..echanized Procedure for Assignment of Traffic to a New Route

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These machine methods developed for assigning traffic to a proposed new highway route are believed to be initial and simple steps easily adaptable even by those with no business machine installation. If a simple business machine installation is already available the automatic calculating equipment which is required can be used on a loan, and as available, basis from agencies equipped with such machines or from business machine service bureaus at very nominal cost.

If conducted without the benefit of automatic machines, the assignment of traffic volumes to proposed new routes is an extremely time-consuming procedure. Each and every zone-to-zone travel movement intercepted during an Origin and Destination Traffic Survey must be studied individually. In the larger urban areas where the number of zones tends to be quite large, the analysis of the many traffic movements which would be affected by the construction of a new route becomes extremely cumbersome since the number of individual zone-to-zone movements increases as the square of the number of zones being dealt with.

All of the essential route analysis steps have been converted to a machine operation except for the initial stages of procedure which require a manual measurement of the distance of travel between the zones being studied both for the existing and the proposed routes of travel. The distance measurements are segregated according to the various average travel speed ranges which exist along the route of travel. This data is then punched into cards with the subsequent steps of converting distance to travel time being performed automatically. The machines also compute the travel-time ratio for each zone-to-zone movement by comparing the travel time which would exist if the proposed new facility were used in comparison to the existing city streets. The machine determines from the travel-time ratio the percentage of the total zone-to-zone movement which would use the new facility and multiplies the total volume by this percentage.

When the entire series of computations are completed for all traffic movements affected, a summary tabulation is machine prepared showing the total volume traveling between each ramp of access and each point of egress. The information which is punched on the cards permits tabulations to be made of the vehicle mile savings in travel distance and the vehicle minute savings in travel time which would be provided by the proposed new facility. This, together with estimated costs for each of the routes being studied, permits the computation of a benefit-cost ratio for each.

A further advantage of having the information on punch cards is the ease of expanding present day travel movements to predicted travel based upon predictions of zonal growth. This expansion can be performed by machine.

The conversion to machine methods of analysis has not only provided a saving in personnel time and analysis cost, but has at the same time yielded far more information than it was possible to obtain when the analyses were being performed manually. This additional information permits an evaluation of various proposed routings on a benefit-cost basis, as well as on an average travel speed improvement basis. These items of information should prove extremely valuable in indicating to responsible authorities, as well as the public in general, the value of providing improved highway facilities and also the factual basis upon which any particular choice of route has been made.

THE State of Washington's first major application of traffic assignment proce was performed in the analysis of the 1946 Seattle origin and destination traffic surv Totals of five separate routes were analyzed as freeways with definite interchange points assumed. In determining the number of trips to be assigned to the proposed routes a travel-time ratio system was used. Where assumed interchanges were quite close together no assignments were made to single route sections, as it was assumed motorists would probably not choose to travel through two interchanges in order to use a short section of new freeway.

At that time route analysis procedures and methods were not yet formalized but it was decided that a travel-time ratio method probably would prove the most accurate and reliable system of assignment. Individual zone-to-zone travel movements were studied, and distance measurements made between common points for travel via existing streets and the proposed new route. These were converted to travel times by applying the findings of trial speed runs on the existing streets and a simple ratio computed of travel-time via the freeway versus travel-time on the existing street system. The scale of traffic assignments which was used was based upon a study of all of the literature and research available at that time on the subject. Interestingly enough the scale is not too greatly different from typical travel-time ratio curves in use today. It can be seen that for simplicity the assignments were broken in even 10 percent ranges as it was not believed that any further refinement could be justified on the basis of the limited information available.

Such a method of analysis was used virtually unchanged for several years for the urban surveys subsequently analyzed by the State. The only modifications were quite slight and consisted primarily of lifting the percentage assignments in the central regions. At the same time assignments were discontinued at the lower end of the scale. This was a result of a study of completed route analyses which revealed that quite substantial distance losses would be incurred in utilizing proposed freeway routes when the travel-time ratios were greater than 1.05. This ratio meant the trip via the freeway would not only take longer in time but also be farther in distance. Trip assignments at the lower end of the scale were, therefore, no longer made as it was not believed that any significant number of motorists would choose a route of travel which would result in a loss in travel-time and distance. The only exception to this rule was applied when it was believed that signing might promote such usage. Completed analyses also showed that, in general, there were not a great number of motorists who would be involved in assignments to the proposed route if assignments were made when travel-time ratios were larger than 1.05.

