Transportation Planning: A Unified Approach

John R. Hamburg

In the 1950s, a transportation planner was expected to consider alternative courses of action affecting the movement of persons and goods and to recommend one or a set of actions that seemed appropriate. This recommended act, or set of actions, constituted a plan—hence, the term, transportation planner.

Today, in the 1980s, we are reassessing the role of transportation planners and the tools of their trade. But things really have not changed that much. The particular courses of action that first pop into a transportation planner's mind have followed the trend of changing emphasis since World War II: Interstate highways, urban freeways, rail rapid transit, topics, TCM, TSM, and bike and pedestrian ways. Ultimately, however, the transportation planner has had to provide (a) a product (an estimate of the amount of travel on one or more facilities or services during a specific time period) and (b) an assessment of the impact of that travel in terms of a number of specific criteria or goal performance levels (e.g., travel time, travel cost, facility or service cost, air quality, safety, energy consumption, etc.).

How do we add up performance? How can we evaluate alternative actions in terms of performance against goals? Well, if each goal performance could be expressed in common units, evaluation would be trivial; otherwise it is harder. Recent federal government policies appear to have given new life to the least-cost approach.

Our perception and definition of the actions that affect the movement of people and goods have become richer and more complex. Transportation planning has gone beyond purchasing new transportation system capacity by the addition of new freeways and transit facilities. But there will be new freeways and rapid transit lines built in the next 20 years when and where they are needed, regardless of whether the funding is labeled federal, state, or local. How did we fall into the notion that there was any such thing as "federal" dollars? I thought the money was collected from people and businesses in the form of taxes and fees. A transportation investment should be justified in terms of its return to the people who must pay for it.

Certainly we have seen a recognition of the need that existing transportation system management must be improved that the near-term, short-range traffic problems must be addressed, and that the problems of specific corridors and subregions or local jurisdictions should receive detailed study.

It is not this expanded view of the range of responsibilities of the transportation planner that concerns me. Rather my concern is that with each new insight into the etiology of traffic congestion, air pollution, energy consumption, etc., a new program and methodology sprang up. Transportation planning has been fragmented into multiple programs, funding, and methodologies.

When I speak of a unified approach to transportation planning, I mean a unification of the methodology of the transportation planning process. This unity would extend from short range to long range—project to corridor to jurisdiction to region—and TSM to system planning.

It is hard to remember exactly when it first became clear that a unified approach was not only possible but necessary. In a paper entitled, *Integrating TSM into the Overall Transportation Planning Process*, delivered to the TSM Conference at Arlington, Texas, in November 1979, a three-stage approach was suggested:

- Establishing a Regional Context within which detailed subregional (corridor) plans can be developed. This includes an assessment of growth in population and employment, the establishment of regional TSM actions which can be expected to be implemented and the identification of committed transportation facilities which will be in place.
- Development of Sub-area (Corridor) Transportation Policies and Plans within the constraints of regional growth and transportation actions.
- Synthesis of an Overall Regional Transportation Plan from the policies and plans developed for each of the sub-areas of the region.

We believe that this approach could represent a major breakthrough in the planning process. Prior approaches to long-range regional transportation planning proposed long-range capital-intensive construction programs which purposely avoided detailed and specific alignments and ignored detailed traffic engineering alternatives for coping with local transport problems. These capital programs were typically to be implemented by the state with the major share of funds coming from the federal government. A specific town or jurisdiction was expected to solve its local transportation problems on its own. But a town's ability to handle its own transportation needs without considering its setting within the region and the impacts that regional growth and transportation plans could have on its transportation system was limited at best. It should not seem surprising then that local jurisdictions felt frustrated in a planning process that looked first to the region and only then to the locality. This frustration often sparked opposition to the regional plan when the latter was translated into a specific proposal within the jurisdiction and presented at public hearings.

Originally the regional efforts were spurred by the recognition that if states, counties, and cities all "did their own thing," chaos would result. However, the past decade has seen many times a public rejection of the elements of the "regional plan" when an element was viewed at the local level in the community in which it would be located. Of course, a large part of this reflects the concern with reducing public expenditures, reducing energy consumption, reducing environmental impacts and improving air quality. Nonetheless, the justification for the regional elements of the plan very often rested on regional benefits and a local case for the facility was not clearly made, if even attempted. The substitutability of TSM actions for other "local" alternatives had not been studied. The "regional good" was just not sufficient to convince the individual jurisdiction of the need for the facility.

