 and 1978 was the most recent data available for the purpose of this study.

In this analysis, the grouping of the 45 PTC sites in Alberta is carried out on the basis of 12 monthly traffic factors for each counter. The monthly factors are defined as the ratios of AADT to the average daily traffic in the month.

DESCRIPTION OF PROPOSED METHOD AND RESULTS

The description of the proposed method and its results has been divided into three separate stages: The first deals with the hierarchical grouping of the counters on the basis of their 12 monthly factors, the second with the determination of the optimum number of counter groups, and the third with the rationalization of the resulting groups.

Hierarchical Grouping of the Counters

The hierarchical grouping method is used mostly in behavioral research. This method as carried out in the present context was developed by Ward (4). The purpose of this method is to compare a set of M objects (e.g., 45 PTCs in this study), each measured on K different variables (e.g., 12 monthly traffic factors), and group them in such a manner that groups are similar in their values of the K variables.

The application of this procedure to the grouping of counters can perhaps be most easily explained by considering a simple example in which the objects are four PTCs described by their traffic volumes as a percentage of AADT over a period of three months:

Counter	Volume 1 (June)	Volume 2 (July)	Volume 3 (August)
A	110	111	110
B	109	112	108
C	114	115	112
D	115	117	110

To begin with, we have four "groups" of one counter each and the "error within" each group is therefore zero. The first stage of the process is to compute a matrix of potential error terms for each pair of counters. This error term is defined as follows:

$$E(i,i') = \sum_{j=1}^{K} [(V_j)_i - (V_j)_{i'}]^2/2 \quad (1)$$

where

$E(i,i')$ = potential error associated with the grouping of objects i and i',
K = number of measured variables,
$(V_j)_i$ = value of variables j for object i, and
$(V_j)_{i'}$ = value of variable j for object i'.

By using Equation 1, we obtain the potential error matrix for our example:

Counter	A	B	C	D
A	0	3.0	18.0	30.5
B		0	25.0	32.5
C			0	4.5
D				0

Since E(A,B) is minimum, we will form a single group from counters A and B, leaving a total of three groups. Let the new group be called X. The group X will retain the error measure E(A,B) = 3.0 since it is within-group error, which will be moved to its diagonal element in the error matrix. The other elements reflecting potential error for combination with X must now be modified also. The weighted mean average error of combining two individual groups can be exemplified for one cell (XC) by the following relation (5):

$$E(X,C) = [E(A,C)(N_A + N_C) + E(B,C)(N_B + N_C) + E(A,B)(N_A + N_B) - E(A,A)(N_A) - E(B,B)(N_B) - E(C,C)(N_C)]/(N_A + N_B + N_C) \quad (2)$$

or

$$E(X,C) = [18.0(2) + 25.0(2) + 3.0(2) - 0(1) - 0(1) - 0(1)]/(1 + 1 + 1) = 30.67$$

Here, E represents an estimate of potential error for combining two groups and N represents the number of cases in a group.

After the first pairing of A and B into a single group X and using Equation 2 to estimate potential error for combining two groups, we obtain the following modified error matrix:

Counter Group	X	C	D
X	3.0	30.67	4.4
C		0	4.5
D			0

It should be clarified here that the decision as to which two groups should be combined at any stage is always made by determining the cell in the error matrix that, when its corresponding diagonal-cell values have been subtracted, yields the smallest value. For example, in the case of grouping A and B together, it was $E(A,B) - E_A - E_B (3.0 - 0 - 0 = 3)$.

The error of grouping C and D together is minimal (4.5 - 0 - 0 = 4.5) in the modified error matrix. Therefore, the process will put together counters C and D. The error matrix will change again because of the latest grouping. The new error matrix, which is also final for our example, is shown here. The group of counters C and D is called Y in this matrix. An error of 49.25 (56.75 - 3.0 - 4.5) results, indicating the "cost" of collapsing the two pairs (X and Y) into a single group of four counters:

Counter Group	X	Y
X	3	56.75
Y		4.5

The errors associated with successive stages of the grouping process indicate the marginal cost of reducing the number of groups by one. Obviously, the error associated with a particular stage of grouping is greater than or equal to the error associated with the previous stage of grouping.

