2443

THE IMPACT OF NEW URBAN HIGHWAYS ON COMMUNITY TRAFFIC

by
Michael J. Demetsky
Assistant Professor of Civil Engineering
University of Virginia
and
Highway Research Engineer
Virginia Highway Research Council
and
Frank D. Shepard
Highway Research Engineer

Virginia Highway Research Council
(A Cooperative Organization Sponsored Jointly by the Virginia
Department of Highways and the University of Virginia)

In Cooperation with the U. S. Department of Transportation
Federal Highway Administration

Charlottesville, Virginia

June 1971
VHRC 70-R52

SUMMARY

This paper investigates the effects of a new highway facility on the traffic on all roads within its range of impact. The measurement of these direct effects is discussed in relation to traffic assignment procedures and a descriptive classification for various categories of traffic is presented. Various strategies for estimating these secondary traffic changes are reviewed in relation to transportation planning procedures and further quantitative research is recommended.

THE IMPACT OF NEW URBAN HIGHWAYS ON COMMUNITY TRAFFIC

by
Michael J. Demetsky
and
Frank D. Shepard

INTRODUCTION

This report presents the results of an investigation of the secondary or local traffic changes resulting from the opening of a new urban highway, as one phase of the project outlined in the working plan entitled "Impact of Urban Highways on Environment."[1] An exhaustive listing of highway impacts on the environment can be broken down into a dichotomy of direct and indirect effects. The former, which are of concern here, relate to actual usage of the transportation system, while the latter indicate the impact of transport investment upon the socioeconomic environment of the system. The elements in the respective categories are in no sense mutually exclusive and it is important to be aware of this fact when delineating the various elements for analysis.

This report considers the problem of measuring the direct effects of a new highway facility on the traffic of other roads within an appropriate system of influence and notes any natural ties to the so-called indirect effects. The outputs required from this task correspond with measures identified and quantified by previous economy studies where the major goal was to estimate the costs and benefits that would accrue to the users of a transportation system as a result of an improvement to the system.[2, 3, 4] The most elementary type of economic study relates only to traffic volumes on the new facility[2] but more comprehensive analyses indicate a need to specify and measure a more diversified type of system traffic. For example, Foster and Beasley,[5] in their classic analysis of the proposed Victoria Rapid Transit Line in London, cited benefits in view of the following "types" of traffic: traffic diverted to the Victoria Line, traffic not diverted to the Victoria Line, and generated traffic. This strategy is also appropriate in the analysis of a new highway facility as can be seen in the literature.[4, 6, 7]

A basic problem of the economy study is that the required descriptive information on network traffic is not readily compatible with the outputs from the transportation planning process. The inputs for the economy study arise from the traffic assignment methodology, which concentrates on areawide major street and expressway volumes. Traffic flows on smaller streets are usually not measured because they are not included in the coded network (here the costs of greater detail have been considered to outweigh the value of the additional information obtained). Thus, in view of current practice, the question of increasing the detail of the traffic assignment methodology or devising other strategies which render information on more detailed secondary traffic volumes must be considered. This report, therefore, investigates the nature of, and the methodology required to measure, the impact of a new highway facility on the traffic of all roads within its range of impact.

TRAFFIC ASSIGNMENTS

Traffic assignment is the last process in a series of analytical planning models commonly referred to as the transportation planning process. The purpose of this procedure is to translate trip making potential (origin-destination flows by mode) into actual traffic volumes on specific transportation facilities. The basic inputs to traffic assignment are a coded network of transportation (highway, in this case) facilities and a matrix of inter-area automobile trip interchanges. The coded network is an abstraction of the real road system in a form suitable for digital computer programming. It usually contains only the major routes in an area and does not include local or community streets at the level required for an environmental study.

