DEPARTMENT OF TRAFFIC AND OPERATIONS

Improving Traffic-Count Procedures by Application of Statistical Method

BORIS B. PETROFF, *Bureau of Public Roads*, and
ROBERT C. BLENSLY, *Oregon State Highway Commission*

AN improved method has been developed for large-scale traffic-counting operations which makes use of the characteristic that if coverage traffic counts are made for 48 consecutive hours on weekdays their mean 24-hour values will vary from the mean 24-hour values of all weekdays in the month by 10 percent or less in about three fourths of all counts on roads carrying approximately 300 vehicles per day or more. For the conversion of the 24-hour counts to the annual average daily traffic, the statistical method of mathematical probability is used. In computing conversion factors, road sections are grouped according to the similarity of patterns of monthly variations of traffic volumes. Then a mean pattern of monthly variations in conversion factors is computed for each group of road sections having similar patterns. This computation is made from sample counts taken by systematic sampling procedure. This sampling can be made for any desired degree of accuracy of estimates of annual average daily traffic, the cost varying with the degree of accuracy sought.

For lower volume, usually local roads for which lesser degree of accuracy is needed, the less-accurate area method is used.

These principles were first used in Oregon in 1951 in application to a rural road system of 8,245 miles. Both control-route and control-area methods were used. The 1949 control stations' data were used for grouping of road sections in accordance with similarity of patterns of monthly variations. The control routes and control areas established in 1936–37 served as guides. A 10-percent range of variation of factors within each month was allowed in each group. This process was supplemented by judgment when historical record was not available. The economic areas within a state as designated by the 1950 census are used as a basis for the designation of control areas for pattern grouping. In each pattern group were located systematically at equal distances 18 to 20 control stations. The schedules of operations provided for sampling of each month seven times. The theoretical locations were sometimes modified by practical considerations. A group of 20 control stations was also selected to determine the urban influence for the rural sections of highway adjacent to cities of 5,000 or more population. For all control groups the total was 304 control stations. Coverage counts were machine counts of 24- or 48-consecutive-hour duration. These counts were to be expanded for each control route or control area by a single set of factors developed for that route or area. All rural portions of the state highway system were covered during the first year of operation of the plan by 3,148 coverage stations.

In actual operation of the plan certain difficulties were encountered. In planning operations for the second year certain modifications of groupings were indicated by the analysis of the data obtained after the first year of operations. The persistency of the

existence and the classifiability of patterns indicate the advantages of establishing permanent continuous-count-recorder installations at locations which exhibit pattern characteristics most similar to the mean pattern of the control route. As a result of the adoption of this plan and ensuing experience, it is the intention of the state highway department to have some 50 permanent installations on rural highways from which all needed expansion data will be provided in the future.

● IT is now possible to design a traffic-counting procedure which will produce annual average daily traffic estimates of predeterminate size of error with relation to need and cost.

All reported annual average daily traffic volumes are estimates. Because of mechanical or human imperfections, or because of the element of chance in sampling, they all have errors. The problem which is here discussed concerns primarily the evaluation of error due to chance and the use of this knowledge in the design of a traffic-volume survey.

The concept that traffic is an expression of human behavior is essential in the appraisal of the methodology here considered. It is characteristic of this behavior to be repetitive and classifiable into patterns of composing elements. This then permits the approach of statistical evaluation of the measurement of the elements and subsequent processes of deduction as to the expectancy of occurrence of events.

DESIGN OF TRAFFIC-COUNTING PROCEDURE

With the advent of extensive traffic studies begun some 25 years ago, there was an intensive search for procedures of obtaining average daily traffic data by means of sampling. The pressure of time and the existing needs did not permit the delay of wide-scale operations until complete understanding of the phenomenon of travel could be obtained. The procedures then devised for sampling traffic thus were based on available current knowledge.

In the early days of investigations it was first necessary to identify the elements of traffic which formed the pattern. Thus the elements of hourly, daily, weekly, and monthly variations were recognized. These elements of repetition and variation through time were observed intensively at a relatively small number of individual locations. These may be termed the studies of individuals.

From these observations of individuals, two important conclusions were drawn: (1) The elements of pattern in the form of variation of traffic volumes in measures of time were present in all individuals. (2) The measurements of these elements indicated that their sizes differed among the individuals.

Since all observed elements had some effect on the average daily traffic, hereafter called the ADT, the idea then was that a master station had similar characteristics, meaning elements of similarity with those of a short-count station. The master-station data include all the important elements affecting the ADT, the short-count-station data, usually total volume for 8 hours when counts were made manually or for 24 hours when machines were used on a weekday, then were expanded to the ADT by the application of relationships among other elements as obtained at the master station. Since it was realized that the relationships of elements varied at different master stations, judgment was exercised as to the selection of a master station in relation to a short-count station. The concept of a measurable sampling error in the mass product of traffic surveys had not been perceived in the design of traffic-counting programs but remained in the sphere of research only.

An attempt at grouping of stations for control purposes was also made during the early years of the statewide highway-planning surveys. Stations then were grouped by areas or by routes in accordance with various economic considerations or opinions of experienced observers.

After the end of World War II, because of the renewal of activities in highway traffic counting, the Bureau of Public Roads continued its studies to improve, if possible, the techniques in that field. It was thought that with better understanding of traffic behavior and proper applications of principles of probability to the traffic-volume measurements, procedures could be devised whereby the results would be commensurate with need and cost. The immediate results of such a study

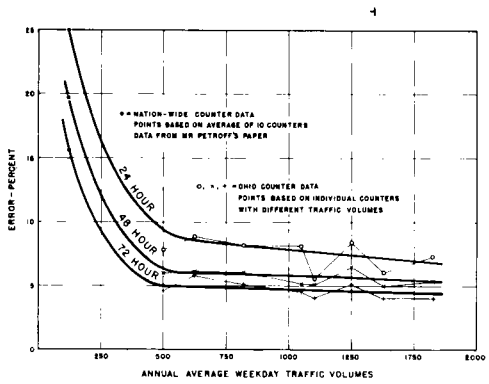

Figure 1.

were presented by Petroff at the 1946 meeting of the Highway Research Board.