Finally, the heart of the methodology of the regional planning process, traffic simulation and assignment, simply was not applicable at the scale or grain required to assess and evaluate alternative TSM actions; the process was just too coarse.

That there is a need for a regional plan is indisputable. The transportation facilities which serve the region must be a system. Major highways have to connect with each other. Public transportation systems must cross jurisdictional boundaries and the service on different lines must be coordinated.

The point is not that the regional plan is *not* needed, but that a regional plan must evolve through a synthesis and integration of local plans which consider regional demand as well as local supply.

This approach has been made possible by the development of simulation software which permits focusing on an area of interest while simultaneously dealing with the remainder of the region. . . . The simulation software has the additional advantage of being able to handle finely detailed networks and very small zones at a subarea level so that impacts which might be lost in the regional approach may be simulated and evaluated. By applying this approach to all of the sub-areas of an entire region, a set of sub-area plans can be developed. Through a synthesis of these sub-area plans a regional plan can evolve. This synthesis may be iterative but will result in a package of improvements tied not simply to local interests but satisfying regional requirements.

WHY TRAFFIC SIMULATION?

While most planners will concede the need for traffic simulation (spelled traffic assignment) for long-range regional planning, the acceptance of simulation in TSM and traffic engineering studies has been grudging and limited if at all. The arguments against the use of simulation for near-term, low-capital, fine-grained analyses are varied but include too expensive, too time-consuming, not accurate, and not necessary. The response to these arguments is that without simulation of some sort, how can one judge the impact of alternative actions?

One can always "try it and see what happens." Of course, this approach carries some risks. The particular action can have adverse impacts on certain groups of people. For example, if travel is to be prohibited or restricted in certain zones or if parking is eliminated, somebody has to feel cheated. Are the burdens of the action equitably distributed or shared? Can the planning agency admit after a fiasco, "Sorry—it just didn't work. Now we'll try something different."

Often, the planning actions under consideration are not singular but may involve several approaches or packages. Actions that are traffic-related such as bus and carpool lanes may be combined with a carpooling program or staggered work hours. Because they may reinforce each other, two or more actions need to be evaluated simultaneously rather than singly.

Furthermore, one cannot measure the effect of removing parking on a street by measuring the traffic-handling performance of the street before and after the change. The changed operating characteristics of the street may affect the traffic volumes on adjacent streets—i.e., a systems effect. How big an impact depends on the magnitude of changed parking on the street. There might be a slight improvement on several adjacent streets in addition to the slight improvement on the street from which parking was removed. This same kind of systems effect hampers the measurement of emission impacts of vehicles. This results because the emission characteristics of a vehicle vary according to the conditions under which it operates. If we know the number of starts and stops, the idling time, the operating speed, whether or not the engine was warmed up, the type and size of engine, the condition of the engine and emission device(s), one could estimate the emission characteristics of that vehicle or an average vehicle from some mix of vehicles. Now if we remove one such "average" vehicle from the vehicle stream, we can calculate the emission reduction on a yellow pad. However, if we continue to remove vehicles from a congested stream, we will significantly underestimate the emission reduction if we simply multiply the emissions per vehicle mile by the number of vehicle miles removed. This is because, as we remove vehicles from the traffic stream, congestion decreases and this means less idling time, fewer stops and starts, higher running speeds, etc. A significant reduction in emissions results from the improved operating conditions experienced by the remaining vehicles, and, because traffic tends to move toward equilibrium, it is often necessary to measure the whole system or a substantial portion of it.

In sum, almost any TSM or TCM will impact system performance; combinations of actions may have greater or lesser impact when implemented simultaneously than their separate impacts may total. And the actions themselves may range from regional to local in terms of implementation as well as impact. Because of this, we think that simulation is essential to estimating the traffic performance impacts of one or more actions, whatever the scale, time frame, or capital costs of the actions.

UNIFICATION

I suggest that the ingredients for unifying or bringing together all of the different planning actions are now available or within the grasp of the transportation planner. Much of the computer software is written, although some of it is prototypical rather than production programming.