In still later analyses assignments were not made if the travel-time ratio was larger than 1.00. This was done, in part, to possibly compensate for over-assignments occurring because of the use in the analysis of travel speeds found on existing streets before freeway construction. Because of the traffic relief which a freeway would provide, these assumed speeds on the existing system might be much too conservative. The remaining street system might, therefore, be more attractive than travel-time studies made at the time of the traffic survey would indicate. A factor of this sort is generally not evaluated in "after" studies since the new route is then in operation and travel-time comparisons are then made on the basis of the relieved existing street system. Assignments in the lower percentage ranges were also not made because of the possibility that the route could or would not be built to as high standards as that assumed in the analysis, and also because the time involved in traveling through interchanges is not fully accounted for in the analysis.

Free route analyses made in recent years have not been changed except in details of procedure, with the assignment scales remaining virtually unchanged. There has not been sufficient reason for abandoning the travel-time ratio method of trip assignments in favor of other assignment methods as most recent research studies have verified this method as probably being at least as good a measure as the best of the alternate methods. In our own state we have not been fortunate enough to be able to obtain motorist interviews in making "after" studies of new facilities. However, traffic count studies have been made on several new rural facilities and, in particular, on two urban freeway facilities. In the case of the Alaskan Way Viaduct and the connecting

Battery Street Subway in Seattle, which provide a downtown bypass, traffic counts indicated a very good agreement with the predicted volumes from the travel-time ratio analysis. In the case of the Vancouver Freeway, however, usage thus far has been somewhat below that predicted. This is believed to be primarily because of the high degree of relief the Freeway has provided the paralleling city streets. A contributing factor is that the facility has been in use for less than one year and usage does not seem to have stabilized. In contrast, traffic growth has been more rapid in Seattle and the reservoir of demand so great that the Viaduct's removal of over 40,000 vehicles per day from the parallel downtown streets has not substantially changed travel speeds on these streets from that found during the traffic survey in 1946.

As the number of route analyses being conducted by the State became greater, the need for improvement of methods became obvious. Not only was the need for personnel time savings becoming imperative but a greater flexibility of data was thought at least equally necessary. After initial route studies are completed and the quite nebulous proposals for freeways come closer to reality and design studies are made, the need for reanalyses inevitably comes up. A revision in interchange location, a slight shifting of route location, a revision in access provisions — each requires additional and cumbersome restudy. If conducted manually the assignment of traffic volumes to proposed new routes is extremely time-consuming. Necessary reanalyses are equally time-consuming. Since each and every zone-to-zone travel movement intercepted during an origin and destination traffic study must be studied individually, studies in the larger urban areas where the number of zones is quite large become quite unmanageable since the number of individual zone-to-zone traffic movements increases as the square of the number of zones being dealt with.