The outstanding feature of that study was that it concerned not single individuals but groups of stations in combinations. Thus, it dealt with the measurement of traffic patterns as a function of time, space, and to some extent, volume. It measured the limiting size of error of estimate and the probability of the frequency of its occurrence at many stations scattered throughout a large area. By the end of 1947, the State of Ohio supplemented and extended the significance of these observations. Figure 1, prepared by Ohio, shows the error in ADT estimates in terms of coefficients of variation for different lengths of counting periods and for different traffic volumes. Since that time studies continued in the Bureau of Public Roads and elsewhere substantiate the observations recorded in the graph.

The observation of the data presented in Figure 1 which is of utmost practical significance is that traffic counts of 24-hour duration on weekdays have a coefficient of variation of 10 percent or less when compared with the mean volume for a weekday in a given month at stations having the mean volume of about 500 vehicles per day or more. This applies usually to all months except the winter months in some of the states. For higher volumes the coefficient of variation decreases but slightly. Counts of 48 hours duration improve the accuracy by 20 to 25 percent, thus raising the confidence limit from 68 percent to about 75 percent for one standard deviation of 10 percent, also extending the range of volumes down to about 300 vpd.

This translated into everyday language means that two thirds to three fourths, depending on the length of the count, of all coverage or blanket counts may be expected to have an error of about 10 percent or less when compared with the true mean weekday volume of the month during which they were taken when volumes are 300 to 500 vehicles per day or more.

This, then, is the basic material with which begins the design of a traffic-counting program.

The end product of a traffic-counting program is an estimate of ADT. For this purpose the next step in the design problem is to develop a procedure of expansion of coverage counts in such a manner as to limit to a practical minimum a determinable and controllable increment of error which is algebraically additive to the sampling error of 24-hour or 48-hour counts. Neither the master-station method nor the old method of grouping are adequate from this point of view, because they are based on judgment or descriptive correlations and fall outside of statistical evaluation of error and its relation to need and cost.

A method based on probability considerations was then developed in the Bureau of Public Roads and applied for the first time in 1951 in designing a program for the State of Oregon. It has since been applied in six other states.

First, it is necessary to segregate the elements of traffic patterns in accordance with their importance as to their effect on estimating ADT. It is almost universal now to make traffic counts by means of machines. Each coverage count is usually of 24 or 48 consecutive hours duration. This eliminates the need of considering hourly variations. The variations among weekdays already are accounted for in the characteristic of 10 percent coefficient of variation discussed above. So are the variations among weekdays in the month. There remain thus the variations of volumes on Saturdays and Sundays and variation among the months. There are also the unique or sporadic elements of special events, among which would be holidays and public gatherings, requiring special solutions.

Special events, however, usually have an insignificant effect on ADT and by eliminating counts on unusual days, they can be dis-

regarded in the design of a program for mass production of ADT estimates. Saturday and Sunday variations from the weekday volumes are appreciable and should be accounted for, but the greatest effect is to be found in the element of monthly variations of traffic volumes. Thus the design is concerned with weekend and monthly variations. The element of monthly variation will then be considered first.

It has been already pointed out that the sizes of elements vary at different locations. If limits of monthly variations are set up and locations falling within these limits can be identified, then the schedule design data can be obtained.

By grouping locations where elements of monthly variations were similar, the mean values of the elements would then become the measures to be used in the expansion of coverage counts. How then is this grouping to be done and how is it to be known to which coverage stations the mean measures are applicable? To answer these questions the statistical methods of sampling and the principles of probability are brought into use. After examining traffic-volume records, a composite route or routes are established which consist of many road sections upon which the monthly traffic patterns are similar. Later in this discussion these routes are referred to as control routes. Dependence is placed on probability in the expectation that at any other locations along such routes the patterns will show the same similarity. To obtain the sample mean pattern most representative of the true mean pattern were it obtainable, systematic sampling is used. Random sampling could be used, but it is less convenient of application.

Since it is the primary roads on which volumes greater than the minimum of 300 to 500 vehicles per day used in the test referred to are usually found, it is to this class of road that the method is generally applicable. Actually, it is used for all primary highways, because even though some of them carry less than 300 vehicles per day and the traffic volumes thus are subject to higher error of estimate, there is usually no need for great accuracy on these lower-volume roads. Conversely, high-volume local roads could be included with the primary highways. The administrative classification by its own virtue does not determine the habit of travel, but because of greater concentration of higher volume roads in the state system, this is the system of major concern in the traffic-counting programs.

In order to group road sections into contiguous routes on which a pattern of similar monthly variations may be expected, attention is directed to the historical record. For every station where data are available, the pattern is determined by computing the ratio of annual average weekday traffic to the monthly average weekday traffic or of the average annual daily traffic (ADT) to the average monthly daily traffic. These patterns are then compared among the stations. A permissible range of variation is assigned so that in the same group of stations in the same month the difference between the ratios is not greater than the allowed value.

There is a vacancy of knowledge in the matter of the determination of the size of the range. There should be found the sizes the differences between which are statistically significant. That is yet to be done. In current experience, the value of 10 percent of the smallest ratio involved in the comparison has been used. The 10-percent range reduces the probability of error of the mean of the patterns to a low percentage. This is the error which when carried over into the estimating of ADT at a coverage station[1] can be attributed to the expansion methodology. The total net effect of this error when measured at a number of coverage stations approaches zero, because of its compensating plus-or-minus feature. A 10-percent range appears to be practical and has been used in the design of the traffic counting program in Oregon and other states.