It has to be emphasized here that this method is primarily descriptive and does not indicate specifically what the optimum number of groups is for the study objectives. However, the errors associated with the successive stages of the grouping process will usually reveal a range of grouping stages that is especially worthy of study. By applying the above procedure and plotting the results, Figure 1 shows the errors associated with the groupings of the 45 PTC sites in the case of the study. It appears from this figure that the optimum number of counter groups lies somewhere between 10 and 6 because a substantially large increase in error is observed in this range and beyond.

Determination of Optimum Number of Groups

The optimum number of counter groups was determined by carrying out standard statistical tests to compare the mean monthly factors of groups resulting from the hierarchical grouping. In particular, Scheffe's S-method of multiple comparisons of group means (6) was used for the number of groups ranging from 6 to 10.

Figure 2 shows the hierarchical grouping at three stages of the process: at Ng = 9, at Ng = 8, and at Ng = 7, where Ng is the number of groups at any stage. Each counter group in the figure is represented by a circle enclosing a certain number of dots, which are equal to the number of counters in that group; e.g., group 1 (G1) contains six counters. It can be seen that G3a and G3b are combined to form G3 when the grouping process reduces the number of groups from nine to eight and G4 and G5 are grouped to G4a in the next reduction stage of the hierarchical grouping.

The multiple group comparisons were performed only for those groups that contained more than two counters. Following is a summary of results obtained from the analysis:

1. At Ng = 9, G3a and G3b were not significantly different from each other at the 95 percent confidence level.
2. At Ng = 8, there were significant differences among all the major groups (G1, G2, G3, and G4) at a 95 percent confidence level.
3. At Ng = 7, the within-group error for G4a was significantly higher in comparison with G4. This resulted from the inclusion of G5 (counter C36) with G4 counters.
4. At Ng = 6, the grouping process combined G1 and G2, which had already been found to be significantly different from each other.

Figure 1. Incremental errors associated with hierarchical grouping of study counters.

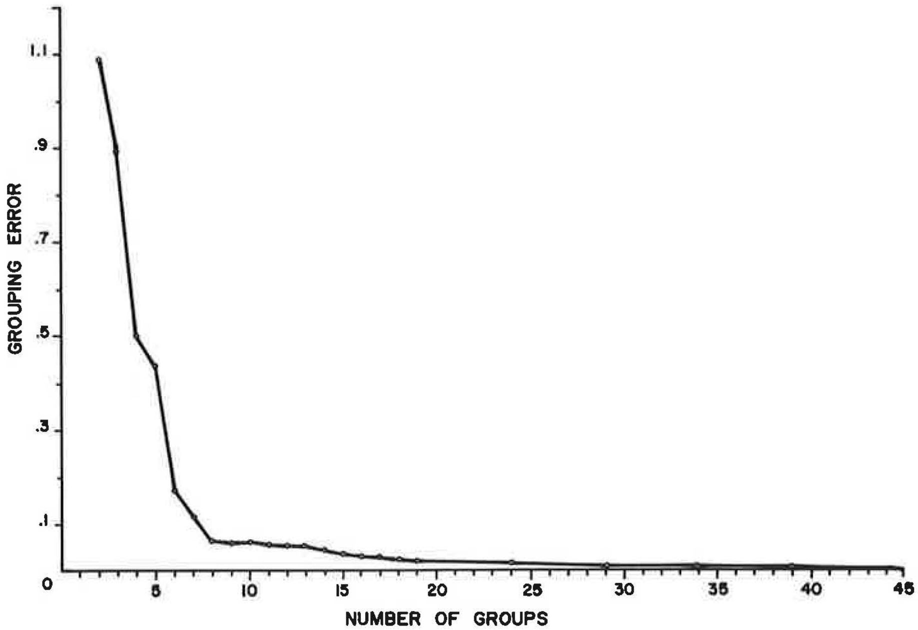
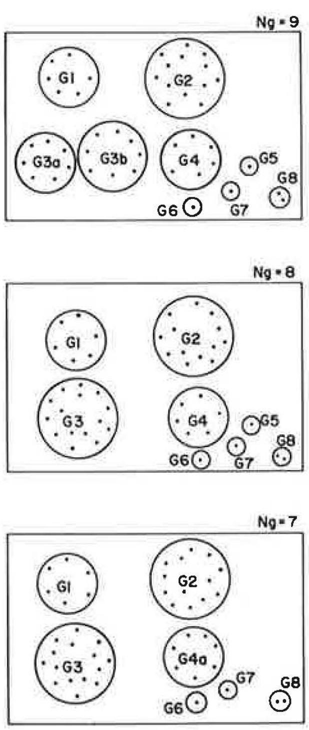


Figure 2. Hierarchical grouping of a number of counter groups ranging from nine to seven.