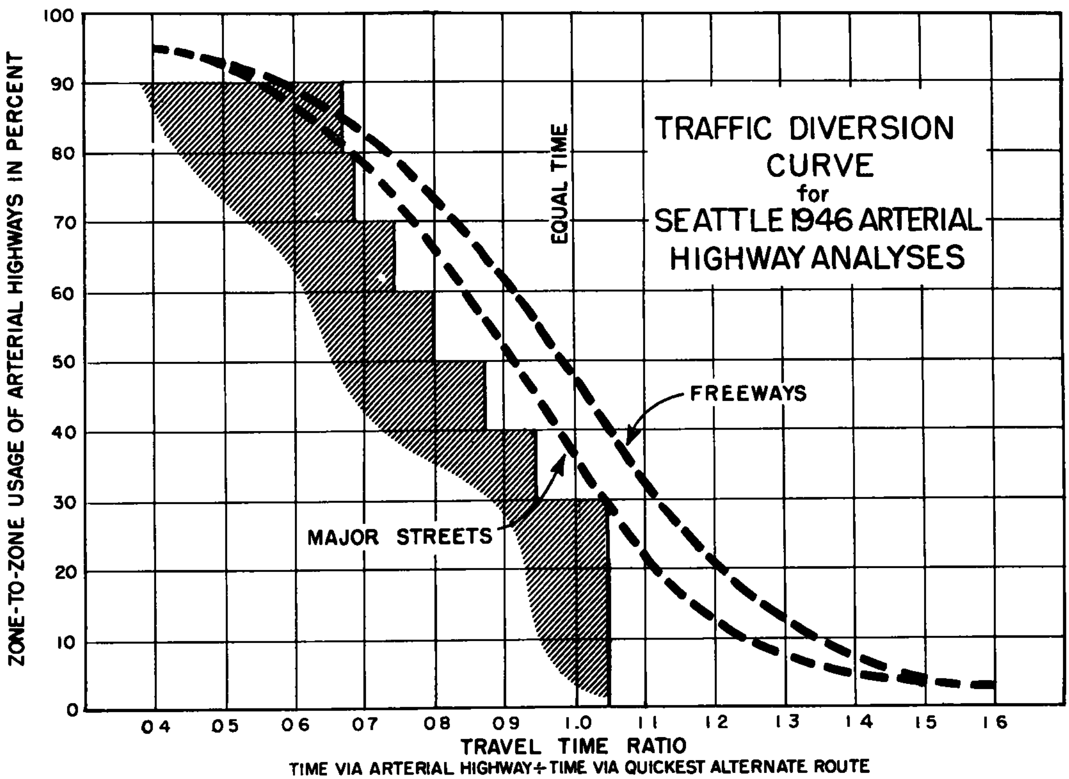

Figure 1.

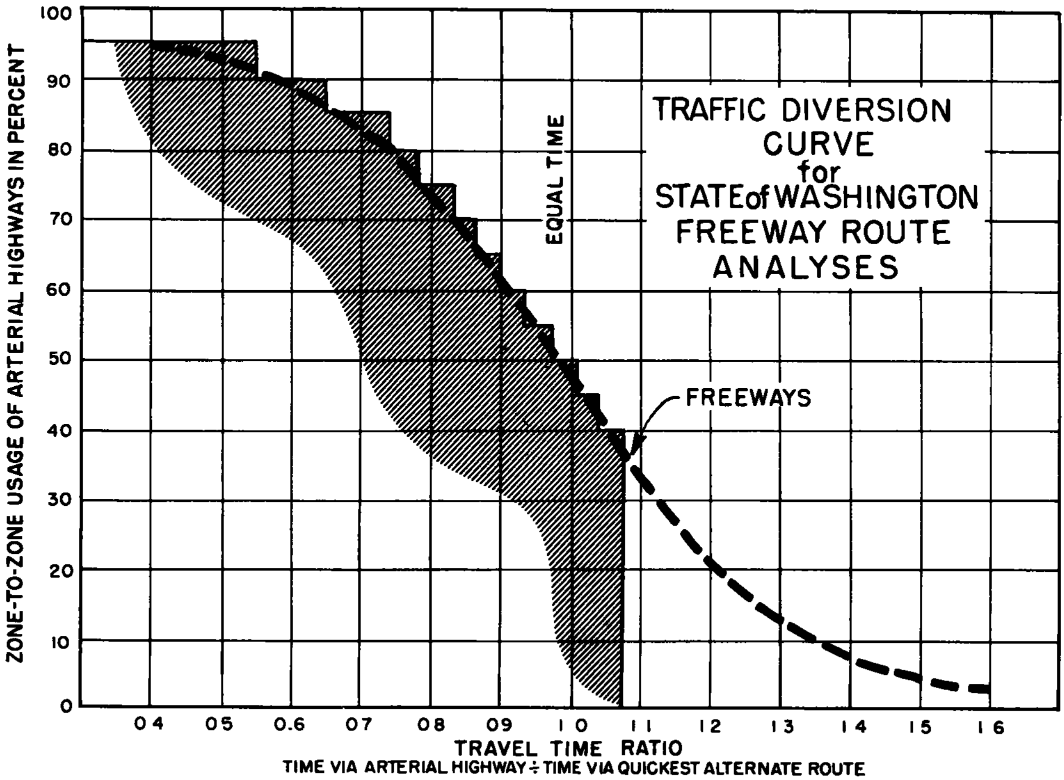

Figure 2.

Development of Machine Methods

Primarily because of personnel time considerations and the need for greater flexibility of data, business machine methods were developed by the State of Washington for assigning traffic to proposed freeways. The method is simple and easily adaptable by even those with access to a minimum business machine installation. Automatic business machine calculators can oftentimes be used on an "as available" basis from other agencies which have such equipment, or, at a very nominal cost, from business machine service bureaus. In any event, the necessary machine time is moderate and inexpensive.