Experience shows that there is a definite tendency for stations having similar patterns to be along contiguous routes. But there may be several such routes noncontiguous with respect to each other, all belonging to the same pattern group, however.

Usually there are not enough historical data available in a state to distribute all the required mileage to the pattern groups, and judgment is then used in assigning the sections of unknown patterns to the known pattern groups.

[1] A coverage or blanket station is a point on a road between intersections where traffic is usually counted once for a period of 24 or 48 consecutive hours.

By sampling the monthly pattern systematically at equal distances within each route and by computing the mean pattern from these samples a single set of factors is obtained. This set of expansion factors is then applied to all coverage-count stations along the particular route. The errors attributable to the expansion factors, although small, tend to offset the improvement in accuracy resulting from the extension of period of count from 24 to 48 hours. Thus it may be expected that two thirds of the estimates thus obtained will have errors of 10 percent or less for 48-hour coverage counts taken during suitable seasons.

For the low-volume roads where dispersions are greater than 10 percent in coefficient of variation, the area method is used for the development of mean patterns. This method is not statistically evaluated but is less accurate than the route method. It is practical, however, because lesser accuracy is usually permissible and because of convenience of handling of expansion data. The Bureau of the Census economic areas serve as a useful basis for designation of areas for control stations[2] and expansion purposes.

The sampling of monthly values for each control route or control area is based on the usually acceptable minimum number of units of five in a sample. This is not to be considered as a final number but to be used only until further research determines a more exact number. The number of control stations depends on schedules. If the minimum of five counts in each control group is adhered to, then a total of 60 counts during the year is needed. There are many ways in which these counts can be made so that at each control station an independent estimate of ADT can be made. Usually, estimates of high degree of accuracy (errors of less than 10 percent) can be obtained from either six counts spaced two months apart, or four counts spaced three months apart. Stations at which counts are made at two-month intervals are called major control stations and those at which counts are made quarterly are called minor control stations. A combination of four major and nine minor control stations for example can satisfy for each control group the minimum sample of 60 counts a year at the rate of five a month. Each count consists of three to five weekdays, one Saturday and one Sunday. The inclusion of weekend counts permits then the necessary adjustment in the computation of expansion factors.

It is true that the errors due to correction for Saturdays and Sundays can be independent of the chance variations in the monthly factor. Nevertheless, no special attention or treatment is usually necessary, because each one has the effect on the average daily estimate of only a seventh of its value.

Special counts are added whenever necessary. It is preferable that counts be distributed as evenly as possible throughout the control route or control area.

It is an important element of the procedure that, because of the number of control stations and their distribution, a series of factors also can be developed which permits the bringing up to date the traffic counts at coverage stations for a number of years, four or five, perhaps longer. With this procedure in effect comprehensive coverage is needed only once in a period of several years. The control station operations, however, need to be continued on yearly basis.

The experience gained in Oregon, however, suggests a possibility of substituting continuous-count permanent machine installation for several control-station operations. The idea is founded on the observation that patterns do distribute themselves along identifiable routes and reasonably persist from one year into another. Thus, if a location can be selected from the control-data stations that has a pattern similar to the mean pattern of that particular control route, then a continuous-count station at that location would provide the necessary expansion factors applicable to coverage counts on that control route. It is believed that permanent stations so established will cost less than the operation of control stations.

The mass production of expansion of coverage counts implied in this procedure also indicates the possibility of efficient use of IBM or other machine methods of factorization which would make the final estimates available at an early date and at a further reduction in cost.

[2] A control station is a point on a road between intersections where a number of counts are usually taken. The data from control stations are used for computing expansion or conversion factors. These factors are used to convert coverage counts to ADT.

THE PROCESS OF APPLICATION OF THE DESIGN IN OREGON

The Oregon State Highway System

The Oregon State Highway Department uses traffic-volume data extensively for planning and design purposes. It is, therefore, imperative that the average daily traffic be available for the various sections of the state highway system. Volume information is also used for the design and programing of those portions of the federal-aid secondary system not coincident with the state system. The state highway system, as of December 1951, was composed of 4,500 miles of rural primary highways and 2,370 miles of rural secondary highways. The federal-aid secondary system not coincident with the state system was 1,375 miles. The state and federal-aid highway systems for which volume information is desirable, therefore, consisted of 8,245 miles of rural highways.

In addition to obtaining traffic volumes on the state and federal-aid systems, the state is also desirous of obtaining the vehicle miles on the county and public roads and city streets. The development of the program to follow was based on the overall plans of the state.

Prior Traffic-Counting Methods

After completion of the comprehensive traffic survey conducted in 1936–37, a system of traffic counting using 104 control stations located at intersections of state highways and major county roads throughout the state and counted manually each month was used for developing expansion factors applicable to suitable stations along designated control routes or in selected control areas, and point control[3] for the expansion of coverage counts to obtain the average annual daily traffic on the state highway system. These manual counts at the control stations were taken one day each month for weekdays, and at half of the stations weekend counts were taken four times a year.

The reduction in available manpower and funds caused by World War II required a reduction in the schedule for counting these control stations. The new schedule obtained manual counts four times a year for weekdays, and the schedule varied considerably for the weekends.

The development of machines to replace or supplement manual counting made possible a revision of the counting program in 1950. In addition to the availability of machines for counting, it was necessary to reduce the operating budget. Therefore, the number of control stations was reduced to 85, all of these stations being on sections of roads between intersections rather than at intersections, as was the case previously. With the use of portable mechanical recorders, counts were obtained at each station for one week in each month of the year. In addition, classification counts of 16-hour duration were taken on a weekday twice a year at all stations.

