Model Systems for Urban Transportation Planning: Where Do We Go From Here?

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•URBAN TRANSPORTATION PLANNING seems to be approaching some kind of maturity. The concept of planning transportation using computer models, introduced in the mid-1950s, is now well established. The procedures for carrying out these studies are technically advanced with support from thousands of scientific and engineering references giving the mathematical derivation, the empirical testing, the use, and the limitations of these models. The procedures are carefully documented and established by law. Cities of over 50,000 population must base their requests for federal highway funds on comprehensive plans established using these general techniques. Manuals detail the step-by-step procedures to be followed (1). From a financial point of view the urban transportation planning process is comparatively well endowed, with funds provided from the Highway Trust Fund. Initial planning reports from most urban areas were completed in the middle to late 1960s and the fairly large staffs that most of the transportation studies had at the outset have now been trimmed to more modest sizes. There is, however, a general recognition that the studies must be continuing in nature if the transportation problems of the cities are to be solved and the necessary funding is to be provided.

However, all is not well with urban transportation planning. The freeway plans for many cities are running into severe opposition. At a time when the public's attention is being increasingly directed to the problems of the city and when public funding for the massive urban transportation expenditures needed could potentially be at hand, the planning establishment and its plans have been largely written off by the public as a failure.

Although the wisdom of past planning attempts has yet to be vindicated and is not likely to extricate us from our problems in any event, this is a good time to pause, to reflect on the planning models and procedures that have been used, and to ask the questions: Where do we go from here? Are the models adequate? Should they be larger, more elaborate, and more richly financed? Should we drop them as being ineffective or study them to improve their effectiveness? Does the planning process need attention? This paper will necessarily examine these questions from my point of view, which is that of an academic with an interest in transportation planning and its application. However, I have had the good fortune to be a part of the study team on two large-scale applications of transportation system modeling at the regional scale, the Harvard Transport Research Program study of Colombia (2) and the Department of Transportation Northeast Corridor Project (3), as well as more typical experience in modeling traffic problems in a number of urban areas. I intend to call on these experiences for illustration where appropriate.

As I survey the urban transportation planning efforts of the past and those currently under way, I see a number of hidden assumptions that appear to underlie the entire planning process and about which I have some doubts. I would like to elaborate on five of these underlying assumptions and their implications for the validity of models and their results. Although I would argue that these assumptions have deleterious consequences that lie at the heart of our problem, there are those who would disagree with

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me on some, if not all, of the points. In return for allowing me to be critical, I hope to justify my negative outlook by advancing what I consider to be better approaches and more attainable goals.

The five hidden assumptions are as follows:

1. The purpose of the planning process is the selection of a design for the urban transportation system that supports the land use anticipated for the design year.
2. Land use is not affected by the location of transportation facilities or, at least, it can be assumed so for the purpose of building transportation planning models.
3. In evaluating alternative transport system designs the desirability of a particular system can be determined by comparing flows on alternative designs and analyzing the net costs and benefits of the systems.
4. System simulation results must be used to help size facility design ramps and plan traffic control installations, inasmuch as they are the best figures we have. System dynamics can be ignored in the planning process because they affect the design of the facilities relatively little.
5. Citizen participation is extremely difficult to incorporate into the technical aspects of transportation planning. The best that can be done is to give lip service to broadly participatory planning but avoid it wherever possible.

Obviously, there will be some who will disagree with my choice of these five premises and charges by others that the accusations are unjust. I must therefore elaborate on each in order to make my point.

THE PLANNING PROCESS

The first assumption states that the urban transportation planning process is a design process whose purpose is the selection of a single recommended system from among those systems investigated. Problems arise here with the initial statement of goals. Goals may vary from case to case, but a frequent goal of the transportation planning process is the selection of that network plan that supports the land uses anticipated for the design year.

The difficulty arises in conjunction with the concept of a design year. Designing urban transportation systems is a complex job that must be simplified to be accomplished. One of the easiest methods of simplifying is to select a target year and then aim for it. The finiteness of the planning budget, the slow speed of computers, and our inability to program them has led us to this use of the design year concept. Because there are so many possible futures, it is very comforting to be able to select one design goal as that utopia to which we aspire. The concept of a design year is well established not only in urban transportation planning but also in engineering, city planning, and government policy-making.