The trip interchanges (distributed traffic) are assumed to originate and terminate at central points (centroids) in each analysis zone. All major street intersections and freeway interchanges are assigned numbers referred to as nodes; each segment of a facility between two nodes is called a link. Thus, each zonal centroid is connected to every other centroid in a system by a series of links called a tree. The computer program assigns traffic volumes to each link based on some minimum path criterion* over relatively long periods of time (usually 24 hrs.).

---

* The simplest method, the all or nothing method, assigns all trips to the shortest freeway route or to the shortest alternate arterial route, based on a comparison of travel times. A more refined approach uses diversion curves, and the most sophisticated rely on a capacity restraint strategy which eliminates overassignment on a given route or link.

The primary concern here is the level of detail given by the coded network and the time period of reported volumes rather than the nature of the specific minimum path algorithm utilized. In present terminology, the assignment of traffic to a smaller sub-network within the primary coded network falls into an area of analysis referred to as micro assignment. Such assignments relate to a very detailed street network and process traffic on a city block-to-block basis over very short intervals of time (i.e., 5 minute intervals). It is also appropriate to mention that the micro assignment operates on micro areas that are compatible with a definition of community traffic (i.e., the local traffic on all roads and streets in a particular geographical area affected by a proposed highway facility).

The micro assignment then performs assignments on local streets which lie within the macroscopic framework of conventional traffic assignment procedures. Interface with the latter is required as nodes in the basic assignment model provide boundary conditions for the micro assignment. At present, the micro assignment techniques available are quite rudimentary and further research and development is required before widespread applications are possible.

Consequently, current evaluations of the impact of new facilities on total communities are to a large degree relatively intuitive and arise from subjective judgements based upon the physical capacities, orientation, zoning, etc. of local streets. In many cases, such approaches are highly acceptable as they require the experience of local officials to evaluate public projects in view of community goals. This is not meant to imply, however, that a comprehensive quantitative methodology is not a valuable tool; since it is needed to provide consistency in statewide applications.

TRAFFIC ADJUSTMENTS

A previous section noted a "personification" of traffic in order to meet the goals of economy studies. Since a total environmental analysis must relate ecological relationships (i.e., man-environment interactions) whenever possible, a humanization of traffic descriptors (user-trip relationships) appears appropriate. By extending these ideas into practice, the following categories are presented to indicate present, redistributed, and new traffic.

Present Traffic

Existing Traffic — The directional traffic on the system prior to the provision of a new improved facility.

Redistributed Traffic

Diverted Traffic— Existing highway travel that is attracted to the new facility without a change of origin or destination.

Transferred Traffic—That component of existing traffic which is attracted to the new highway facility from other modes of travel.

Shifted Traffic— That component of existing traffic which is attracted to the new facility and exhibits a change in origin and/or destination.

Generated or Induced Traffic— A consequence of a new highway facility only because that new facility is available.

Natural Traffic— A result of the natural growth rate in traffic generating activity independent of network modification.

Developed Traffic—Traffic developed after a facility is completed because of any changing use of the land served by the highway facility (overlaps natural, diverted, and transferred traffic in some cases).

Measures of the above can be inferred to indicate the impact of a new highway facility on the streets and roads within the geographical area affected by the proposed facility.

The actual count of pre-facility and post-facility local traffic patterns can be obtained via before and after studies, but the measurement of each individual traffic component is relatively complicated as will be shown later. The before and after information, however, presents a potential for establishing simplified empirical relationships between traffic and local social, economic, and geographic conditions. Such models would be similar to the type which relate the average flow during peak periods to the average flow during peak hours as a function of the population of the community, the location of the point of interest from the CBD, and the peak hour volume.[8] In this case hypotheses can be tested concerning approximate relationships between traffic volumes and such possible indicators as orientation toward new facilities (parallel or feeder roads), distance from the new facility, population density, commercial activity, etc. The purpose of a new facility, whether it is intended as a CBD feeder or an urban bypass, also provides implications as to the type of impact it may have on local streets.