With approximately 6,900 miles on the state highway system and only 85 control stations to provide expansion factors for groups of road sections forming control routes, control areas, and point control, it was necessary for each station to control an average of 81 miles of highway. It was the feeling of the department that 81 miles was too long a section for a control station; therefore, a review of the traffic-counting program was requested of the Bureau of Public Roads. At the time of the request for the review it was not the intention that a completely new program would be developed, but rather that an analysis of the adequacy of the program being used would be made.

As a result of discussions with the personnel of the Bureau of Public Roads, it was the feeling of state personnel that the method which the Bureau was proposing had considerable merit and was far superior to that being used by the state.

The method proposed by BPR was similar in some respects to the system being used by the state. Both methods used route and area factors for the expansion of permanent coverage counts to average daily traffic. The major difference in the two methods was in the criteria for grouping of road sections into routes and the selection and operation of control stations.

Selection of Control Routes and Control Areas

The data developed from the control stations operated in 1949 were applied to the control routes and control areas as shown on Figure 2 which were developed from 1936–37

[3] Point control is a single control station from which expansion factors are computed.

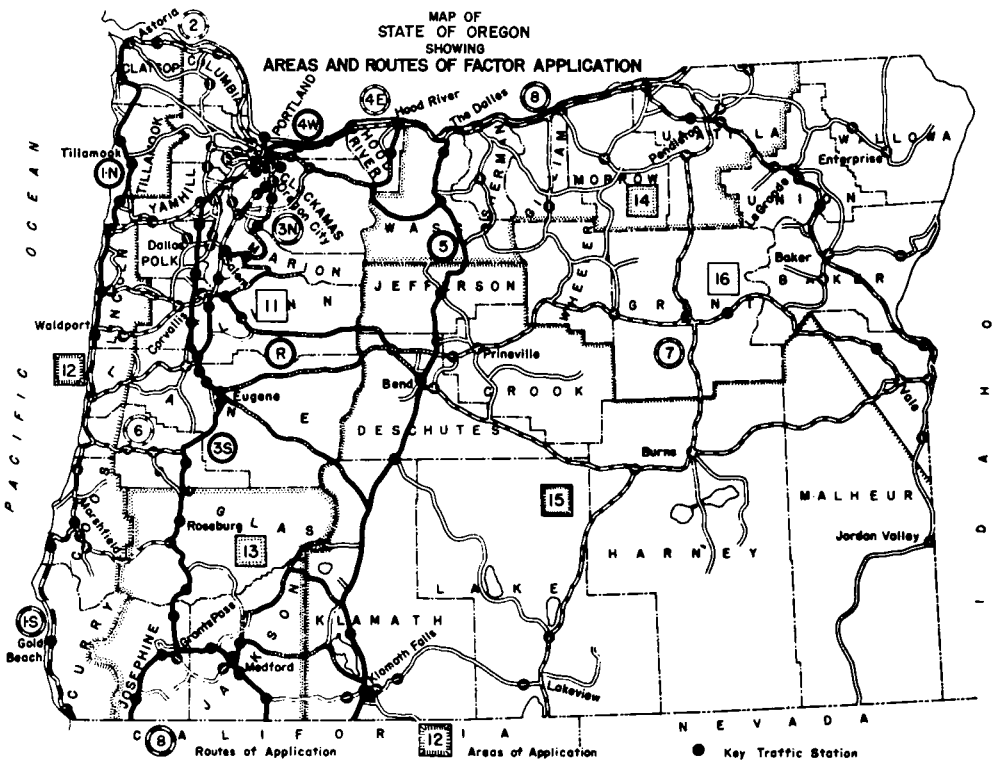

Figure 2.

TABLE 1
COMPARISON OF SEASONAL FACTORS FOR TWO ROUTES DEVELOPED FROM 1949 CONTROL STATION COUNTS

Month	Seasonal Factors		% Variation Based on Route 3-S
	Route 3-N	Route 3-S	
Jan.	1.33	1.47	−9
Feb.	1.23	1.38	−11
Mar.	1.20	1.31	−8
Apr.	1.14	1.15	−1
May	1.09	1.09	—
June	0.96	0.89	8
July	0.91	0.88	3
Aug.	0.92	0.91	1
Sept.	0.91	0.95	−4
Oct.	1.07	1.05	2
Nov.	1.19	1.14	4
Dec.	1.15	1.13	2

comprehensive traffic survey. A review of these control route and control area factors in the light of the criterion of permissible range of monthly variation of 10 percent, indicated that too many control routes were being used. In other words, if the deviation of the monthly factors for two control routes was less than 10 percent in each case, these two control routes could be combined into a single control route. In the process of grouping of road sections into routes and in designating control areas, it was required to maintain the expected accuracy of the majority of resulting estimates of average daily traffic as measured by errors not greater than plus or minus 10 percent. Table 1 shows a comparison of control routes having seasonal factors which do not vary more than 10 percent, except in the month of February, and could probably be combined into a single control route.

A similar review of the control-area factors indicated that some combining could be accomplished there also. The application of the 1949 control station counts to the control routes and control areas as established in 1936–37 was not readily available in sufficient detail to indicate the dispersion of individual stations from the mean of each route; however, the knowledge of the state personnel of the traffic patterns throughout the state indicated that, because of reconstruction, the

