The Continuing Traffic Study: Methods of Keeping O-D Data Up-to-Date

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● IT IS NOW widely recognized that a home-interview O-D study is the only available objective basis for planning an urban transportation system. Consequently, scores of cities have undertaken such studies, a fact which is noteworthy because it symbolizes a widespread desire to base social action on something more substantial than guesswork. But the studies may easily become as misleading as guesswork if they are not constantly re-evaluated to measure the effects of ever-accelerating social and technological change. The solution is a continuing study of traffic.

It is as a representative continuing effort that the Detroit Area Traffic Study (D.A.T.S.) is discussed. The Study, now an integral part of Wayne State University, is sponsored by the Michigan State Highway Department, the City of Detroit, the Wayne County Road Commission, and the U.S. Department of Commerce, Bureau of Public Roads, as a follow-up to the Detroit Area Origin and Destination Study of 1953.

The follow-up includes the two basic types of research which are usually termed "applied" and "pure." The emphasis of applied traffic research is on supplying current data on such matters as desire-line magnitudes and inter-zonal trip volumes needed by traffic engineers for guidance in making decisions about practical problems. Pure research, as conducted by the D.A.T.S., consists of a never-ending attempt to find new sources of data and new analysis techniques. Such basic research, properly done, should serve to prevent the compounding of errors that may be in an original set of data, and should reduce prediction errors by revealing the "why" of travel behavior as a supplement to the "what" disclosed by conventional O-D studies. Pure research can, of course, be done most efficiently in a university setting, as at Wayne State University, where sociologists, economists, planners, and mathematicians, can be brought together to work in cooperation with traffic engineers.

In the day-to-day operation of the D.A.T.S., the pure and applied research approaches to a continuing study of traffic are necessarily and most profitably intertwined. Getting the answer to a traffic engineer's specific question has made the opportunity for some experiment in pure research. Or, a new procedure developed by pure research. Or, a new procedure developed by pure research is tested in such a way as to yield information of use to participating agencies interested primarily in solutions to everyday problems. There is emerging from such activities in the D.A.T.S. a reasonably well-integrated methodology for improving knowledge of and control over traffic in the metropolitan area.

INTER-ZONAL TRAFFIC VOLUMES

Three Basic Variables

Among the data necessary for planning an efficient metropolitan traffic network, those dealing with traffic volumes between various sub-areas of the metropolis are most important from the travel engineer's point of view. Such data were supplied to the D.A.T.S., as a continuing study, by the O-D survey of 1953. The data were based on counts of traffic between a large number of "traffic analysis zones," and included predictions of what inter-zonal volumes would be in 1980. It is such predictions that the continuing traffic study must constantly re-examine in the light of changing conditions.

The phrase "changing conditions" refers primarily to changes in population, land use, and tripmaker characteristics, because these are known to be the important variables in traffic generation. Among the three variables, population is the most significant. This is, in a sense, unfortunate, because reliable and complete population counts are seldom made with sufficient frequency for traffic study purposes. In the 10-yr intervals between the Federal censuses, population changes can be so extensive as to call for complete alteration in the plans for a traffic network.

One solution to the problems implied is to use dwelling units as a basis for population estimates. In Detroit, this is made possible by the fact that minor civil divisions send counts of all building and demolition permits to the Metropolitan Area Regional Planning Commission for an annual net summary. The traffic study, with a careful check on the number of occupied DUs and on the average number of occupants per DU, converts the data into current population estimates for each traffic analysis zone. Thus, the population aspects of future inter-zonal traffic are subjected to an annual review—a review which often reveals the need for greater or lesser changes in established plans.

Changes in land use are another important source of variation in traffic volumes. This means that the continuing traffic study must maintain a current inventory of land use. Fortunately, urban planning commissions share the traffic study's need to know about land use, and are therefore likely to keep records on major changes. But more than major changes must be known if traffic prediction is to be accurate. Even block statistics are insufficient because, for example, a single supermarket in an otherwise residential block can alter localized estimates considerably. Hence, in Detroit both regional and city planning agencies are cooperating with the D.A.T.S. in an effort to create and maintain a continuing, parcel-by-parcel inventory—but the difficulties are formidable.