The reduction in number of counter groups from nine to eight in the hierarchical process appears to be desirable because G3a and G3b are not significantly different from each other. It is also apparent that the number of groups should not be smaller than seven because any reduction beyond this stage results in either an unacceptably high within-group error or a grouping of dissimilar counters. Thus, the most appropriate number of groups in the present case appears to be eight.

It should be added here that the significance of difference among the counter-group means was established on the basis of group comparisons for each month of the year. The various group contrasts differed significantly from each other for a number of months at the 95 percent confidence level; for example, the group contrast G1-G2 differed for 4 out of 12 months. The number of months that showed a significant difference for the other contrasts were 7 for G1-G3, 8 for G1-G4, 4 for G2-G3, 7 for G2-G4, and 4 for G3-G4. All these counter groups were found to have equal mean monthly factors for the month of May.

There is a need to exercise caution in that F-tests computed for the S-method in comparing the mean monthly factors can be artificially and unreliably significant, particularly if a significance level of 99 percent is used in the analysis. The experience gained in this study indicates that the counter groups should be considered different if the F-tests are significant for three or more months at a 95 percent confidence level.

Rationalization of Resulting Groups

The eight different counter groups that resulted from the hierarchical grouping and statistical comparisons of mean monthly traffic factors were further analyzed in terms of their ability to represent functional categorization of the provincial road system in Alberta. The basic presumption made in this analysis was that the difference in overall flow patterns observed at traffic counter sites resulted from different mixes of trip characteristics, such as trip-purpose and trip-length distribution.

Information on trip purpose and journey length corresponding to some of the counter locations in the province was available from past origin-destination studies done by Alberta Transportation. The various trip purposes were grouped into two broad categories: (a) work-business trips, where the number of trips is not considered to vary much throughout the year, and (b) social-recreational trips, where the amount of travel obviously increases during certain seasons of the year, such as the summer months. Table 1 gives the available data in percentages of work-business and social-recreational trips for a limited number of counters

Table 1. Trip purposes for some counters of different groups during summer weekdays.

Group	Counter	Trip Purpose (%) Social-Recreational	Trip Purpose (%) Work-Business
1	C9	17	83
	C66	20	80
	C75	18	82
	C144	19	81
	C147	22	78
	Avg	19	81
2	C12	31	69
	C33	33	67
	C42	38	62
	C93	32	68
	C102	32	68
	Avg	33	67
3	C39	43	57
	C60	44	56
	C63	40	60
	C132	42	58
	Avg	42	58
4	C18	63	37
Other	C36	62	38
	C114	75	25

of different groups during the summer weekdays.

Figure 3 shows the average monthly factors for the four major groups, which account for nearly 90 percent of the study counters. The seasonal variation in traffic of these groups can easily be explained by the corresponding variation in the trip purposes of typical counters from each group as shown in Figure 4. The lowest seasonal variation in the case of group 1 is due to the very high proportion of work-business trips for this group. The high seasonal variation for group 4 counters can be attributed to the high proportion of social-recreational trips for this group.

The cumulative trip-length distributions for the same typical counters are shown in Figure 5. In the case of group 1 and group 2 counters, it is obvious that a good majority of trips are shorter than 60 min. These two groups seem to represent roads that serve predominately local and regional trips. Group 3 and group 4 counters exhibit longer trip-length distributions and generally represent provincial and interprovincial road functions.

Figure 3. Average monthly factors for the four major counter groups.