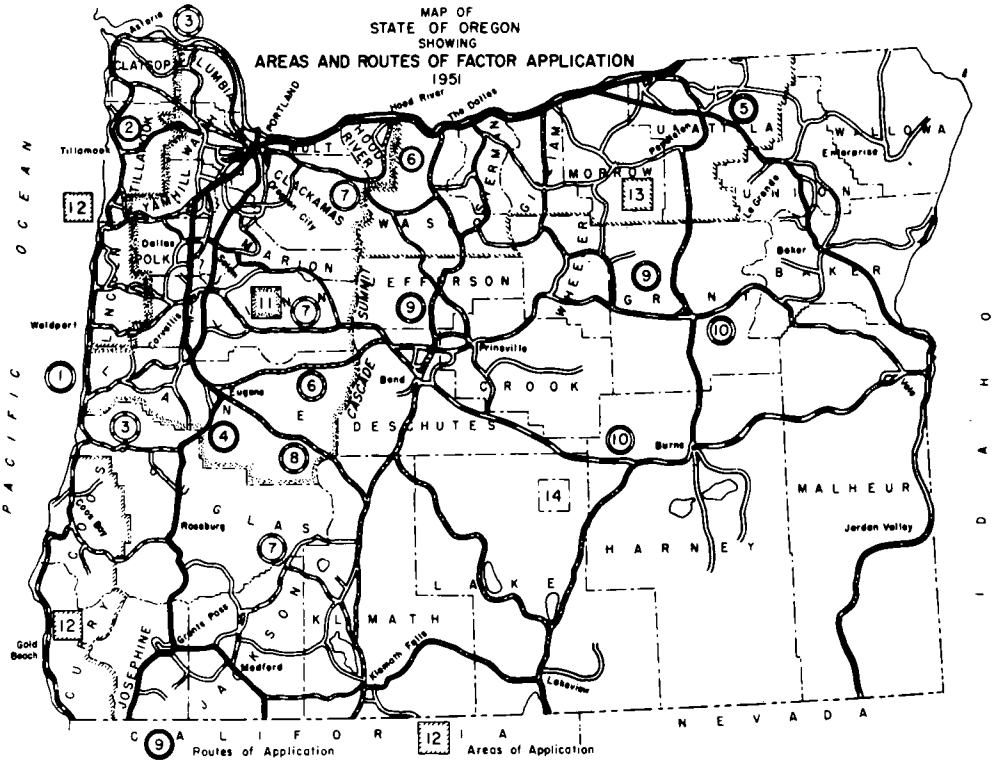

Figure 3.

general movement of traffic in certain areas had changed and that certain minor revisions in the original routes would be necessary. In addition, all mileage of the state primary highways had not been combined into routes in the previous study. Therefore, some were combined on the basis of judgment of the state personnel. In combining road sections into control routes upon which traffic patterns of monthly variations are similar, it was decided that only the primary highways and the high-volume secondary highways warranted sufficient accuracy to be combined into control routes. Some of the low-volume primary and secondary highways were arbitrarily assigned to the areas for expansion of their coverage counts. This review and the resulting combinations established the ten control routes to be used for the state. Each of these control routes was expected to have different monthly patterns of expansion factors.

The preliminary selection of control routes and control areas to be used are shown in Figure 3.

The control areas selected by the state for factoring purposes were compared with the economic areas as developed by the Department of Commerce for the 1950 Census of Agriculture,[4] and it was found that the boundaries were almost identical. The major difference in the control areas selected by the state and the economic areas was the grouping of two of the economic areas into one for the state purposes.

In the most-densely populated section of the state, namely the Willamette Valley, many of the local county roads and state secondary highways have volumes in excess of 300 vehicles per day. In the other sections of the state volumes in excess of 300 vehicles per day are an exception for roads other than the state primary system. Because of the large range in ADT in the Willamette Valley, it was

[4] U. S. Bureau of the Census, "State Economic Areas" by Donald J. Bogue, U. S. Government Printing Office, Washington, D. C., 1951.

decided that that control area should have two sets of seasonal factors, one for roads with an average daily traffic in excess of 300 vehicles per day and one for those with a volume of 300 or less.

Selection of Control Stations

After the control routes and control areas had been selected, a minimum requirement of accuracy so that the error not in excess of 10 percent should occur two thirds of the time was selected for the counting program.

For the purpose of sampling monthly variations for each control route and control area according to information supplied by the Bureau of Public Roads, a minimum of five counts per month for each route and area was suggested. As the control stations were to consist of approximately one third major and two thirds minor, this would require at least 13 for each route and each area. Rather than settle for the minimum requirement, the state elected to use seven counts per month for each route and area or 18 to 20 control stations.

Not having satisfactory control-count data for complete coverage of the highway system, it was necessary to locate the control stations by some random means. A systematic method of locating the control stations at regular mileage intervals was selected for the control routes. In this method the total length of the control route was divided by the number of control stations desired. This provided the distance between control stations.

Because the state had some permanent automatic traffic recorders located throughout the state, it was not desirable to adhere strictly to the indicated distance interval. In all cases the theoretical mile point was determined and if that point was within a reasonable distance of a former control station or a permanent installation, then the actual control station was established at the same location where the former control station had been or at the permanent automatic recorder. The location of the next station was determined by going to the theoretical point and again measuring the required distance. In all cases 20 stations were used as a theoretical number; however, because of adjustments for location of the permanent recorders, previous control stations and urban areas, two control routes ended up with 19 control stations and one with 18 control stations.

Two control routes of very-short length were modified and only 13 control stations were used. The use of 20 control stations for these two control routes would have spaced them so close that the additional counts would have served no purpose.

For the control areas, 20 control stations were taken as the number required. Because the control areas could not be handled by a distance interval as the control routes were, some other means had to be developed for establishing the location of the control stations. The first step was to proportion the control stations among the counties on the basis of the mileage of roads for which coverage counts would be expanded by the control-area factors. These stations were so selected within each county from the state secondary highway system and the county roads that in the judgment of the personnel they would be representative of that control area. An attempt was made to avoid very-low-volume roads and roads influenced by urban areas.