Even when minimum necessary land-use information is available, personnel of the continuing traffic study must still try to solve the difficult problem of estimating the effect of land-use changes on rates of traffic generation. At present, crude estimates are based on number of employees per acre or on size of parking lots. Attempts have been made to refine the estimates, but the results have not been heartening. We now have research findings to substantiate such problematical points as the fact that some residential areas attract large numbers of work trips and the fact that there is no direct correlation between floor space on commercial land and the traffic-generating capacity of the land.

In short, far too little is yet known about the relationship between the characteristics of tripmakers and the nature of their trips. Perhaps some significantly new information will be provided by the exhaustive analysis now being made by the D.A.T.S. of the 1953 O-D questionnaires—an analysis which the original surveyors had neither the time nor the money to complete. But such basic research is still at the stage of raising more problems than it solves.

Iteration: Possibilities and Problems

Among the methods intended to increase the accuracy of inter-zonal traffic volume predictions, the process known as "iteration" is widely used. For those unfamiliar with iteration, a general description is given here (in three steps) as a necessary prelude to understanding the technique's possibilities and problems:

1. First, an estimate is made of total area growth which will occur as of a given year. Such large-scale estimates are known to be reasonably accurate because the effects of various types of inherent error tend to counteract one another—a "smoothing" that does not occur when the area involved is smaller.
2. The growth for the entire area is then used as a basis for predicting the total trip-ends in the area as of the chosen date.
3. Predicted trip-ends for each traffic analysis zone, relative to each other zone, are then calculated on the basis of estimated growth in the various zones. The resulting figures are initial predictions of inter-zonal traffic volumes. But experience has shown that such predictions, based as they are on the relatively small traffic analysis zones, are usually erroneous (just as predictions about individual persons, in comparison with predictions about groups of people, are likely to be unreliable). They can be corrected through the iteration technique. Although the technique appears complicated to the uninitiated, it is based on these two simple facts: (a) when the trip-ends for all the separate zones are totaled, they should equal the trip-ends predicted (in step 2) for the whole area; and, (b) if the growth for each zone, and the growth for the whole area, are stated as ratios and termed growth factors, then the growth factors for all the zones,

when averaged, should equal the growth factor for the whole area. If these equalities, termed "balance" (or "convergence") in the language of iteration, do not exist, then it is apparent that there are errors in the predictions; and, it can be presumed, for the reasons stated above, that it is the zonal or inter-zonal, and not the whole area, predictions that are in error. The iteration formula achieves balance, and thus corrects the wrong predictions, by altering the growth factor for each zone by an amount that is (when calculations are completed) proportionate to the zone's size and growth in comparison with the total area's size and growth. In turn, the corrected zonal growth factors produce corrected inter-zonal volume predictions.

Although iteration, as described, potentially increases the accuracy of inter-zonal traffic volume predictions, it has serious limitations. One obvious flaw is the assumption that O-D data are reliable; another is the exaggeration of errors inherent in data obtained through home interviews—a zone in which 100 trips are missed in the O-D study, and for which 100 percent growth is predicted, will be credited after iteration with 200 less trips than it will probably generate. Another limitation of iteration is associated with its proportional increase of growth factors for each zone—although it may be known that a particular area with no present traffic volume will grow, its "post-iteration" volume will be reported as zero since any proportion of zero is still zero. It is also true that iteration, being purely mechanical, cannot predict changes in the character of inter-zonal volumes. These difficulties, and related problems, have encouraged personnel of the D. A. T. S. to develop some new methods of studying inter-zonal traffic volumes (discussed in the section on "New Directions in Traffic Research.")