The Right Amount of Data

An essential key to this process is having just the right amount of data for the problem being addressed. It is easier to cartoon the situations that miss on this account rather than to exactly specify what is required, although this can and must be done.

When planners had finally mastered the art of regional traffic assignment, an art form which George Wickstrom once described as the Glopada-Glopada Machine, they noticed a peculiar characteristic. The greater the number of zones, the higher the cost of an assignment (and not a simple linear cost increase, but an exponential one). They also noticed, to their dismay, that the larger the average zone size (which gave a lower number of zones in total and therefore lower costs), the less the results resembled the traffic volumes that the process was attempting to reproduce. In short, precision seemed to be directly correlated to computer costs and the number of zones. Splendid versions of this approach were marshalled to estimate regional freeway volumes as well as collector volumes in suburban villages. By increasing the zones to 1000 and even beyond, the planner managed to drive the cost of a simple run into the thousands of dollars, sometimes to the $10,000-$20,000 range. Of course, at this price they could not be run very often, and the estimated volumes were not very good unless the process restrained the link volumes to the counted or observed volume. That is okay when one knows the answer, but then, why bother?

The lesson that must be learned from this is that the entire region cannot be treated at the level of detail needed to estimate accurately volumes on collectors, minor arterials, and ramps; it is just too expensive. One region, which was simply too big to fit into anybody's computer, was the New York City Metropolitan Area. And it was there, under the direction of Douglas Carroll and Morton Schneider, that the concept of hierarchical zones and networks came to be implemented. Schneider observed that as the distance from a link of interest increased, the exactitude of geographic location of an originating trip and the detail of its surrounding network diminish for a given level of precision on the link of interest. That is, for simulating traffic volumes on a street in Manhattan, adjacent streets needed to be specified and nearby zone sizes needed to be very small. But for trips on that same Manhattan street segment that originate in Newark, the exact location of origin can be generalized to a relatively large zone with little loss in precision of trip length or duration. Also, the detail of the street network surrounding the Newark trip's origin is largely irrelevant. Put in a different part of the country, for trips on the streets of downtown Dallas that come from Fort Worth, the local street system in Fort Worth hardly needs to be in the network, nor does it matter if the zone of origin is 1, 4, 9, or 25 miles in area.

The lesson is not to limit the precision of the assignment process to that resulting from cramming as many zones and links into the computer as one's budget will permit. Do not accept the least common denominator of precision that comes from the regional traffic assignment system of zones and networks. Use flexible (hierarchical) system zones and networks and assemble them in a way that yields the greatest precision for a given cost or meets a prescribed precision level at the least cost.

Hierarchical Treatment of a Unified Data Base

It is not enough to tailor the zone structure and the number, length, and type of transport links that go into making up the network. There are some other hangovers from the assignment process that need review and revision if the process is to be unified.

Basically, there are three characteristics attributed to a segment of the highway system:

1. Length,
2. Speed or impedance, and
3. Capacity.

Of these, only the first has received treatment adequate to the task of simulation of traffic with precision sufficient for most planning purposes; that is, we have learned to measure the length of transportation segments pretty well.

The limitations of speed and capacity in conventional assignment procedures have been known for many years but largely ignored. Speed is clearly a function of intersection control treatment, posted speed limits, and traffic congestion. Capacity is also a function of intersection controls, turn prohibition, pedestrian and heavy vehicle interference, and traffic congestion. Capacity in fact cannot be defined in terms of vehicles per hour per lane in the absence of knowledge of what is taking place at the intersection. It is in fact dynamic, varying throughout the day according to a host of factors that are knowable but largely ignored in the traffic assignment process.

Algorithms exist for calculating speed and capacity, taking the relevant detailed factors into account. But two problems surface immediately. The first is the fact that the need for precision of speed and capacity specification vary according to the type of study and also with respect to proximity to the area of interest. This problem can be handled by using a process that is flexible in terms of how much detail is required. Intersections within the area of interest can be specified and all of the power of the details of signal timing, turn provisions or proscriptions, opposing traffic volumes, turn interference from conflicting traffic and pedestrian movements, etc., can be brought to bear on the calculation of speed and capacity. At the same time, less detailed specification of more distant links can be used with reductions in the cost of running and little or no reduction in precision within the area of interest. In short, by using a hierarchical description of network detail, regional impacts can be had without the high costs of large-scale assignment but with precise ramp and collector volumes not usually thought possible. The notion of doing it is trivial; yet, if done manually, it is very tedious. A software system of selecting the zone structure, network links, and network detail exists and is being used by the North Central Texas Council of Governments. Such a system will be used in Charlotte, North Carolina, and may be used in Pittsburgh. However, in addition to the software for actually windowing and inserting a micro network, a rich data base needs to be maintained. This requires an information system to both feed the process as well as to maintain a record of what the results were and to evaluate those results.

