

Traffic Assignment Analysis and Evaluation

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Traffic assignment by computer is one of the most useful tools presently available to the transportation planner. But like all tools, traffic assignment is only as good as the manpower behind it. To use it most advantageously requires understanding of the capabilities and limitations not only of the tool but also of the inputs and related assumptions that go hand in hand. Properly employed, the assignment is invaluable, and not just in producing volumes on networks.

Assignment analysis should be designed and carried out with the following purposes in mind: (a) establishing validity of assignment results; (b) systematically producing workable data for evaluation (including economic evaluations, further general planning, design volumes); (c) permitting evaluation of internal system performance (identifying good and weak points in system, spotlighting deficiencies, etc.); (d) permitting comparative evaluations with other outputs to aid in planning and design toward the "best" system; and (e) permitting evaluation and interpretation of results for use by highway designers. These points are discussed both in general and with particular reference to PATS procedures. Emphasis is also given to the application and interpretation of results within the study for its own benefit and also for the benefit of participating agencies.

•TRAFFIC assignment is a process of allocating trips to a system to ascertain probable loads on part or all of the system. Although this can be accomplished in many ways, in this paper assignment refers to the process as done by electronic computer. Even though there are a variety of computer assignment techniques and disagreements concerning the most suitable approach, there is general similarity in both the end products and the end uses. Further, this paper is not concerned with trip forecasting or trip distribution techniques, which also exist in some variety and which frequently are associated directly with the computer assignment of trips to a system.

What is discussed here are the applications of computer outputs, their values and limitations, and the consequent responsibilities which thereby appear to devolve on the agency making the assignments. These comments are centered principally on the experiences and procedures reported elsewhere (1, p. 159). However, they are probably applicable to other groups similarly engaged, despite the different trip distribution or assignment techniques that may be employed. It is hoped, therefore, that this paper will be mutually useful toward the exchange of information and ideas between those involved in making assignments and also useful toward increasing understanding of computer assignment among other users of the output data.

CONTRIBUTION OF TRAFFIC ASSIGNMENT

The principal benefits of traffic assignment (including, as needed, the preceding steps of trip forecast and distribution) are its speed and low cost as a means of assessing traffic volumes. This may be done in terms of one ramp, one route, or an entire metropolitan area. It permits the highway designer to test many alternate schemes for an interchange or route. It permits the planner to design transportation systems using something more substantial than intuition.

Assignment procedures can be and obviously are varied according to the specific need at hand. But a general characteristic of all assignment techniques is that they provide, as an output, volumes on all parts of the system being tested. Variations in techniques are designed principally to give additional related output data or to include differing degrees of complexity in loading trips onto the network. Assignment philosophy may accept "minimum path" loadings or diversion curves, may or may not employ capacity restraints. Whatever the case, output data could include "trees," could show the origins of trips on selected links, could include travel costs, etc. However, these matters are generally subsidiary to the desired end of network loadings. These network loadings are needed by two types of users: the transportation system planner and the route designer (either highway or transit). The nature of application by the two types of users differs, and this is perhaps why problems sometimes arise. Although traffic assignment by computer developed as a tool for both the system planner and the designer, it has characteristics that are more appropriate at the planning level than at the design level.

TRAFFIC ASSIGNMENT AND THE TRANSPORTATION SYSTEM PLANNER

Assignment Values

The value of traffic assignment to the transportation planner is sometimes misconstrued. It does not take the place of planning; it merely enables the planner to determine the salient good and bad characteristics of various preconceived plans. The planner is concerned with providing a total transportation system that maximizes benefits and minimizes costs, according to whatever criteria might have been established. The traffic assignment technique that will be most useful, therefore, is that which will permit the planner to determine how well his goals have been achieved by a given plan, to determine the plan's shortcomings, and to provide information that may guide him toward a better plan. But even then, this is just one part of the planning process. The performance of a plan as it can be measured by assignment does not necessarily reflect its performance in meeting other criteria based on design standards or, more importantly, on other community objectives, such as the preservation of residential neighborhoods, the economic health of a business district, or encouragement of industrial or recreational development. The merits and limitations of a transportation plan reach beyond the aspects that are measurable through traffic assignment. These considerations, however, do not detract from the value of assignments as a tool in the development of a sound plan.

Useful Outputs from Traffic Assignment

The basic output from assignment is a listing of all the segments or "links" in a network with the traffic volumes that have been assigned individually to them. Such an output, which can be arrived at through a variety of techniques, is almost always supplemented with additional data. These might pertain to summaries useful as validity checks on the "run," to network usage from selected zones, to the source and/or destination of trips using certain selected links, or to other special subroutines of assignments, such as travel cost data or overflows from expressways to arterials.