DESIRE LINES

Important as inter-zonal traffic volumes are, knowledge about them is not sufficient for planning an effective traffic network. The routes people will wish to use in getting from zone A to zone Z, from zone B to zone X, and so on, must also be known. The phrase, "routes people will wish to use" needs special emphasis to underscore the fact that a traffic plan designed primarily to improve presently congested facilities may simply perpetuate out-of-the-way routes tripmakers are forced to follow because facilities for more direct routes are non-existent or totally inadequate. To avoid such perpetuation of the undesired, the pattern of "desire lines" must be considered.

A desire line is simply a straight "as-the-crow-would-fly" path traced from the origin to the destination of a particular trip. When such lines—based on inter-zonal traffic volume data—are drawn on a map for all trips made on an average weekday, the result is the "desire line density map." A map showing desire-line densities graphically demonstrates: (a) the inadequacies of existing facilities; (b) where new expressways and improved surface arterials would be most effective; and (c) where mass transit facilities should be located. Thus, knowledge about desire-line density changes—changes which will occur in accordance with alterations in inter-zonal traffic volumes—is a basic concern of the continuing traffic study.

TRAFFIC ASSIGNMENT

In Detroit, as in other cities, desire-line densities established by the original O-D study were used as a basis for formulating a new expressway plan. The proposed network was tested by "assigning" predicted inter-zonal traffic volumes to it. Assignment was in accordance with what may be termed a best-path procedure— that is, it was accomplished by (a) calculating the time and distance of both the best expressway route and the best surface street route between each pair of zones, and (b) assigning a part of each inter-zonal volume to the expressways, the part being proportional to the time-and-distance advantage of the expressway route.

A count was kept of the number of vehicles assigned to each segment of the network. These counts served the two functions of determining whether the segments planned could handle the tripmakers desiring to use them, and demonstrating that the degree of use they would receive would be sufficient to justify the cost of constructing them.

If, as in Detroit, the ideal expressway network proves too costly to be built in the foreseeable future, personnel of the continuing traffic study are faced with still another important task. They must test, through traffic assignment where necessary and with adequate new techniques when possible, the constantly modified partial networks proposed as a compromise between the real and the ideal so far as traffic movement is concerned.

NEW DIRECTIONS IN TRAFFIC RESEARCH

Some of the standard methods of obtaining, using, and up-dating data describing inter-zonal traffic volumes, desire-line densities, and traffic assignment have been mentioned. The attendent problems described or implied justify a constant effort to refine the O-D data and techniques with which every continuing traffic study must begin. In Detroit, refinement efforts are presently proceeding in three major directions and are here termed "The Sample Survey," "Zone-Assignment," and "Computer Models."

The Sample Survey

In 1959, the D.A.T.S. began outlining the plans necessary for re-surveying its entire area on a small sample basis. Because the sample will be carefully drawn to represent its universe, the reliability of the results should closely approximate the reliability of a full-scale study. It is intended that the sample will include as many as possible of the households involved in the original O-D study, injecting a dynamic time-perspective lacking to date in most travel surveys. It should be clear that this sample re-survey will permit the following to be accomplished at the moderate cost:

1. It will test and refine the methods of the original O-D study.
2. It will reveal travel pattern changes caused by new developments (such as a rebuilt central business district), thus providing a basis for estimating the degree of error in the predictions of the purely mechanical iteration procedure.
3. It will provide an opportunity to test the contention that the only way to get full and accurate travel information is to interview every tripmaker in the household.
4. It will provide an opportunity to get some more data than is practical in the full-scale survey. Useful information can be obtained about weekend travel, the frequency of inter-city travel, exact trip purpose and route selection, reasons for use or non-use of expressways, and the like.
5. It will provide an opportunity to test travel-prediction formulas by revealing population characteristics associated most closely with amount, distance, direction, and mode of travel (a technique sometimes termed the gravity-model method).
6. It will facilitate the search for effective ways to combine original study area data with more recent data describing relatively new population concentrations.