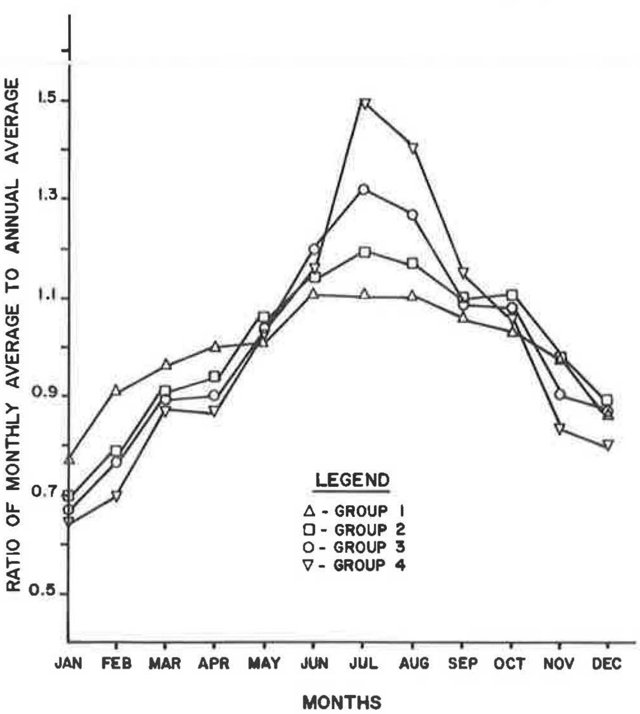
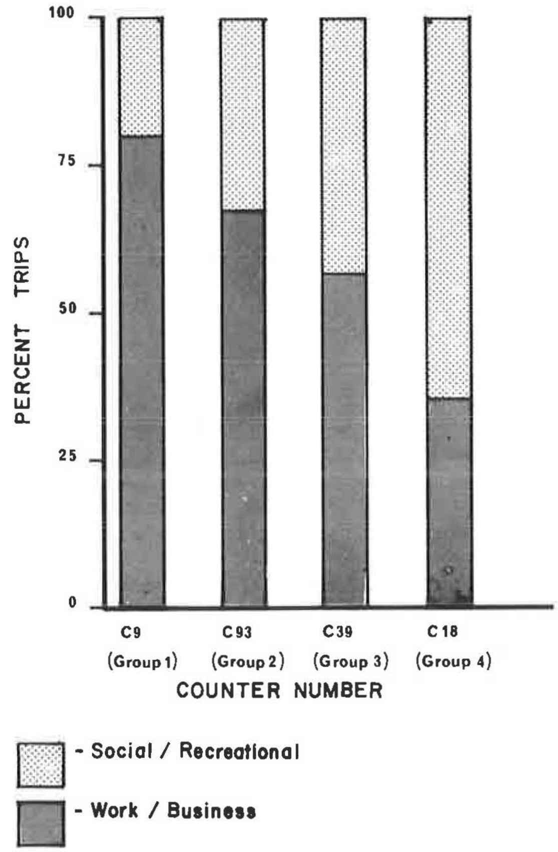


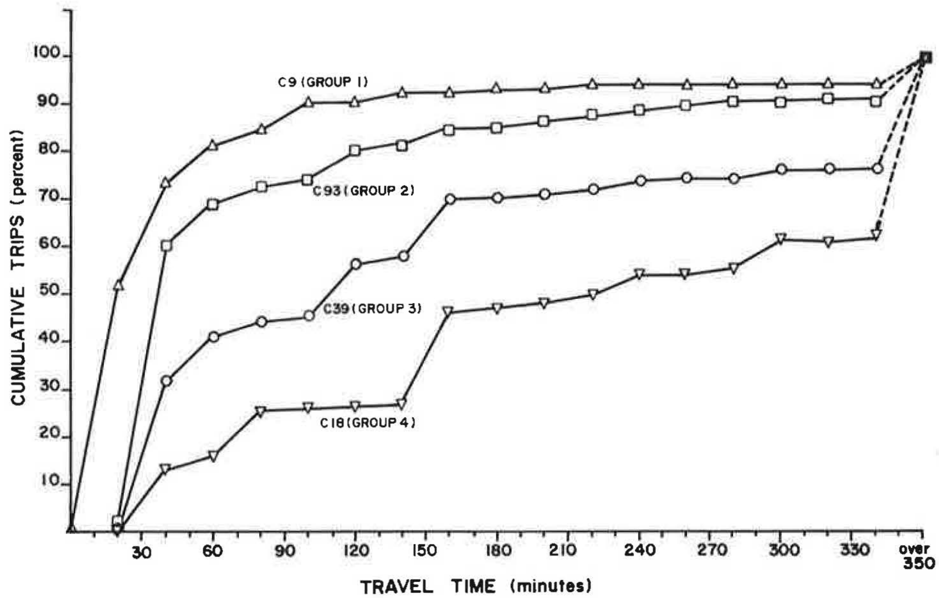
Figure 4. Trip purposes for some typical counters during summer weekdays.