A typical output from the assignment program in use at the Pittsburgh Area Transportation Study (PATS) contains the following data: on-line printouts from computer storage, principally various summary data; printouts obtained from off-line tapes of link loads and selected characteristics of zonal interchanges; and two separate decks of punch cards, totaling about 3,500 cards, containing data by zone and by link. This total volume of output, requiring little more than brief-case space, is sufficient to generate up to 50 man-days of work in analysis and presentation procedures (2).

The test of one network generally will involve the following work: a "free" assignment, more or less a trip desire line map fitted to the network regardless of link capacity; a "restrained" assignment, which forces a pattern of loading reflecting the capacity limitations of links in the network; one or more "trees," which indicate the paths followed to all other zones by trips from selected origins; and a conversion of the as-

signed travel characteristics of each link to the costs of travel. Of course, the design of the outputs is influenced primarily by the type of analysis to follow and, secondarily, by the desire to facilitate processing on EAM equipment.

Analysis Procedures

For discussion purposes, analysis procedures may be put into three categories: validity checks, manual and graphic procedures, and machine analysis of punch card outputs. The first need is to confirm the validity of the computer outputs. If some input or operating error, not apparent during the assignment run itself, caused an error in the results, then it needs to be found before other analysis proceeds. The reasonableness of results is initially established largely from over-all summaries. These can be judged against summaries of vehicle-miles and vehicle-hours of travel, travel costs, screenline and corridor crossings, and various other measures from previous comparable assignments. Because the PATS trip distribution and assignment are coupled together, a plot of the trips distributed to and from each zone is a performance check generally made of the distribution technique. Accounting machine checks are made at the same time, to verify card totals against printout totals and to insure that no omissions or errors have occurred in the tape-to-card conversion. This series of initial checks can be completed within a day after the computer work is accomplished.

Following these operations, the task of posting link volumes is begun. The arterial network and freeway system are depicted on a series of maps covering the 420-sq mi study area at a scale of 1 in. to 2,000 ft. These maps are assembled from the culture plates of standard USGS quadrangles on which have been drafted the basic network with complete numbering of nodes and interchanges (3). Volumes assigned to each link are posted on a reproducible set of the maps so that they can be distributed later as needed. Thus, complete detail of the network loading is available. Figure 1 is a section of a typical assignment map, showing the degree to which the network is coded. The arterial network comprises the major streets, in this case at fairly close spacing because of the travel density in the part of Pittsburgh illustrated. Nodes prefixed on this map with double zeros are where trips are loaded on the network from the surrounding origin zone. On the right is shown typical coding of a freeway interchange, where individual ramps are coded in detail.

The manual posting of volumes is clearly a time-consuming and tedious task. With over 1,500 arterial links and almost the same number of freeway and ramp links when a freeway system is superimposed, over ten man-days often are required to complete the entire posting for one network test. The use of data plotters and node numbering

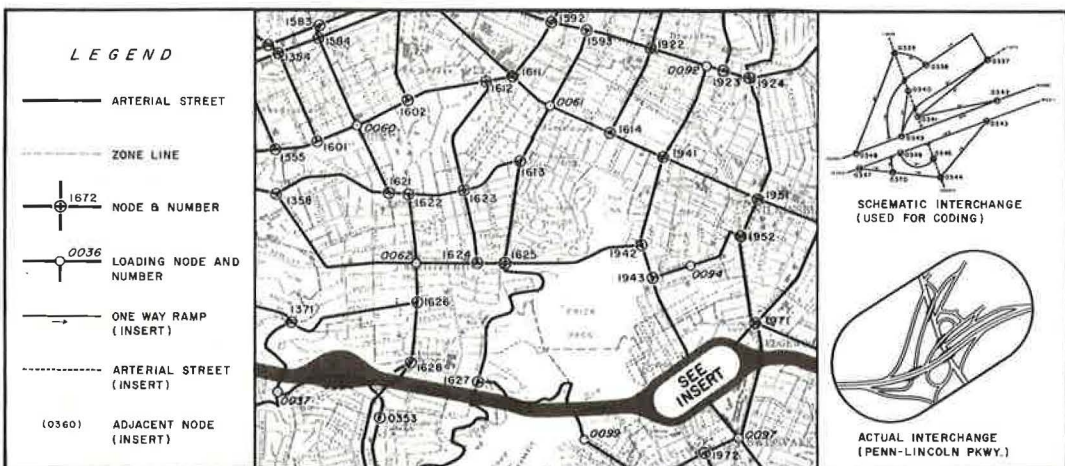


Figure 1. Typical network coding on base map (source: 1).