Zone-Assignment

The important part played by desire-line densities in the effective traffic plan has been discussed previously. Not discussed, but perhaps equally important from the practical point of view, is the fact that the desire-line type of information has heretofore been dependent on a complex and time-consuming process of drawing, counting, and describing tens of thousands of separate lines. The process has, indeed, involved so much effort that it has probably been too often neglected with the ultimate result that some unrealistic traffic plans have been evolved from inter-zonal traffic volume data alone.

These considerations have prompted personnel of the D.A.T.S. to develop a new way of summarizing the desire-line-type of information. Termed "zone-assignment," the technique involves the assignment of inter-zonal traffic volumes to a network of linked zone centers on the basis of the best-path procedure. This permits desire-line-type densities to be presented in terms of just a few hundred links. Thus, desire-line densities are in effect simplified, yet they can be depicted both tabularly and graphically at a zonal level of detail.

Computer Models

Because the parts of every metropolitan traffic system are interdependent, alterations in one part of a system will have a greater or lesser effect on almost all other parts. This phenomenon is quite obvious where a network of expressways is imposed on an existing traffic pattern; less obvious, but in the aggregate perhaps just as important, are the results of seemingly minor changes. For example, a point of traffic congestion may appear or disappear when some new facility is built at a location far distant from the point.

In either case—where proposed or actual changes are major or minor—it is expedient to know what modifications may be needed in an existing street system for smooth accommodation to change. There are a number of methods whereby such knowledge may be obtained, but in terms of efficiency it seems evident that the most effective technique would be an electronic computer procedure which would assign inter-zonal volumes to a model of an entire transportation system, surface arterials as well as expressways included. In other words, what is needed is a machine simulating traffic flow and therefore showing the effects of modifications to the flow. To such a machine could be "fed" one proposed modification after another, until the flashing lights on the front of the machine indicated the "layout" having the least degree of congestion the particular community could afford. Accurate "traffic assignment" (as defined previously) would thus be achieved with speed and ease.

Although the perfect machine model of a complex traffic system remains but a distant goal, a significant step toward the goal has been achieved in Detroit. Here, a skeletal computer model has been completed—skeletal because of the limitations of available computers. The model incorporates traffic volumes between 1,000 major intersections, termed links, and each link has been given values relative to its time-distance from every other link. When actual and predicted inter-zonal traffic volumes are assigned to the model, it produces a fairly detailed picture, suitable for tabular and for flow-map presentation, of the congestion existing on Detroit's major streets and expressways. It has already shown that some expressways, built to carry 100,000 vehicles per day, would have to carry more than 300,000 vehicles daily if all tripmakers were actually able to follow their best-path when moving from origin to destination; and it has shown that some arterial streets which theoretically should have near-zero traffic volume because they play a part in so few best-paths, are actually severely congested because they are carrying part of the excess load that cannot get onto the expressways. Such findings suggest that time-distance values assigned to the links in a computer model of a traffic system must include a variable that will reflect time and speed loss due to congestion; such findings also suggest that an efficient model must include other variables to reflect tripmaker choice, in proportion to amount of congestion, of second and third best-paths. These two improvements in the model will be accomplished if the basic research in traffic assignment now being conducted produces the results hoped for.

SUMMARY

It may be said that nearly all the methods available to social science research can be used by the continuing traffic study in keeping up-to-date, and in refining, the major categories (inter-zonal traffic volumes, desire-line densities, and traffic assignment) of O-D data. None of the available methods—including population estimates and forecasts, land-use inventories, iteration, prediction formulas, zonal growth formulas, small-scale re-interviewing, computer models, and the like—are cheap, quick, or easy. But their cost is relatively modest when viewed, first, as the only possible protection for the large investment of the full-scale O-D study, and second, as reliable insurance that the community involved will be faced with as few as possible of the social problems associated with an inadequate traffic plan.