It has been the experience in the past that the rural sections of highway adjacent to urban areas will not necessarily have the same seasonal pattern as the other rural sections. Therefore, a group of 20 control stations was selected to determine the urban influence for the rural sections of highway adjacent to cities of 5,000 population or more. Cities were selected from each of the economic areas as determined by the Department of Commerce to aid in developing statewide factors. The state highways and major county roads adjacent to these cities were then used for locating the control stations. This method provided fairly good coverage in all areas of the state except the coastal region. Two additional stations were selected adjacent to the larger cities on the coast and included with the urban influence group.

The smaller cities in Oregon have not developed the fringe suburban areas found around the larger cities; therefore, it was not considered necessary to have an urban influence factor for cities under 5,000 population.

For all control groups a total of 304 control stations were selected. These were further divided into 107 major control stations and 197 minor control stations.

The selection of control stations for the

control routes was made systematically from an arbitrary beginning point which was an old control station, preferably a permanent recorder station which was now designated as a major control station. Every third station thereafter and before was then designated as a major control; all others were minor. This procedure was varied in some cases so that additional permanent recorder could be used as major control stations. For the control areas an attempt was made to select from each county, if possible, at least one major control station; however, it was not always possible to do this. For the urban influence group an attempt was made to select one major control station adjacent to each city.

All control-station counts were obtained with Streeter-Amet portable recording traffic counters and the coverage counts were taken with Streeter-Amet and K-Hill nonrecording traffic counters.

Plan of Operation

The major control stations were to be operated for one week six times a year, and the minor control stations were to be operated one week four times a year. It was necessary to assign five counting schedules to the control stations: Schedules 1 and 2 for the major stations, for Schedule 1 the first count being made in January and every second month following and Schedule 2 the first count to be made in February and every second month following. The minor control stations were assigned three schedules: one to start in January and repeat every third month, one in February and repeat every third month, and one in March and repeat every third month.

The schedules were assigned to the control routes by beginning at one end of the control route and alternating first the major controls (Schedules 1 and then 2) and second the minor controls (Schedules 3, 4, and 5).

For the control areas the schedules were assigned so that each station in a county when possible would be on a different schedule. The same procedure was used for the urban-influenced group.

Coverage counts were to be obtained in the first year of operation on all the rural portions of the state highway system. These would be machine counts of 24-hour or 48-hour duration. These counts then in turn would be expanded to the ADT using the seasonal factors for the control route or control area, whichever may apply, as developed from the control stations. Weather conditions in Oregon limited the operation of obtaining coverage counts to approximately eight months a year east of the Cascade Mountains because of the extreme fluctuation in volume caused by winter weather and snow conditions. West of the Cascade Mountains and principally in the Willamette Valley the winters are relatively mild with little snow; therefore, coverage counts were planned for all 12 months of the year. Coverage counts were to be taken on all sections of highway that varied from the adjoining section by 10 percent or more in volume.

Manual Classification Counts

In addition to the average daily traffic on a section of road, proper planning and design requires some information on the composition of the traffic. Therefore, a schedule for manual classification counts at the control stations was developed.

Recommendations by the Bureau of Public Roads indicated that 12 to 13 stations throughout the state should be counted for a 24-hour period on a weekday four times a year and for a 24-hour period on Saturday and Sunday two times a year. Thirteen stations of this nature were selected for Oregon. The selection was made to provide as wide a distribution throughout the state as possible and at the same time, provide representation for as many routes and areas or control groups as possible. Additional manual counts were to be obtained at the remaining major control stations. One-fifth of these or 17 were to be counted for a 16-hour period on a weekday two times a year and a 16-hour period on Saturday and Sunday two times a year. These stations were again selected to provide statewide distribution and representation on each control group. The remaining major control stations, which numbered 77, were scheduled for a 16-hour weekday count two times a year

RESULTS OF THE FIRST YEAR OF OPERATION

A review of the average monthly mileage traveled by the field personnel in obtaining control and coverage counts has indicated that every effort should be made to reduce this monthly average. Because of the size of each of the field districts, and the distances

between control stations, the field men traveled an average of 3,300 miles per month. The mileage ranging from a low 2,200 miles to 5,000 miles per month. No information is available as to the relationship or the portion of mileage traveled to obtain control counts as compared to the mileage traveled for obtaining coverage counts; therefore, adjustments in locations of the count stations, either control or coverage, was selected as the first step in attempting to reduce the monthly average mileage traveled by the field personnel.

The location of the coverage counts are governed by the breaks in traffic and, therefore, these locations are not arbitrary selections; however, more emphasis was given in the instructions to the field personnel to obtain coverage counts in the same general areas in which control counts were being taken.

Control Stations

All control stations were reviewed to determine if slight adjustments along a section with the same traffic pattern could be made. It was found that a limited number of stations could be moved and thereby result in considerable mileage savings by eliminating some dead-head travel—travel into a station and back out again. Some of the minor control stations located on sections of highways in the sparsely populated areas indicated a similar pattern at two or more adjoining stations. These stations were combined into a single location which was operated in the case of two stations eight times a year and in the case of three stations 12 times a year. This procedure tampers with systematic sampling and, therefore, with the significance of the mean. Because all the points along a given route are expected to fall within the 10-percent range of variation of monthly factors, this tampering is not expected to have serious practical effect on the mean pattern.

In one case, a major station was combined with two minor stations. The resulting station was operated each month of the year. The primary purpose in this was to combine three stations on a section of highway closed by snow during the winter months. The operation of the control stations on highways with winter closure resulted in insufficient information on those highways. The revision of the control stations resulted in information for each month that the highway was open to traffic.

Coverage Counts

The original plans for coverage counts contemplated 48-hour counts at every location. However, because it was necessary to use the same personnel to obtain counts at both the control stations and coverage stations, it was necessary to confine a large number of the coverage counts to 24-hours.