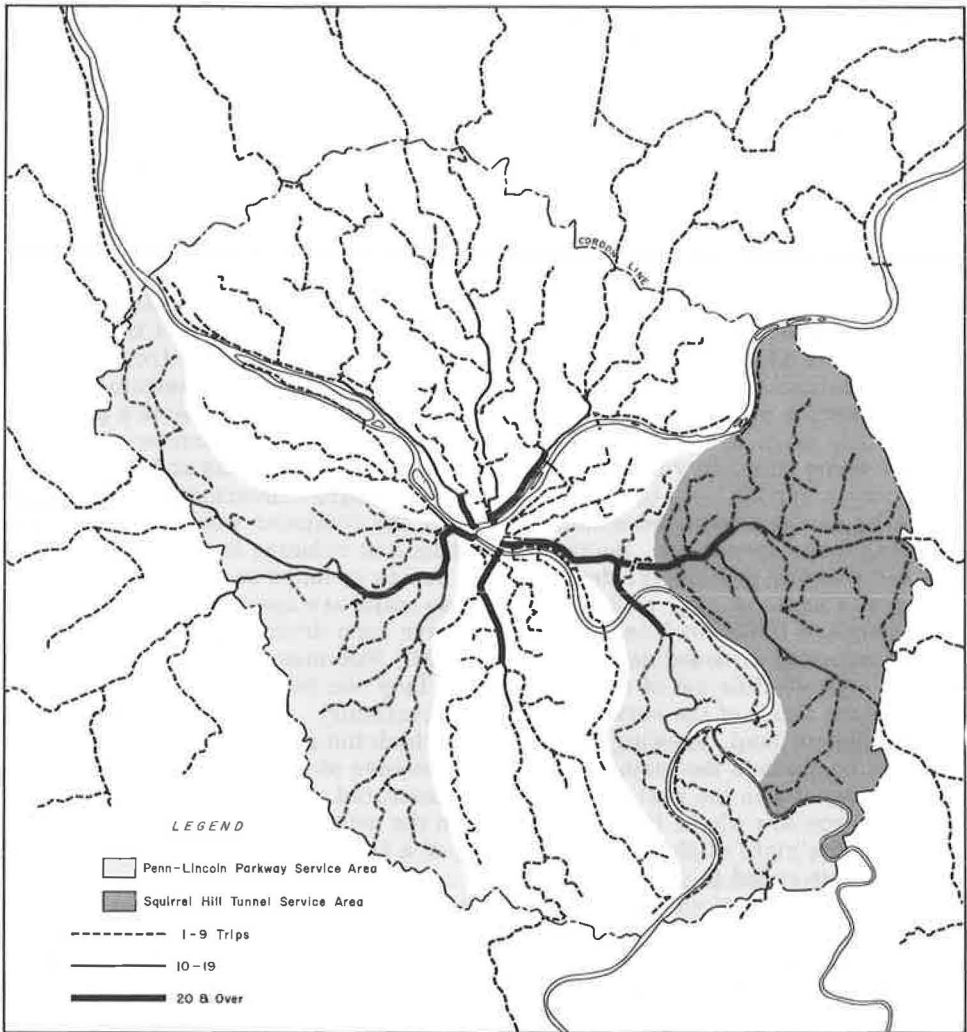


Figure 2. Minimum path tree for Golden Triangle to all other zones (1958 network).

based on a coordinate system is being developed by some studies to accelerate the process. But even so, manual work will still probably be necessary to show desirable detail at the scale of interchange layouts.

The value of the maps arises primarily from the fact that a permanent, detailed record of each assignment is available, not only for analysis of small areas or for taking off information used to make other study area evaluations, but also for comparisons with assignments made earlier or that may follow subsequently.

The maps themselves are used in a variety of ways for further analysis. For example, screenline checks can be summarized readily or examined by area. Volumes on links crossing the outer cordon line in different sectors of the study area can be taken off readily. The raw information is available to construct traffic flow maps for the benefit of technical or advisory committees or for public presentation. In such cases, volumes may be shown for the freeway system only or on both arterials and freeways by color coding and band widths. Such maps can be prepared best from the detailed assignment maps.