This approach of utilizing simplified relationships is very appealing when previous studies on the performance of urban highway systems are viewed.[9,10,11] McElhiney[9] notes that although various new freeways observed in Los Angeles become overloaded during a few peak hours, they have significantly reduced utilization of paralleling arterials. It was also stated here that off-peak flows experienced better levels of service in all cases.

The experience of Chicago's Congress Street Expressway(10) also shows that parallel streets benefited, even though total travel within the study area increased. In this instance, traffic volumes on local streets decreased 7 percent. This study also cited secondary increases on some nearby arterials. More specifically, the opening of the Congress Street Expressway led to significant volume increases on intersecting north-south arterials. Similar observations were also obtained in Boston. (11)

The previous discussion, therefore, develops a deeper insight into a network utilization pattern than that realized in typical traffic assignment analyses. The potential use of "before and after" data in impact analyses must be given consideration in view of the relatively static data obtained in cross-sectional origin-destination studies. In the next section an alternative approach to the study of community traffic, which is indicative of a more detailed assignment methodology, is presented.

TRAFFIC FORECASTS

The previous discussion cited three primary methods for predicting the impact of a new highway facility on local or community traffic which are now summarized in order of their presentation in this paper.

1) Empirical models based on before and after data

2) Micro assignments

3) Subjective evaluations

Detailed estimates of traffic volumes on local streets are necessary in order to completely evaluate the environmental impact of a new highway facility. The considerations necessary to the development of a comprehensive quantitative methodology can be associated in reference to the modeling system of the transportation planning process, which is shown in Figure 1. The shaded blocks represent the prediction of "direct effects" or traffic volumes. A micro assignment model would appear subsequent to the traffic assignment phase and would then bring traffic volume estimates to the community level.

The relationships between this modeling process and the descriptive traffic-trip adjustments are somewhat vague. Existing traffic is easily measured via volume counts and/or origin-destination surveys. These measures present a definite characterization of the "before" situation. The redistributed traffic measures, however, are rather implicit