The normal schedule of operation was to pick up the recorders at the control stations on Monday and, when necessary, to continue into Tuesday and then reset the recorders at new control stations on Tuesday and, when necessary, on Wednesday. This schedule allowed a maximum of three weekdays during which coverage counts could be obtained; in some cases only two days were available. On those weeks when three days were available, it was found that the machines for the coverage counts could be set out on Wednesday and picked up Thursday or Friday. If they were picked up on Thursday, there was normally not sufficient time remaining in the day to obtain another set of coverage counts without including a portion of Saturday in the counts. Therefore, these machines were normally picked up on Friday with the resulting count being of 48-hour duration. At stations where the machines were set out on Thursday, 24-hour counts were obtained.

The application of the control-route and control-area factors to expand the coverage counts to an ADT indicated that counts obtained in January, February, November, and December were erratic and unreliable in the section of the state which had snow conditions during the winter. In the Willamette Valley, which has a relatively mild winter with little or no snow, the winter counts were normally usable.

Some difficulty was encountered in the use of coverage counts obtained just prior to or just following a holiday, therefore, these were avoided when possible.

As was expected, some of the expanded coverage counts did not fit the traffic pattern established by other counts along the highway; therefore, all counts were screened to assure an even flow of traffic along the high-

way. This procedure required the occasional adjustment in an expanded count.

The original estimate of the number of coverage counts necessary was based on an average interval of 2 miles of road for each count. This indicated that 3,117 counts would be required. The actual number of coverage counts obtained was 3,148, which was approximately 1 percent over the estimate.

Personnel Schedule

For the operation of the control stations and obtaining the coverage counts, five men were permanently assigned throughout the state with each man assigned a definite district in which to work. The boundaries for these districts were selected so that all men would have approximately the same number of control stations. This distribution resulted in an average of six control stations to be operated every week in each district. In addition, monthly counts were taken in the state parks for use by the parks department. The combination of the control stations and the park counts required from five to eight control and park stations to be operated each week. The annual schedule set up for each man provided four weeks during the year in which no control or park counts were necessary.

The use of two and sometimes three days of the week to obtain the counts at the control stations limited the number of coverage counts that could be obtained. The five persons obtained 2,179 coverage counts during the year or an average of 13 counts per week based on an actual average eight months of operation. In addition, it was necessary to use three supplementary persons who obtained 969 coverage counts. This supplementary personnel did not obtain coverage counts on a full time basis; therefore, no average weekly figures are available.

The average number of counts and the counts referred to above do not include any counts lost through machine failure, loss of road tube, or other reasons. If the bad counts were included in the weekly average, the five permanent persons would have averaged approximately 20 counts per week, which was also the number of machines each man had to operate.

APPLICATION OF ANALYTICAL REVIEW OF THE OPERATION OF THE OREGON PLAN

Regrouping of Control Stations

The analytical review for the first year was primarily a check of each control station to determine if they were grouped properly for control routes and control areas. If a variation was found between a control station and the mean of its group of more than 10 percent in most of the months, then it was removed from that group and combined with another of similar pattern. The control stations were regrouped and new control routes were established. It was found that in some instances a control station for a section in the middle of the control route varied from the mean of the route more than allowed. It was felt that this variation was more likely to be a chance variation than a caused variation and, therefore, these stations were included in the control route. On the other hand, a large number of the control stations located on isolated sections of different highways throughout the state were found to have similar patterns. These could not be combined into groups for expansion purposes without establishing the section limits within which the group data could be applied. In addition, there was a fairly large number that had no control route or group pattern. In all these comparisons the months from March through October were given primary consideration for grouping. If it was found that these months fit the pattern but the other months did not, then the station was combined with the group.

The process of combining control stations into groups with similar patterns encountered some difficulty, particularly with those stations for which only four counts a year were available. This was particularly apparent when stations did not appear to have the same seasonal patterns as stations on adjoining sections of highway which were counted on a different schedule. Occasionally, it was noted after tabulating the third count that the trend or seasonal pattern did not indicate the pattern expected in that particular area. The difference may or may not have been the true seasonal pattern. On the basis of the foregoing statements, serious consideration should be given to operating major control stations 12 times a year and minor control stations six

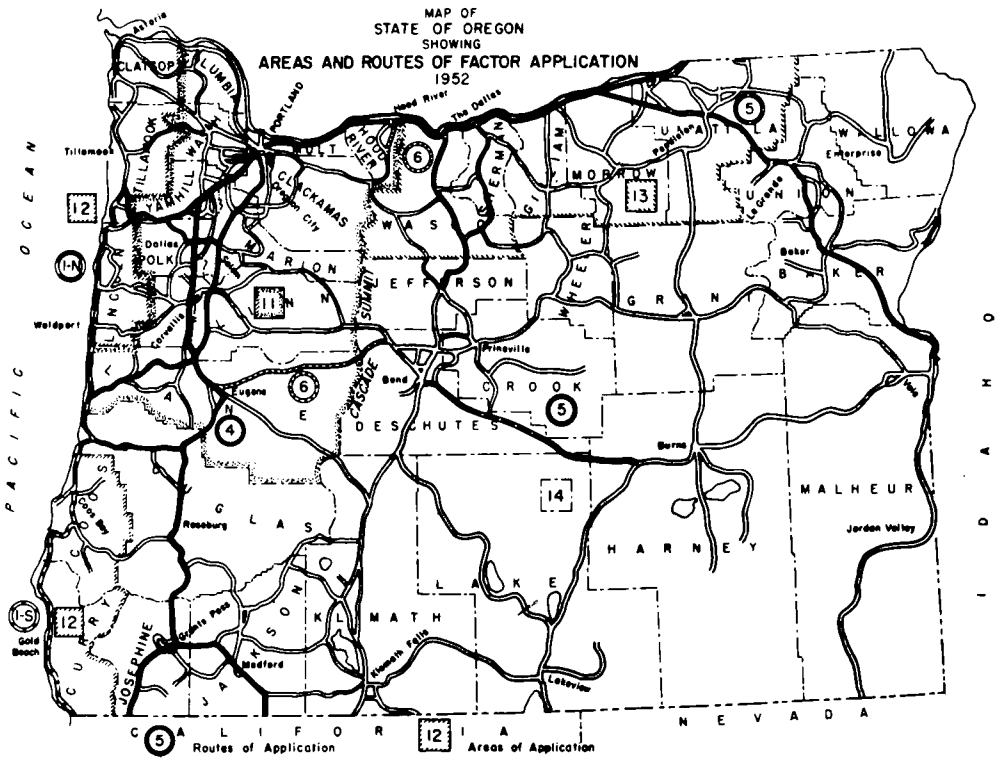

Figure 4.