The volumes posted for planning purposes are generally those from both "free" and

"restrained" assignments. Free assignments, as used in Pittsburgh, assign all trips via the minimum time-paths between zones based on freely moving travel speeds. Some links develop loads far beyond their capacity, and others develop no loads at all. Such results are of particular value in planning because they show whether the preconceived network tends to satisfy the travel desires of present or future users. Analysis of free network volumes after posting presents a good opportunity to evaluate a network, because both underloaded or overloaded routes indicate network deficiencies that should be corrected.

Equally valuable is the restrained assignment. In this type of assignment zonal transfers still follow minimum paths, but path times are increased as the ratio of assigned volume to link capacity increases in the assignment of trips. Original minimum paths increase in time until another path may become faster, the net effect being more evenly distributed travel and more realistic simulation of traffic flows. What may have appeared as a highly loaded route in a free assignment may appear as a group of less heavily loaded routes. The restrained assignment, which recognizes the realistic capacity limitations of network segments, will show where freeways are relieving arterial capacity problems as well as those areas where congestion may be expected as a result of inadequate design. Because both types of assignments are useful in system planning, all network tests at PATS include an assignment with each technique.

Another graphic version of output analysis can be obtained from "trees." Here the paths followed by trips from selected origins to all destination zones are plotted. The principal objectives in tree plotting are either to check the reasonableness of network coding or to demonstrate the part played by a freeway system in serving the origin zone. Posting minimum path trees tends to point up travel time deficiencies in network coding which might otherwise pass unnoticed. Devious routes that appear as minimum paths, or heavily loaded paths, may suggest either error in or unreasonable establishment of link travel times.

However, of greater interest is the use of trees in depicting the role of a system. For example, Figure 2 shows a somewhat abstracted version of a tree. In this case, an east-west freeway serving the Golden Triangle (GT) clearly carries the burden of GT trips. Shaded in is the "watershed" of this one freeway as a distributor of GT trips. By itself, the illustration is not overly significant; added to other assignment results, however, it provides further insight into system performance.

An illustration of zone-to-zone movements using a selected link, or of the origin zones contributing trips to a link of special interest, is another useful form of presentation for analysis purposes. But of more value than graphics is the machine-accounting evaluation of assignment results.

The link output cards are the source of most tabulations prepared from assignment data. They are summarized and processed to produce results at several levels of interest. Analyses by ring and sector (the largest units of the study area), by district, by zone, and by link, all play a part in the total evaluation of assignment results. Starting with the link card data, more than thirty tabulations are often developed by the PATS machine room.

Study area values are selected first. These are part of the early checks and summaries of network performance. Of particular value here are the travel costs incurred on the network—a function of speeds on each link after the capacity restraint is applied (4). Although over-all volume-capacity relationships also are compiled, the principal value is in summarizing travel costs for later use in benefit-cost analysis.

Investigation into performance by ring, sector, and district follows similar lines. There are 54 internal districts in the PATS study area, and in these it is possible to compare the amounts of travel on arterials and freeways with the total capacity provided by each type of route. Travel costs can be studied to assess where the system is performing efficiently or inefficiently. For more detailed inspection, the 226 zones can be used as the base point.

An example of evaluations at the zone level is shown in Figure 3, which illustrates the degree of service provided by freeways. One of the assignment outputs on punch cards can be used to determine the percent of total trips from each zone that used freeways. Grouping of zones into three levels of freeway trip percentages (0 to 19, 20 to