All of the essential route analysis steps have been converted to machine operations except for the initial steps which still require a manual measurement of the distance of travel between the zones being studied both for the existing and the proposed routes of travel. No longer, however, is it necessary for the analyst to convert the individual distance measurements to time measurements in accordance with the particular travel speed found on each section of the route of travel. The analyst now merely lists the distance at each travel speed in the appropriate columns of prepared forms. He notes down the ramps of access and egress for the route of freeway travel. After this information is punched into cards, all subsequent operations are machine conducted.

The first machine operation is the conversion of the distance measurements into minutes of travel-time. The factors inserted into the machine to make this conversion are a function of the scale of the map used in the analysis of the travel distances and the speed of travel for each of the measured distances. The factors are, therefore, generally different for each series of route analyses as map scales are chosen to best suit the particular area being studied. The machine computes the travel times and then totals them for each individual zone-to-zone movement by summing up the time of travel at each travel speed. These travel-time totals are then machine compared and a travel-time ratio automatically computed—the travel-time via the proposed new route being divided by the travel-time via existing streets, the result being punched in the card.

Determination of Assignment Percentages

At this point the automatic calculating equipment available for use would have permitted determining the exact percentage assignment which a conventional time-ratio assignment curve would indicate appropriate. However, it was not considered that the time necessary to compute the appropriate equations to insert into the machine was warranted as the basic data is of insufficient accuracy to justify such exactitude in analysis methods. Assignments to the nearest 5 percent seems sufficiently exact and moreover, the machine operations are thereby simplified. The machine compares the computed travel-time ratio with the predetermined scale of assignments, punches the corresponding assignment percentage into the card, multiplies the total zone-to-zone movement volume by this percentage, and punches the answer in the card.

This results in the cards containing: (1) the total number of trips traveling between the individual pair of zones; (2) the distance each trip between these zones would travel at each of various operating speeds if the trip were made via the existing street system; (3) the corresponding distances if the trip were made via the proposed new route; (4) the ramps of access and egress to the proposed new route; (5) the travel times for each of the speeds for which travel distance was incurred in items 2 and 3 above; (6) the total travel-time and the total travel distance between origin and destination via existing routes and via the proposed route; (7) the travel-time ratio; (8) the percentage assignment for this travel-time ratio; (9) the assigned traffic volume.

The cards are then summarized, the result being a tabulation showing the proposed route's individual ramp to ramp volumes, from which the entire route's expected usage can be obtained. Formerly each of the outlined steps was done manually, and besides being extremely time consuming, unwieldy, and tedious, the procedure was subject to human error at each step.

Further Advantages of Machine Method

Any route modification can now easily be handled in reanalyses by simply machine extracting all of the ramp or route section movements which will be affected by the change. The necessary changes can be machine applied and a new summary tabulation prepared. This flexibility of data is believed to be a prime advantage of such a machine method of operation for any organization that will be developing a series of route studies which will eventually culminate in design and construction. Route refinements may take place right up to construction contract letting and intelligent decisions of the effect of such changes cannot be reached without traffic analyses. Oftentimes the initial analysis of a route proves to be the minor part of the overall continuing study culminating in the route's construction.

An added advantage of having the traffic analysis on punch cards is the ease with which predicted growth rates can be applied to zone-to-zone traffic movements to permit developing predicted future traffic flows. In some instances the growth factors can be applied to an entire ramp's volume. However, in most instances they are applied to the individual zone or to the separate zone-to-zone movements and the ramp volumes recalculated for the year desired. This is an extremely rapid calculation in comparison to manual expansion methods.

Frequently it has been necessary to make analyses to indicate the relative value of several alternate proposed routes through a particular area. Before machine methods of analysis were developed decisions on route choice could not be based upon any more than general considerations such as estimated costs, available funds, estimated overall traffic attraction, and possible time and distance advantages conferred upon certain large individual traffic movements.