TABLE 2
COMPARISON OF AREA SEASONAL FACTORS

Month	Area 11 under 300	Area 11 over 300	Area 12	Area 13	Area 14	Average Factor
Jan.	1.152	1.399	1.347	1.627	1.745	1.454
Feb.	1.181	1.306	1.338	1.533	1.612	1.394
Mar.	1.281	1.156	1.206	1.262	1.528	1.287
Apr.	1.199	1.041	1.162	1.213	1.213	1.166
May	0.909	0.998	1.037	0.880	0.857	0.936
June	0.785	0.924	0.863	0.940	0.965	0.895
July	0.800	0.789	0.796	0.778	0.864	0.805
Aug.	0.894	0.834	0.732	1.043	0.735	0.848
Sept.	1.051	0.908	0.958	1.038	0.830	0.957
Oct.	0.933	1.068	1.056	1.007	0.851	0.983
Nov.	1.104	1.108	1.131	1.100	1.250	1.139
Dec.	1.120	1.077	1.239	1.204	1.409	1.210

TABLE 3
COMPARISON OF PERMANENT STATION AND ROUTE SEASONAL FACTORS

Month	Permanent Stations			Route[a] 4
	17-A	24-A	Average	
Jan.	1.59	1.48	1.54	1.40
Feb.	1.35	1.37	1.36	1.32
Mar.	1.23	1.27	1.25	1.26
Apr.	0.98	1.12	1.05	1.11
May	0.94	1.00	0.97	1.01
June	0.81	0.89	0.85	0.90
July	0.72	0.90	0.81	0.83
Aug.	0.76	0.87	0.82	0.84
Sept.	1.02	0.93	0.98	0.91
Oct.	1.20	1.10	1.15	1.15
Nov.	1.20	1.14	1.17	1.23
Dec.	1.20	1.14	1.17	1.30

[a] Route 4 is an average of 18 control stations and includes the two permanent stations.

times a year. This schedule would require approximately half as many control stations as the schedule used in Oregon to obtain the same number of samples for each control group. It would not provide as wide a coverage of different sections of the highways; however, it would provide additional data desirable for grouping of the control stations.

Comparison of Figures 3 and 4 shows the preliminary regrouping of control routes and areas based on the data obtained during the first year of operation.

The control groups for the control areas indicated that for all practical purposes one control area for the state would provide factors within the desired range of accuracy. A comparison of the area factors is shown in Table 2. Although all control areas had simi-

lar patterns, the patterns for the individual control stations within an area had a large dispersion around the mean of the group. This large dispersion in the area groups was not surprising because of the low-volume roads included.

The urban influence groups were found to have the same characteristic as the control area group, that is, a large dispersion of the patterns for the control stations around the mean of the group. A check was made with the urban-influence stations to see if there was a material difference in the stations in the different geographical areas of the state. For this check the state was divided into three regions, the coastal area, the area east of the Cascade Range and the area located between these two. It was found that the variation of these individual control areas was, in all cases except a month for one control area, within 10 percent of the mean of the group. The exact meaning of this comparison is somewhat vague in that the number of samples for each month was less than the needed five.

Selection of Locations for Permanent Recorders

The development of the traffic-counting program in Oregon has indicated a need of permanent traffic-recording installations throughout the state. It is the intention of the state to have 50 installations on the rural highways. A review of the data obtained at the control stations which were also the location for the permanent installations had indicated that some control-route factors can be developed from the information obtained at the permanent installations. A review of the control stations for the control routes and the control areas will be used as a guide in selecting the location for future permanent installations. Control stations which match the pattern of their mean group will be considered as possible locations for the installation of permanent counting equipment. A comparison of the seasonal pattern of the permanent installations located on a control route with the seasonal pattern for that control route is shown in Table 3. This comparison indicates that for this particular control route, two permanent installations will provide seasonal factors within the desired degree of accuracy.

SOME STATISTICAL SIDELIGHTS

The rudiments of probability theory when translated into utilitarian usage in this case means that two thirds to three fourths of all counts can be expected to have errors of 10 percent or less. Practically all estimates will have errors of 20 percent or less. But there can be expected a few counts which will have large errors of more than 20 percent. The difficulty lies in the fact that by studying a single station there is no way of determining the size of the error in the count.

A large portion of problems which arose in the analysis of the first year data in Oregon can be attributed to this characteristic of distribution of error. Therefore, the identification of a fourth to a third of all coverage stations cannot be readily made. The majority of these larger errors can be identified and the errors reduced from an examination of a series of adjacent counts.

When grouping road sections into control routes, it will be recalled that many road sections were assigned to a control route in accordance with opinion rather than historical data. Some of these sections apparently were misplaced as to pattern characteristics. Also, the dispersion of errors added to the difficulty of reconciliation of some of the data.

In control-station operation a coefficient of variation of less than 5 percent can be expected. The distribution of larger errors as determined by this measure coupled with the allowed range of variation of 10 percent within each pattern indicates the probability of some of the values deviating more than 10 percent from the mean. However, careful study and a few readjustments have corrected most of the difficulties arising from these sources.