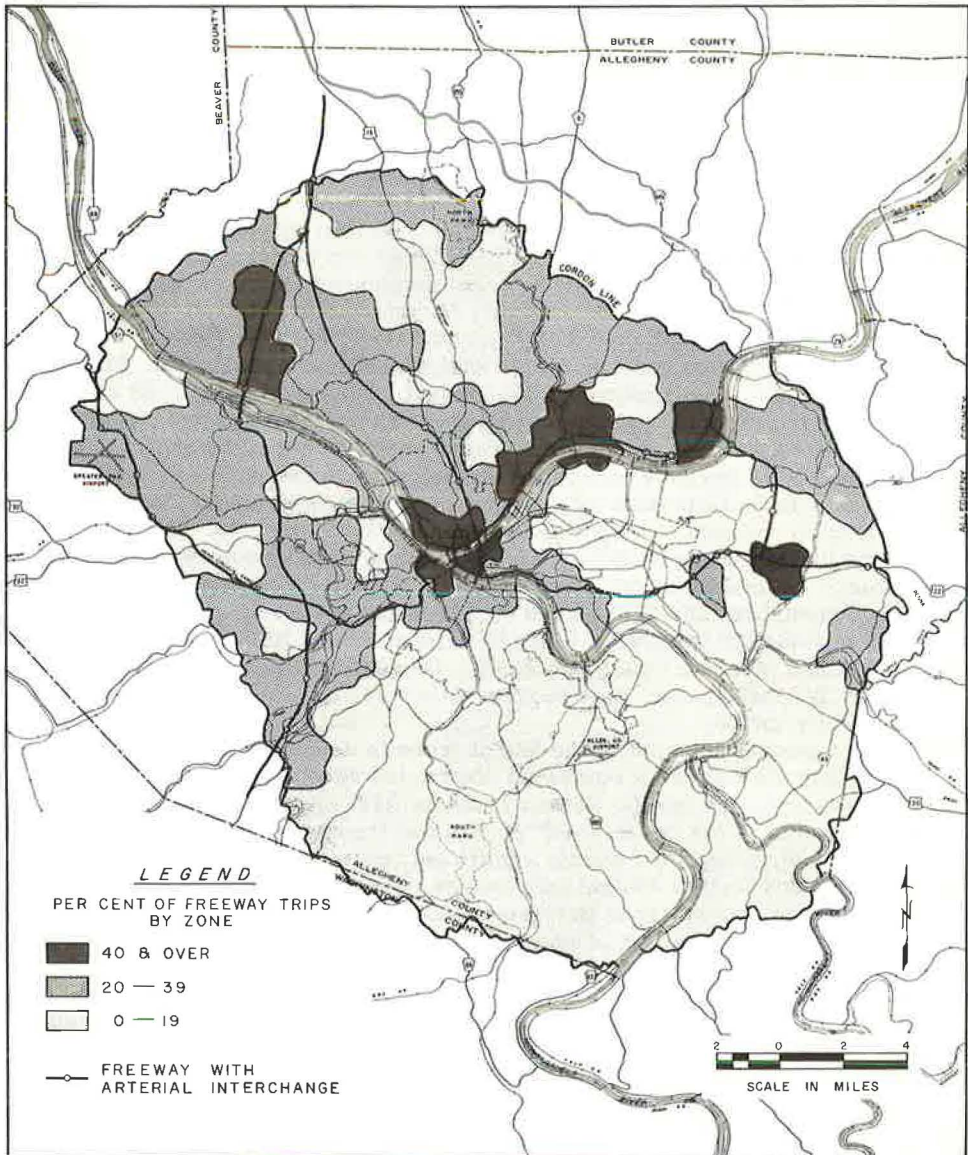


Figure 3. Map showing degree of freeway service (source: 2).

39, and 40 percent and over) provides a dramatic illustration, in this case, of service inequalities. One would not expect, for example, that a suburban area would make as extensive use of freeways as would a downtown commercial district. The illustration points out the obvious but provides a measure of the inequities, suggesting the degree of necessary additional facilities in various area. To a lesser extent, the effectiveness of proposed interchange spacing can be evaluated. A similar graphic summary, also compiled from punch card data, can show the relationship of travel to network capacity by zone. Some areas, because of low trip densities or relatively high amounts of freeway mileage may show unused capacity. Others may show a major deficiency in street capacity. Here, again, the map points out the obvious but, at the same time, shows both the degrees of deficiency and the generalized locations. This type of information, coupled with the data on assignment maps, forms a measure of what may be needed to

bring the transportation system to an adequate level of service.

Lastly, the punch card output data can be aggregated by individual links to assess performance. Average speeds can be computed; the amounts and costs of travel on different classes of arterials can be assessed, and the underloaded and overloaded proportions of the network can be derived. Figure 4 shows a cumulative curve plot of arterial street mileage against volume-capacity ratios resulting from three different assignments. A ratio of 1.0 represents a balance between assigned volume and link capacity. Obviously, extremes of underloading or overloading are equally inefficient even if underloading represents a high quality of service. The three curves represent conditions on arterials in 1958, conditions in 1980 without highway improvements, and conditions in 1980 with PATS recommended plan. In all cases, there are a few links with volumes more than double their capacity. This result is a reflection of computer mechanics, particularly on links connecting with loading nodes, and is an example of one of the difficulties that can arise from evaluating assignment data at the individual link level. The indicated overloads do not disturb the system planner who is aware of their cause—the necessity of loading trips at a zone centroid rather than distributing them over local streets to and from their actual terminals.