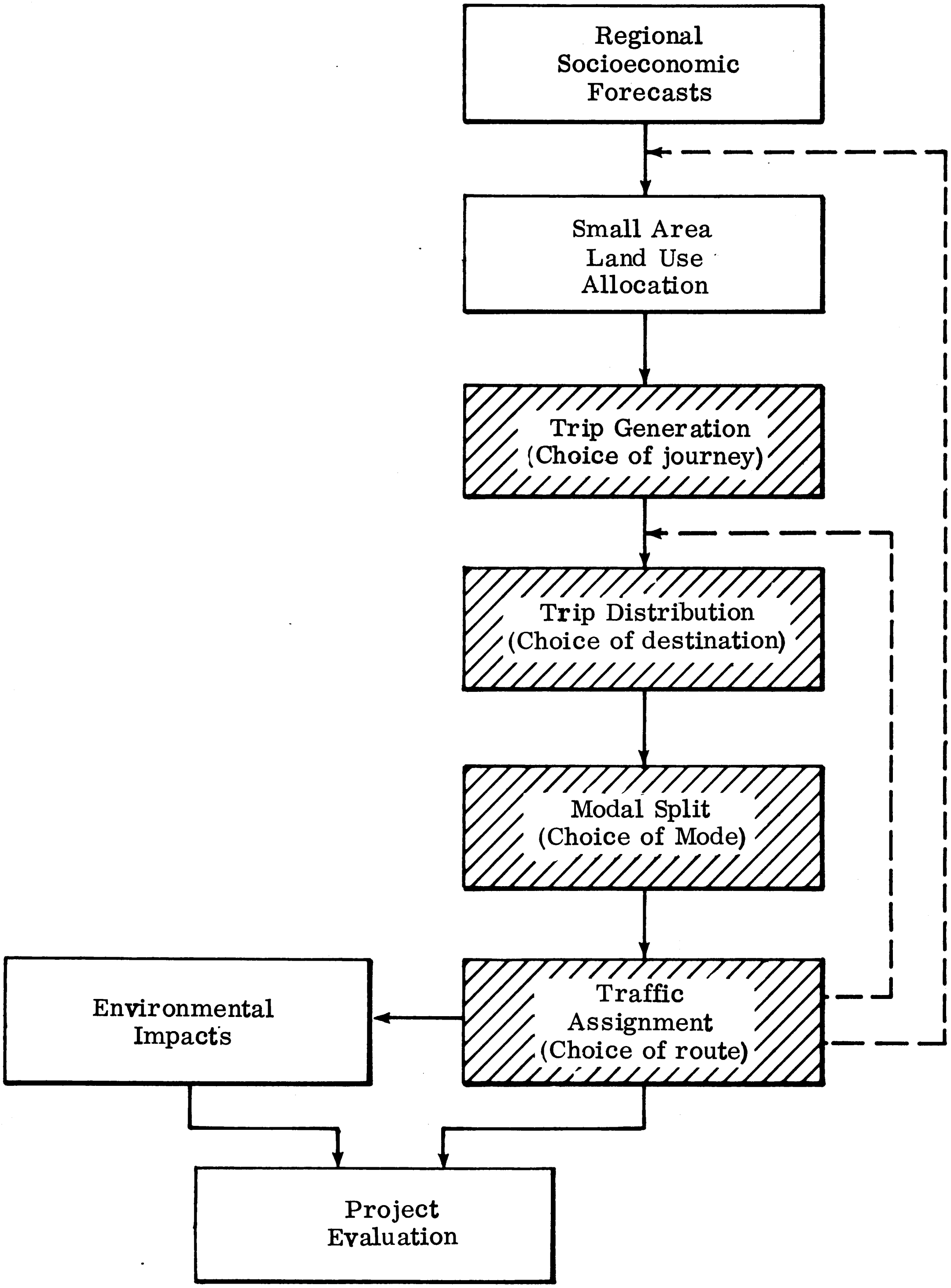

Figure 1. The forecasting model system in the transportation planning process.

in this process. Diverted traffic is accounted for by the assignment model and transferred traffic is indicated in the model split analysis, i.e., the increased number of auto trips at the expense of transit as the result of a new or improved facility. Trip distribution procedures which render desire lines of travel can be used to show shifted traffic patterns. Thus, redistributed traffic measures can be obtained from the planning models by inputting the existing small area land use distribution and new system characteristics.

The estimation of new traffic is, however, a more complicated matter since the estimates are directly related to changes in land use. The post-facility small area land use allocations are the result of two specific events; natural growth pattern over time and growth and redistribution as a result of the new facility. Thus, the accuracy of estimated traffic is relative to the accuracy of the socioeconomic and land use changes which provide the primary inputs to the traffic models. Increased accessibility between zonal pairs will induce local traffic to seek more distant destinations and thus more inter-zonal trips would be generated. Also, natural traffic growth is the result of the projected growth in land use activity and is directly vulnerable to errors in such forecasts. Finally, developed traffic, by definition, follows the growth resulting from new transportation and shows the need to make socioeconomic activity sensitive to the same. In the framework shown in Figure 1, the iterative process, which is implied by the traffic assignment to the small area land use information channel, is directed toward making the land use allocation sensitive to transportation.

The descriptive traffic measures that were noted at their accountable stages within the planning process become blurred by the end of the analysis and, if such fine descriptors of local traffic are warranted, their origination within the modeling system must be traced. Accounting for the traffic adjustment terminology within the framework of the transportation planning process, therefore, gives a refined analysis of traffic impacts.

The technique cited that derives simplified empirical relationships for the impact of a new highway on local traffic is useful either as a substitute for or a complement to the conventional model system. These measures that derive from "before and after" data can ultimately be used as a cross check on the validity of alternative approaches, in particular, micro assignment strategies. Approximate procedures can be used to indicate "feasible alternative designs", which may then be subjected to the more rigorous analysis via micro assignment techniques.