Computing Benefit-Cost Ratio Values

It was readily apparent in developing the machine procedures that they would permit

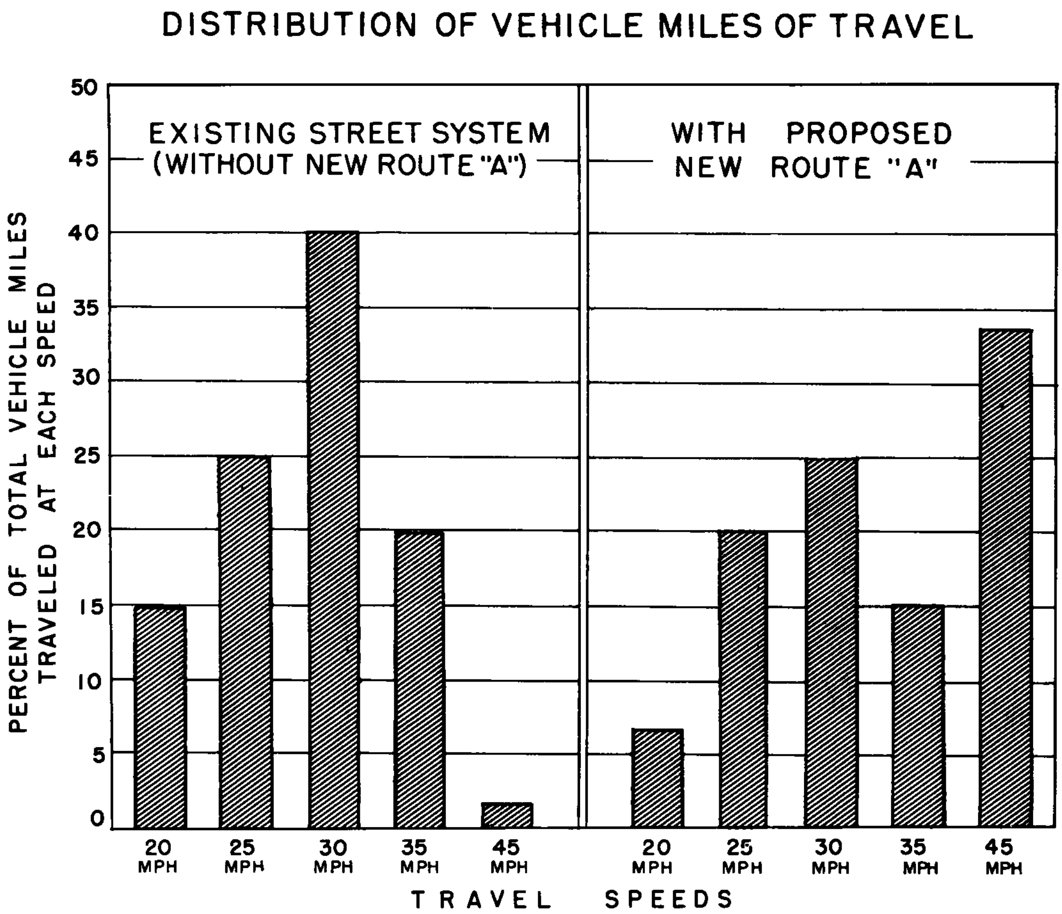

Figure 3.

machine computations to be made of vehicle miles and vehicle minutes for those zone-to-zone movements which the analysis indicates would use the proposed route. Such computations permit the determination of benefit-cost ratios for the various alternate new routes being considered. Although these computations are somewhat complicated in comparison to traffic volume assignment procedures they are nonetheless relatively easy to apply. In contrast, manual methods would tend to be entirely too extended to warrant making the study.

The total time saved by those motorists assigned to a proposed new route should be determined as this represents an actual money saving. This is done by computing the overall travel-time assuming it to be performed via the new route, then assuming it to be done on the existing street system, the difference being the time savings which would be gained from provision of the new route. A monetary value can be placed on the time savings by utilizing values found in the American Association of State Highway officials' publication entitled "Road User Benefit Analyses for Highway Improvements." [1]

Distance savings are more difficult to evaluate since the cost of operating a vehicle is not only dependent upon the type of vehicle and the distance which it is operated, but also the speed of operation and the type of operation, specified as so-called free,

[1] "Road User Benefit Analyses for Highway Improvements," Committee on Planning and Design Policies, American Association of State Highway Officials, Washington, D.C., 1952.

normal, or restricted, depending upon the degree of congestion experienced in the flow. Monetary values obtained from the AASHO publication on Benefit Analyses are applied to the vehicle miles of operation found to exist at each operating speed. The trips assigned to the proposed new route are assumed to be traveling the existing street system, and the cost of the vehicle miles of travel computed. This is repeated for the assumption that these trips travel via the proposed route. The difference in costs reveals the possible benefits bestowed on motorists in terms of operating costs. In actual usage it has been found that because of the higher operating speeds, the proposed freeway routes in urban areas will usually bring about higher overall motorist operating costs which are, however, far and away over-shadowed by the much greater value of time savings. The negative operating cost benefit due to increased operating speeds (as determined from the application of the AASHO publication values) is borne out by actual "in-the-field" measurements of improved routes in actual operation[2].