The situation just described points out the paradox in the use of traffic assignments for transportation planning. The assignment produces a wealth of details, some of which could be termed minutiae; for example, the cost of vehicle operations on a link $\frac{1}{10}$ mi long in the business district. But the planner cannot and must not accept this degree of detail. Instead, after measuring performance with an apparently fine degree of precision, he must apply his evaluations much more broadly in solving a metropolitan area transportation problem. If the assignment shows a need for improvement in a specific area, the planner must then apply judgment as to whether such improvement should be provided by tightening freeway spacing, by providing more freeway capacity on existing routes, by adding another freeway, by improving arterial access to freeways, or simply by adding arterial capacity. Individually balancing capacity and volumes on overloaded links is probably the least likely solution even though it might appear appropriate from examination of assignment link loads.

The objective behind the analysis of minutiae is to sift out the travel-related advantages and disadvantages of a transportation system for a given level of travel movement. The planner may want to develop a shift of through traffic away from the downtown area and may test various proposals accordingly. He may find that too extensive a freeway system is producing too small a return in travel cost reduction and is leaving existing arterial capacity unused. He may find an imbalance in freeway loadings because freeway spacing does not fit the underlying trip desires. The assignment provides this type of information, enabling the planner to improve his designs and to work toward the solution that best satisfies his planning criteria.

What can be accomplished by assignment is naturally dependent on the computer programs and the design of the output data. The more supporting detail the assignment can offer, the more soundly and quickly can a plan be achieved and the less intuitive and subjective will be its development and evaluation. The traffic assignment, because of its low cost and speed, makes possible the testing of many alternate schemes and

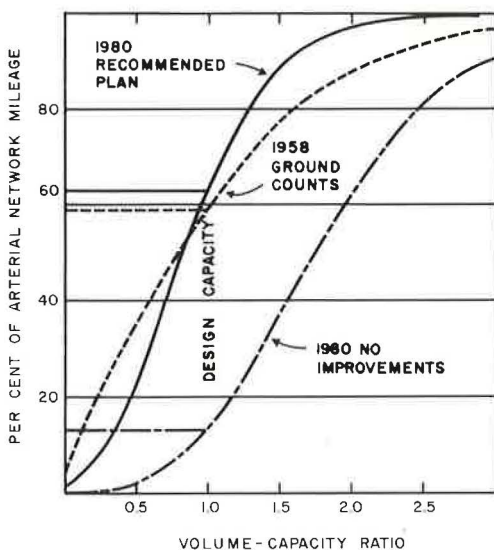


Figure 4. Cumulative percentage curve of arterial network by volume-capacity ratio (source: 1).

provides results in a degree of detail that permits sound evaluations. It does not provide all the answers, even on just the traffic-related criteria of system planning; it does provide direction, however, to the planning effort. It is when assignments as used by the planner are modified or adapted to the more specific ends of the highway designer that the technique calls for even more discretion in its application.

TRAFFIC ASSIGNMENT FOR THE HIGHWAY DESIGNER

Assignment Values

The principal utility of traffic assignment to the highway designer appears to be in obtaining design traffic estimates on the facility with which he is immediately concerned. Traffic assignment tests the facility as a part of a system, and thus represents a tremendous technical gain over past procedures for estimating traffic on a single route. The assignment works with trip inputs for a whole area and a network of highways to provide, in effect, a working model of the route under consideration. A given route can be tested at various stages: for example, as partly built under stage construction or as a complete facility at different periods when it may be subject to the influence of other proposed projects. Traffic volumes for each situation can be predicted.

Assignment can produce traffic volumes with design variations for the individual route. Alternate alignments may be tested, or interchanges relocated or dropped, to determine the shifts in traffic flow on both the route and adjacent facilities; or the assignment can produce, in a difficult weaving area, for example, data on the origins, destinations, and volumes of weaving movements.

The outputs of greatest value to the designer are, therefore, the individual link loads, whether these give truck percentages and design-hour volume directly or require further manipulation. Though the designer does not need to know all about assignments or the values of different outputs to the system planner, he does need to know the qualifications that should be applied to the posted numbers appearing on an assignment map. These qualifications, which arise in part out of the design of assignments for planning purposes, must be made clear.

Some Dangers in Using Assignments for Design

Assignment outputs developed for use in system planning cannot be applied to design problems without discrimination. Assignment techniques and network design developed principally for regional transportation studies are concerned with planning on an area-wide scale. The degree of detail in network design, trip interchange, and trip assignment is thereby conditioned. The sensitivity of the computer technique employed in PATS and other transportation studies is more than sufficient for area planning but, perhaps, is insufficient for the degree of detail desired by a designer.