On the basis of the preceding discussion on the relation of seasonal traffic variation with trip purpose and trip-length distribution and the subjective understanding of Alberta's road system, the functional characteristics of the different groups can be generalized as follows:

1. Group 1 represents mainly three types of roads: suburban commuter on provincial-interprovincial roads, commuter on regional roads, and low-volume (AADT < 1500), nonrecreational roads.
2. Group 2 includes provincial-interprovincial roads that carry a significant amount of regional commuter traffic. These are generally higher-volume roads that are close to the major communities, such as Edmonton and Calgary.
3. Group 3 roads are provincial-interprovincial roads that carry social-recreational and other long-distance traffic. The roads in this group are generally a further continuation of group 2 roads away from the major regional centers. There is still some influence of regional travel on such roads.
4. Group 4 roads are provincial-interprovincial facilities that are not significantly affected by either commuter travel or any other type of regional traffic. As indicated previously, the majority of summer traffic on these roads, even on weekdays, is social-recreational in nature.

Figure 5. Cumulative trip-length distributions for typical counters.



5. Counter C36 (group 5) is located on the Trans-Canada Highway between the city of Calgary and Banff National Park. There is a high proportion of weekend and holiday recreational travel on this road during the summer months.

6. Counter C114 (group 6) represents a highly recreational route. It is located on Yellowhead Highway at the east entrance of Jasper National Park. Because of its relatively low AADT, the summer traffic at this counter site is subjected to higher peaking than that at the C36 site.

7. Counter C165 (group 7) is located at a site where the volume of recreational traffic is extremely high and there is very little other long-distance travel.

8. There are seemingly two yearly peaks of travel in the cases of counters C156 and C162 (group 8). Counter C156 is located on highway 35 north on High Level and represents traffic to and from the Northwest Territories. It appears that traffic during the spring season decreases in this case because of such factors as ice melting and the thawing of winter roads in the region. The winter traffic peaking at the C162 site is caused by the winter recreational activities in the Kananaskis area.

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This paper proposes a new method of grouping provincewide permanent traffic counters on the basis of their average monthly patterns. The method involves the application of two standard procedures: hierarchical grouping and such statistical tests of multiple group comparisons as Scheffe's S-method. Conclusions regarding the proposed method and its merits and applications can be summarized as follows:

1. The analysis carried out for this study indicates that existing methods of grouping PTCs are subjective and manual in nature. The new method introduced in this paper can objectively group PTCs, classify roads into different functional categories, and lead agencies to a better understanding and functional classification of their road systems.

2. The new method is simple and statistically more credible than existing methods. It also provides flexibility in that one can decide to further consider and study the counter groups at any level of hierarchical grouping.

3. The analysis and classification of road functions into different categories, as carried out in this paper, should provide a better framework for rationalization of the different data-collection programs, particularly the continuous traffic counting by PTCs, seasonal counting by use of portable counters, and the short-period manual counting program.

4. The new method has implications for a standard functional classification of roads on a national and provincial basis. It is hoped that such a classification can lead to an overall consistency in the planning and design of roads for both safety and economy purposes.

5. Another application of the method is in the area of policy development. Further research into the area of highest-hourly-volume characteristics for different classes of roads can help agencies to develop their own policies regarding design hourly volume and the upgrading of two-lane roads.

6. It is recommended that further investigations be conducted in the area of daily and hourly variations by applying the proposed method in order to further refine the functional characteristics of the road system.

ACKNOWLEDGMENT

We are grateful to Alberta Transportation for providing the necessary data for this study and to the Transportation Planning Services staff who assisted in the work carried out for this project.

REFERENCES

1. Guide for Traffic Volume Counting Manual. Bureau of Public Roads, U.S. Department of Commerce, 1965.
2. P.H. Bellamy. Seasonal Variation in Traffic Flows. Transport and Road Research Laboratory, Crowthorne, Berkshire, England, Supplementary Rept. 437, 1978.
3. Discussion of Topics by Planning, Design, and Traffic Group. Annual Conference, Western Assn. of Canadian Highway Officials, Regina, Saskatchewan, April 22-24, 1980.
4. J.H. Ward. Hierarchical Grouping to Optimize an Objective Function. Journal of American Statistical Assn., Vol. 58, 1963, pp. 236-244.