The net monetary saving to motorists from the time and distance computations is easily inserted into a benefit-cost calculation, the result being an easily understood and quite reliable comparative measure of the worth of alternate proposed new routes.

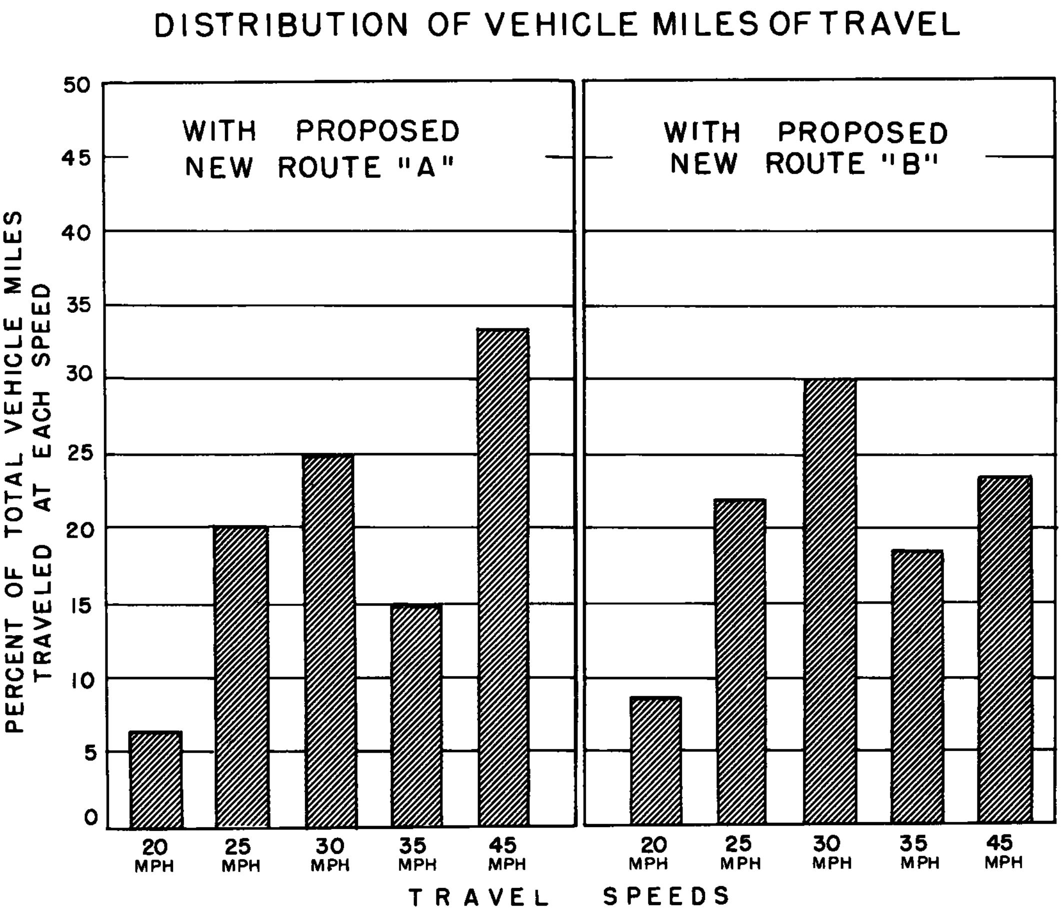

Figure 4.

Such benefit-cost ratio calculations are being relied upon more and more by responsible policy makers as a valuable tool in the making of decisions as to choice of route

[2] "Vehicle Operation as Affected by Traffic Control and Highway Type," Highway Research Board Bulletin 107, Washington D.C., 1955.