The matter of scale in network design and in its representation to the computer is the source of some difficulties. In PATS' case, link lengths are coded to tenths of a mile; travel speeds are represented in 5-mph increments; and capacity in a series of increments is calculated from standardized intersections. Such characteristics are not refined sufficiently to use in determining individual intersection performance.

Added to this are the gross techniques (from a designer's viewpoint) of loading trips from an area of major trip generation at one intersection within the area. Many thousands of trips to and from a zone, consequently, may appear on just one link within the zone or on a series of links leading to a ramp being studied. A prime example of this occurred in Pittsburgh when one ramp developed volumes exceeding 20,000 vehicles per day, whereas the adjacent ramp showed almost no traffic. This was a result of loading node placement. Obviously, trips, in reality, are generated on a plane surface rather than at a point; and ramp volumes should be distributed accordingly. But the scale of network design and the mechanics of assignment for system planning really do not need to reflect this degree of detail when the concern is to develop a transportation system for an area of several hundred square miles.

What is less evident, and perhaps of greater concern to the system planner when his assignment results are used for design, are qualifications that need to be applied

because of programming or other techniques. Here, again, the techniques—even though providing detail—are designed for broader analysis than that of the designer. Everything leading up to the individual link load in the computer output is designed for regional rather than local use. This is true of forecasts, mode splits, trip inputs, network design, trip distribution techniques, and the assignment itself. Developers of trip distribution models and assignment programs are far from agreement on what constitutes the best approach to traffic forecasting. It is not unreasonable, as a result, that the transportation planner should shrink from standing pat on an assigned volume of 4,256 vehicles on ramp X of a downtown interchange.

The significance of predicting turns or delays at arterial intersections in 1980 is even more questionable. For example, in PATS' assignments, the intrazonal trips do not even appear on the network, and all trips between adjacent zones cross the common boundary on one link only. In either case, this is not a simulation of movement in reality. How then can turning movements be predicted for design purposes? This gets to the fundamental questions of how much accuracy of detail is needed and how it is to be achieved.

It would be unseemly for transportation planners to suggest the level of detail needed by the designers. But, as pointed out in a recent report (5, pp. 45-56) the reporting of design-hour volumes as a neatly packaged, arithmetically balanced presentation on design drawings seems neither necessary nor appropriate. Design-hours on the ramps and roadways of a freeway do not necessarily occur in the same hour of an evening or morning peak. In some cases, they may not coincide with any of the traditional peak periods. Perhaps the designer should work more within ranges of volume than with specific values. In PATS' experience, at least, it appears that designers expect too much detail and that planners (as assignment makers) obligingly provide it.

Assignments can, and some do, provide peak-hour turning movements at arterial intersections, and perhaps it is best that they do so. Despite the limitations that exist within any assignment technique, traffic assignment does provide the most sound basis on which to establish design-hour volumes. However, computer-produced numbers in such detail are almost certainly spurious if taken literally, even though they may appear realistic. Computer outputs, thus, are of most value in design when used comparatively, with judgment based on knowledge of the forecasting and other limitations inherent in the processes.

In effect, the designer should examine closely the details available and then form his conclusions from a broader perspective in the same sense as the system planner must. To insure this approach, there is a need for interpretive judgment somewhere between the computer laboratory and the drafting room. The agency generating assignments would appear most responsible for providing such advice.

Responsibilities for Assignment Interpretation

Without the intermediate step of interpretation, there are too many opportunities for misunderstanding, misguidance, or misuse of assignment data by the many agencies that need this type of information. The problem may not arise when the assignment and its application to design is performed within, and is wholly restricted to, one organization. But in most cases, the assignment makers and the design users are organizationally removed from one another. At PATS, it has become clear that transmittal of assignment data to other agencies must incorporate some means of conveying judgments related to application of the data. Several procedures could be followed.

First, the assignment-making agency can transmit data to designers with accompanying explanations and qualifications on how the data can be used. However, such a procedure generates much report writing and places the burden of translating numbers plus qualifications into design-hour volumes on the designer—who is not likely to be interested in this additional work. In addition, the assignment maker should feel responsible to follow up and ascertain whether the data have been properly interpreted.

A second possibility would be for the assignment makers to provide analysis and interpretation for all data requests. Considering the variety of these requests and their sources, this could be a really burdensome task. It is possibly the best solution in

terms of getting the most meaningful interpretation of assignment results, but the time and manpower involved would add considerably to budgets. A drawback might be that the assignment agency may not be properly qualified to assess other important aspects of the requesting agency's problem, such as the influence of right-of-way costs in one design location versus another, or the planner's need for balancing street capacity requirements against requirements for public open space or other activities.