The value of subjective evaluations of local traffic which combine experience and relatively macroscopic information should not go unnoticed. The more sophisticated mathematical methods may render diminishing returns, as their results may not provide additional accuracy worthy of the extra costs.

RECOMMENDATIONS

This paper has investigated the nature, measurement, and implications within contemporary urban transportation planning methodology of the secondary traffic impacts resulting from the opening of a new highway facility. These traffic data are a primary requirement for a comprehensive analysis of the impact of a new road on the urban environment, since traffic volumes provide the basis for estimates of such environmental consequences as air and noise pollution levels, high volumes on previously bypassed residential streets, and social adjustments. It was shown that the conventional transportation planning methodology does not provide measures of traffic volumes at the level of detail required to study local community traffic. The micro assignment approach is a possible means of adapting traffic assignment techniques to community analysis and is compatible with the goals of environmental analysis.

Since the range of environmental impacts is very broad, consisting of the physical, economic, social, etc. effects on man and his environment, social as well as dimensional qualities of traffic should be recognized. Thus, it was necessary to indicate a relatively subjective classification of traffic; namely, redistributed and new traffic. Such a classification then makes it possible to cite intangible ecological impacts as well as physical disturbances on the community.

The goals of a particular study must establish exactly what impacts the traffic data are required to relate in terms of environmental consequences. The traffic analyst or planner can then utilize the appropriate procedures to provide the desired information. It is conceivable that different urban structures within the Commonwealth will reflect the need for more than one means of traffic evaluation and, hence, the three approaches discussed here must be thoroughly investigated to test their validity and to establish guidelines for application. Accordingly, situations wherein only subjective evaluations are sufficient should be fully described.

Further research is required to determine if micro assignment models are in fact worthwhile. Their validity can be examined with before and after data. Such information can also be employed to test empirical models that directly relate traffic changes to such measures as prior traffic, orientation in reference to the new facility, proximity to the new road and land use distributions. Therefore, it is concluded here that only after more thorough research on local traffic impacts is accomplished can general guidelines for measuring secondary traffic impacts which meet the needs of environmental studies be presented.

REFERENCES

1. Dillard, J. H., and L. E. Walton, Impact of Urban Highways on Environment, Virginia Highway Research Council, August 1970.

2. Oglesby, C. H., L. I. Hewes, Highway Engineering, John Wiley & Sons, New York, New York, 1963.

3. Wohl, Martin, and B. V. Martin, Traffic Systems Analysis for Engineers and Planners, McGraw-Hill, New York, New York, 1967.

4. Winfrey, Robley, Economic Analysis for Highways, International Textbook Company, Scranton, Pennsylvania, 1969.

5. Foster, C. D., and M. E. Beasley, Estimating the Social Benefit of Constructing an Underground Railway in London, Journal of the Royal Statistical Society, Volume 126 (1963), pp. 46-58.

6. Schmidt, R. E., and M. E. Campbell, Highway Traffic Estimation, Eno Foundation, Saugatuck, Connecticut, 1956.

7. Methodological Framework for Comprehensive Transportation Planning, Final Report, prepared for the Governor's Committee for Transportation, Commonwealth of Pennsylvania, May 1958.

8. Drew, Donald R., Traffic Flow Theory and Control, McGraw-Hill, New York, New York, 1968.

9. McElhiney, Paul T., Evaluating Freeway Performance in Los Angeles, Traffic Quarterly, July 1960, pp. 296-313.

10. Frye, Frederick F., The Effect of an Expressway on the Distribution of Traffic and Accidents, Chicago Area Transportation Study Publication 66, 549, presented at the 42nd Annual Meeting of the Highway Research Board, Washington, D. C., January 1963.

11. Bone, Alexander J., and F. W. Memmot, Travel Time Studies in Boston, 1960, Joint Highway Research Project, MIT and Massachusetts Department of Public Works, Cambridge, Massachusetts, January 1961.