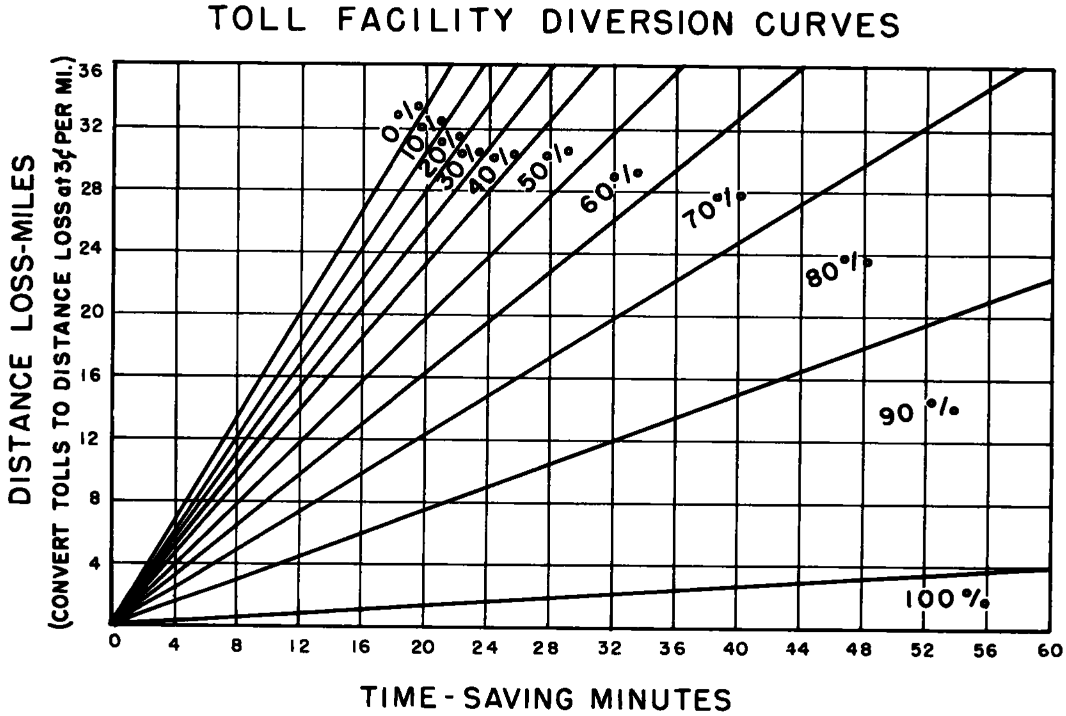

Figure 5.

to construct. This is especially true in urban areas where costs are high, and decisions are difficult to make because of the complexity of the problems involved and the difficulty of properly evaluating the many factors which must be considered. Of course, the benefit ratio is only a tool and not an absolute determinant. However, not only does it permit departmental decisions to be made on a more factual basis, but contacts with local agencies and groups are on a firmer footing when such factual information is available for use in discussing the alternate routes being considered.

Another easily understood pictorial representation of the value of various routes is a comparison of what any particular new facility will provide in the way of improved travel from an up-grading of the operating speed of the vehicle miles of travel performed in the area served by the route. The illustrations are typical of those which can be prepared to show not only the improvement which a new route will provide over existing facilities but also the relative degrees of improvement which various proposed alternates will provide.

Other Assignment Methods Used

The State has not used travel-time ratio assignment methods exclusively. In the analysis of proposed toll facilities it was found necessary to depart from a time ratio method of assingment in order to permit including the effect of tolls on the motorist's choice of route. One of the prime considerations in such analyses was to obtain an estimated traffic volume from analysis methods acceptable to bonding houses that might be called in on the necessary revenue bond issue.