A third possibility is for the agency making assignments to designate a staff member to work closely with the requesting agency as long as assignment data are being used. Such a procedure certainly would be effective in providing good guidance and understanding on both sides. But this takes a lot of staff time, and qualified staff is generally in short supply, at least on most transportation studies. In a similar but reversed manner, the requesting agency could assign a designer to work with the assignment makers. All requests for traffic estimates for design purposes could be channeled through this individual, who would be able to assess the designer's needs and provide information accordingly.

A fourth alternative, which is being practiced in the Pittsburgh area with some success, is to bring in an intermediary person who is familiar with the problems of both the assignment makers and the designers. Using PATS' assignment data as the starting point, a local traffic consultant is providing the Pennsylvania Department of Highways with traffic estimates for design purposes. Introducing a third party obviously means added direct cost, but it also means that both PATS and design personnel are enabled to concentrate on their individually specialized tasks. The consultant, through experience with assignment techniques, is familiar with the capabilities and limitations of assignment data. He has a knowledge of local conditions and problems which are beyond the scope of a regional study and is familiar, also, with the geometric and structural considerations of design. A principal benefit is minimization of the duplicated work that might occur if the study staff had to explore local conditions which were already known elsewhere. Furthermore, because a local highway engineer was quoted as "viewing PATS with a mixture of awe and suspicion," it appears to be beneficial for the Department of Highways to obtain an outside view on the meaning of assignments. The consultant, of course, eventually may find himself viewed dubiously from both directions.

Regardless of the procedure followed (and each of the preceding is practiced at PATS according to the nature of the data request), all require initiative on the part of the agency making assignments. This group must provide information on the significance of output data, because it is generally the only group qualified to do so. The assignment makers should feel, also, a responsibility to follow through and ascertain that assignment outputs have been used properly. This is partly for their own self-protection but more importantly to prevent what, otherwise, might be costly mistakes. In addition to the Department of Highways and its consultants, organizations that have made use of PATS' assignment results include the City of Pittsburgh's City Planning Department, Traffic Engineering Bureau, and Urban Renewal Authority; the Allegheny County Redevelopment Authority; Pittsburgh Regional Planning Association; and consultants with clients ranging from the Federal government to local department stores. Most, if not all, of these users wish to make local or detailed application of assignment information. All need to be advised of the limitations on assigned link-load values for such purposes.

The use of assignment results in design applications must be regarded, by transportation planners at least, as a secondary benefit to be obtained from what is primarily a tool for regional planning. Assignments can be devised to specify turning movements at individual intersections, but it must be remembered that the accuracy of such predictions is as much a function of forecasting and trip distribution techniques as it is of assignment technology. Because assignment results are sought out for design or other local applications, the assignment makers have a clear responsibility to assure proper evaluation and avoid misuse on the part of other organizations.

SUMMARY

The end uses of traffic assignment are, of course, directly related to the characteristics of computer programs. But regardless of the diversity that exists in the techniques, all assignment outputs have basic similarity in their production of individual link volumes after distributing trips over a network of highway or transit routes. This discussion has not been concerned with areas in which improvement in technique would be desirable, only with the uses that can be made of assignment output data, based on the experience of one transportation study.

It is felt that traffic assignment is most beneficial as a planning tool in the development of area-wide systems. Its employment and value in design (for example, in developing design volumes on interchange ramps) is a collateral benefit. Traffic assignments are undoubtedly the best means available today of reaching design-hour traffic estimates, but computer outputs cannot be applied without qualification and considerable study. Possibly, assignments for design should provide the maximum level of detail attainable, so that the designer can examine the details but ignore them as such, extracting the broader conclusions only in the same sense as the system planner must. The danger lies in the assumption of accuracy merely because results are detailed. Because the computer does produce detailed results quickly and cheaply, its virtues lie in permitting more testing of alternates, more freedom of choice, and the bringing to bear of more complex relationships, all of which require judgment in evaluation and in making subsequent decisions. These aspects, of course, represent the principal benefit of traffic assignment for design purposes. The agency making assignments for system planning purposes thus has a dual responsibility. First, in using assignments to derive a plan, the agency must apply the judgments needed for its own purposes and then must weigh the traffic advantages with the other criteria essential to system planning. Second, the assignment makers must be certain that the proper judgments are made by the many other agencies which expect to, and can, benefit from traffic assignment techniques.

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