The question that immediately arises is how the land use will be determined for the design year. Because land use has a lot to do with trip origins and destinations, it is obviously important to transportation planning. In Manhattan, for example, 700,000 trip destinations per square mile are possible (4). In other urban areas trips may be attracted at a rate of less than one-half trip per acre. Because land use is so important to transportation planning, obtaining a statement of the land use for the design year is imperative. Some possibilities for obtaining this land use statement are as follows:

1. If you believe that land use can in fact be effectively controlled, then decide what the land use should be and state this as a goal to be achieved. The final statement will appear in the form of a land use plan.
2. If you view land use as the aggregated decision of many individual decision-makers and beyond the control of any single planning authority, then the land use for the target year should be predicted.
3. Some combination of these two may be adopted.

Obviously, the third point of view is more correct than either of the other two, because all land use plans will contain some elements of central control and will typically involve some decisions by others that are beyond central control. In an urban society like ours, current land use is probably best viewed as a manifestation of past policies rather than as the product of some plan. The control variables, therefore, are the policies pursued by government, not the statement of land use (Fig. 1).

The frequent ploy of transportation planners is to abdicate the responsibility for this land use plan for the design year as being outside of their authority. Frequently the plan is furnished by another agency or authority. Another approach commonly found in practice is to embrace several alternative land use plans and to design transportation systems to support each. The assumption, which underlies the use of a design year in the case of either a predicted or a projected land use plan, is that we can move from the land use we have now to that anticipated for the design year, and the major question to be resolved by the transportation planning process is the selection of the transportation system that will best support the design plan.

The use of a design year and the testing of alternative systems for this design year is appealing because of its simplicity. However, I cannot accept the oversimplifications involved. The design year is just not a realistic conception. It is, after all, just an artist's rendering of what the world could be like if everything went the way we wanted it to. However, it is only one possibility out of millions. It is not clear for more extreme cases whether the design year land use plan can even be achieved. By this I mean to question whether it is sufficiently within the control of the planning and decision-making group that it can be achieved. "It may be," as the old-timer from Maine said to the tourist asking directions, "that you just can't get there from here." Even if we could get there from here, the intermediate steps would still be important. In fact, I would argue that how you get from here to there is actually more important than where you are when you get there. The time value of money offers an analogy that is valid in this context. The economist discounts each year by the factor $1/(1 + i)^n$. Therefore, money available in the first years of the series contributes more importantly than that available later. For any time series in which the interest rate is fairly large the 20th year may be inconsequential. This suggests that the sequencing of a transportation plan may be more important than the final plan itself.

Furthermore, in our world it is naive to believe that any plan can be constructed exactly as conceived. The best laid plans sometimes go awry, and we must plan for that occurrence. In extreme cases the inability to finish important links in a freeway system will render the entire system useless. In all cases the benefits measured for the completed system are quite different from those for the incomplete system. Therefore, to select a strategy promising early benefits from where we are now is better than to plan on being able to build an entire system as conceived.

I am not arguing that it is fallacious to attempt to complete entire systems, including ring-roads, innerbelts, and bypasses. I am merely pointing out that to plan for a design year is starting at the wrong end of the process. The design year plan can be argued, and usually is. It can be obstructed, and usually is. Finally, it can be modified, and usually is. Therefore, to base our entire planning on the benefits achievable for a completed plan, whether the plan is predicted or prespecified, is fallacious.

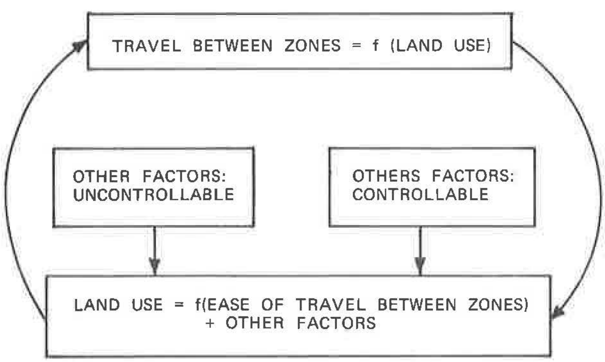

Figure 1. Land use and travel interrelationships.