A review of a number of reports on proposed toll facilities by nationally recognized consulting firms revealed that a so-called "cost per minute saved" method was widely used. In this method the cost of the trip via the toll facility is calculated in cents, including the toll charge as a cost and also the possible distance losses which are converted to cents at a rate of 3 cents per mile. The time savings in minutes are divided into the thus calculated trip cost, the result being the so-called "cost per minute saved" which determines the assignment percentage. For a fixed toll rate this can be more easily put in terms of time savings and distance losses, as shown on the accompanying graph. It must be emphasized that the values shown have been derived from a study of analysis methods reported by consultants on many large toll projects. Inasmuch as there has been no known published research study on the validity of such an assignment method, there may be some doubt attached to its use. The value placed on mileage and time also appears to be arbitrary, lacking factual data to the contrary. Moreover it is obvious that at the low end of the time and distance scales, the curves are difficult to apply. One other aspect of the method is that regardless of the length of trip a unit of time saving has an equal value. It is believed, however, that time savings should probably assume importance in an inverse relation to overall trip time rather than as a unit value. This appears to be borne out by the studies which show that travel time ratios are a superior method of assignment. However, the "cost per minute saved" assignment method not only appears to be generally accepted for toll facility revenue bond issue projects, but also is admirably suited to business machine operations.

In studying toll facilities traffic assingments have also been made by consulting firms by assigning a money value to a unit minute saving and a unit mileage saving and balancing this against the toll charge. The percentage assignment is then frequently taken as a straight line function of the net monetary saving. This system of assignment is also admirably suited to business machine calculating and summarizing. However, some of the same considerations seem to apply to this method as to the "cost per minute saved" method. In studying a proposed toll bridge facility in competition with ferry routes, time and distance savings or losses were found to be quite large. It seemed logical to assume that as the savings of time became greater that motorists would tend to attach an increasing value to time. A modification was, therefore, attempted by the

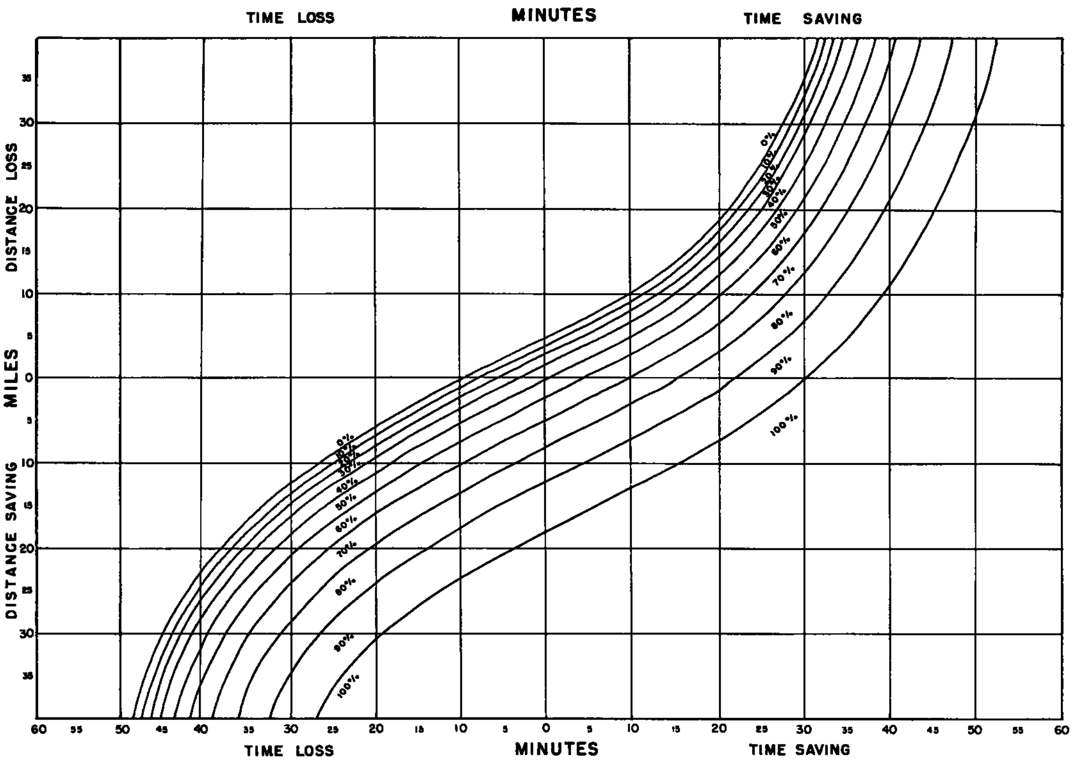

Figure 6.

State of Washington by increasing the value of time as time savings increased. This is shown on an accompanying graph. However, without factual studies such curves are known to be of doubtful validity. It would be desirable to restudy available data from actual surveys of new facilities to attempt to set up such curves and test their value in relation to the more generally accepted time-ratio assignment method.