The notion of 24-hour assignments with 24-hour capacity restraint mechanisms is essentially bankrupt except for the crudest of assignments. But this area is fairly well documented. Moreover, with computers becoming cheaper and more accessible, it seems clear that we should take greater advantage of existing algorithms to provide a more precise and unified approach to traffic simulation that will give inexpensive, timely, and useful answers.

Integration and/or Unification of Highway and Transit Simulation (Mode Split Including Automobile Occupancy)

The biggest shortcoming to transit simulation is our inability to simultaneously represent highway and transit networks and build paths that utilize both automobile and transit. We continue, with a few notable exceptions, to proceed along the notion that a minimum path exists between two points measurable by a single metric—usually time or sometimes weighted time and cost. Yet it was shown in 1957 that there are at least two dimensions to travel that people consider: time and cost. For some people, the least-time path is preferred. For others, the least-cost path is chosen. These paths are usually not one and the same. Moreover, the infamous irrelevant mode issue that has plagued the users of the logit model and single-dimension minimum paths disappears when two-dimensional trees are built and used as a basis for allocating travel to mode.

Zone size and access links also plague the simulation of transit. Walk access and ride access are clumsily handled in most procedures.

The notion that highway times and costs are the same to people making a choice between automobile and transit regardless of car availability seems childlike. Yet only limited attention has been given to the problem of estimating car ownership by small areas.

The automobile occupancy problem, so vital to high-occupancy-vehicle projects, has not proven to be amenable to multinomial logit efforts—but certainly not for lack of trying to calibrate models.

CONCLUSION

There is more that could be said and complaints, regrets, and criticisms that might be spewed forth. But my conclusion is simply that unification of transportation planning is long overdue.

One cannot make local plans without considering the impacts that regional growth, traffic, and transportation facilities will have on the locality. Nor can one plan regional transportation facilities in the absence of local inputs regarding transportation facilities and actions. There must be an integration of planning across time, space, and capital requirements if we hope to get the most out of our planning efforts, not to mention our planning dollars. There is very little standing in the way of such a unification—MPOs were born, painfully, in order to house such a unified approach.

The theoretical concepts necessary are all available for a flexible hierarchical approach to representing transportation systems; representing the spatially detailed settlement pattern of regions (the socioeconomic characteristics of regions); the storage and retrieval of these data at the appropriate level of detail, geography, and time; the models of social interaction that result in travel; the diagnosis of problems; and the evaluation of alternative actions directed to the solution of those problems.

Much of the software for implementing these concepts is in place. A handful of regions are already undertaking the approach. What is needed is to continue this effort and move to a sharing of methods and procedures.

Perhaps out of this conference can be born a user's organization to compare and share techniques and methodologies that can hasten the unification of transportation planning functionally, spatially (local to regional), financially (low-capital to capital-intensive), and temporally (short-term, long-range).

An Outline of the Emerging Urban Transportation Planning Process

Douglass Lee

Transportation planning and the transportation planning process have been severely buffeted from sources both inside and outside the field, primarily throughout the 1970s. To transportation planners who experienced the clear direction and exciting achievements of the previous post-war decades, the prolonged milling about of the current period has been frustrating and distressing. Yet this apparently aimless indecision has permitted a productive review and rethinking of the basic planning paradigm, and a new paradigm is finally taking shape as the fog lifts. This paper is an effort to describe and clarify the new shape.

The slowness of the new pattern to emerge is because its difference is at the most fundamental level. This does not mean that everything must be done over from scratch; on the contrary, many professionals are actively practicing in the new paradigm while thinking of themselves as being forced into an undesirable (and preferably temporary) departure from the old process. New theory, new methods, new concepts, and new professional standards are necessary, of course, but most of the tools are already available and in use by transportation planners. Primarily, it is the framework by which these elements are integrated and synthesized that is changing.