5. D.J. Veldman. FORTRAN Programming for the Behavioral Sciences. Holt, Rinehart, and Winston, New York, 1967, pp. 308-317.
6. H. Scheffe. The Analysis of Variance. Wiley, New York, 1964, pp. 55-73.

Transit Information System and Evaluation Capability to Support Subarea Transportation Planning and Implementation

TOM K. RYDEN, MICHAEL MORRIS, AND PHILLIP ROUSSERE

The key features of a multipurpose information system and detailed evaluation capability to support transit system planning in the Dallas-Fort Worth area are summarized. The system was specifically designed to enhance a sophisticated subarea travel demand and evaluation technology so as to allow short- and long-range multimodal planning efforts to be conducted. The system was developed jointly by the North Central Texas Council of Governments, local transit operators, and a consultant. Essential transportation planning data are available on both a transit link and line basis, including supply, utilization, environmental, and financial performance measures. The use of the information system is illustrated by a case study example.

In response to the increasing demands placed on the transportation planning process in recent years, the North Central Texas Council of Governments (NCTCOG) has been active in developing a technical planning capability to assist transportation decision making in the Dallas-Fort Worth area. This technical planning capability has three key components. They include regional sketch-planning analysis that adapts the Short-Range Generalized Policy model system (1,2), detailed travel forecasting analysis and evaluation by use of sophisticated subarea (subregional, corridor) focusing techniques (3,4), and individual transportation project evaluation that involves the use of a handbook of manual methods (5).

This paper describes a recent enhancement to NCTCOG subarea capabilities--namely, a multipurpose information system and detailed evaluation capability for transit. A parallel effort not described here is the development of the subarea travel demand forecasting capability for transit. This new transit capability in its entirety, along with the existing subarea planning technology, provides a powerful multimodal planning tool. This technology is responsive to short- and long-range planning needs, sensitive to transportation system management (TSM) actions, applicable to analysis of capital-intensive transit alternatives, beneficial for the evaluation of transportation control measures, and generally applicable to the transportation evaluation needs of local governments.

The principal focus of this paper is to describe the subarea transit information system and evaluation capability. This new system was designed with the aid of John Hamburg and Associates, Inc. (6), to be compatible with travel forecasting requirements, Urban Transportation Planning System (UTPS) programs including INET, and the NCTCOG Thoroughfare Information System (7). This paper describes the context of the information system in view of the total subarea capability, network coding and processing, and overall data-base management to satisfy both evaluation needs and requirements of the travel forecasting process, plus example performance measures and computer graphics support available for planning applications. The final section discusses the major conclusions and future directions for development.

BACKGROUND

As mentioned previously, the transit information system operates within the context of a larger multimodal subarea analysis and evaluation system. An overview of that system is shown in Figure 1. Its principal features are outlined below:

1. Subarea focusing--Computerized procedures build network and zonal activity files that contain extensive detail for the subarea under investigation. Typically, these files include the finest detail in the area of interest and gradually less detail as distance from a subarea increases.
2. Structured data base--Subarea focusing is made possible by a rich hierarchical data base. At the finest level of detail, more than 12 000 highway links, 4000 transit links, and socioeconomic data for 7000 zones are available for a region that covers more than 2500 $miles^2$. For a particular application, automatic zone aggregation and network culling may result in 200-400 zones and 2000-4000 highway and transit links.
3. Evaluation capability--To facilitate the definition and evaluation of alternatives, analysis process outputs and network and zonal files are merged and input to computational procedures that provide an automatic accounting of performance measures. The measures describe network supply, utilization, operation, and impacts such as fuel consumption and air pollution emissions. Measures can be summarized in tables or displayed with network and zonal graphics.
4. Streamlined processing--The validated multimodal transportation analysis process (shown as MTAP in Figure 1) has been highly streamlined. Its execution is flexible, allowing either the submodules of the process to be run independently or the entire process to be run sequentially. If desired, the user can enter the process and alter parameters in response to special analysis needs.

Since the primary focus of this paper is the transit information and evaluation capability, the analysis process (MTAP) is shown in Figure 1 as a single