A better approach would be to start with today's system and to introduce changes. These changes can and should be time-sequenced steps toward some long-range plan or, better, alternative plans. The emphasis, however, must be on the short-term future and on achievable first steps, with flexibility left for alternative future steps. These first few steps are, or should be, realistic, achievable steps based on solving today's needs. They should add up to longer range goals as well, but by concentrating the planning efforts on the achievable, we introduce realism into the process. This also reduces the chance of being seduced into believing that the unachievable can be had by merely wishing for it. Showing how these first steps are related to the long-term goal makes it more achievable. Many a planning report is gathering dust on a shelf because it did not indicate the first steps toward the recommended long-term utopia.

A point that must be understood for any planning process to be put into practice is a careful definition of the control variables and who holds them. It cannot be assumed that an enlightened group of decentralized decision-makers will convene and act in concert for the public good. One must instead take the more limited view that only those control variables that are in the hands of the authority doing the planning can actually be manipulated. This was dramatically illustrated for me by comparing the Colombian Transport Plan prepared for the Minister of Public Works of the Republic of Colombia with the Northeast Corridor Study, which, although prepared for the U.S. Secretary of Transportation, is really more for Congress. During the course of the Colombian model studies, actual construction projects were recommended, and the Minister could initiate construction activities almost immediately. In contrast, for the Northeast Corridor Study, the recommendation is only the beginning.

LAND USE AND TRANSPORTATION

Most transportation planning processes and models involve implicitly or explicitly the assumption that land use is not affected by the location of transportation facilities. This assumption is the obvious corollary of using the concept of a design year. Many transportation planners know that the assumption is not true. Others adamantly refuse to admit it. If the design year land use plan could be influenced by the way transportation develops during the interim, the whole concept of a design year would be in trouble. Furthermore, this fact, if faced directly, would render today's planning models inadequate. Thus, it is easier to believe that transportation is incapable of causing a change.

It is clear, however, that transportation does influence land use by affecting the choice of location for various enterprises. Some establishments, such as gasoline stations and restaurants, depend quite directly on highway traffic for their livelihood. Where these establishments have been bypassed by controlled-access facilities, many have become unprofitable and failed. Certain industry types appear to favor locations along expressways. Interchanges, in particular, are sites for industries requiring access to skilled employees over a large portion of the urban area and large parking. Likewise, large suburban shopping centers appear to favor locations near freeways.

The major arterials are the primary locations for a number of establishment types, including automobile sales and service, strip commercial, and other service-oriented industries. Residential locations also require some form of access, although direct access to freeways is not as important. Multifamily dwellings by contrast are almost always located near some form of public transportation. Service industries are frequently located in the central city, replacing older industry forms such as warehouses and manufacturing. At the margin of the urban area, land is either unoccupied or occupied by lower intensity land uses such as agriculture, forestry, or recreation. This margin is clearly related to transportation.

If, as we believe, land use is a function of transportation, this has a number of important implications both for the system and for the planning process. Let us first examine the real world process set in motion by introducing a change in the system.

Once a transportation facility is installed in the real world, there is then a certain amount of adjustment to it. This phenomenon is typically obscured by the overall growth of the system, but there is always a sort of dynamic equilibrium between use of the transportation system and land use. When trips are easy and cheap more trips are made. Trips divert from other paths and other modes, and relocating parties find it to their advantage to avail themselves of the relatively cheap commodity—transport—by changing locations. As trip-making becomes more difficult and costly, trips are curtailed or rescheduled to off hours, and finally changes are made in location.

Similarly, if a poor choice of transport facility location is made, initially there is a certain amount of healing that goes on within the system to correct this poor choice location. The nation's commuter railroads offer one case in point. It was not anticipated at the time of the location of most of these facilities that they would become unprofitable to operate. The residential location decisions made by many individuals place a tremendous pressure on the authorities to maintain this uneconomical service long after it should be discontinued. Although it is not clear what the economic impact of discontinuing this service would be, it is clear that it would be substantial.

The dynamic equilibrium that is set up between land use and transportation is in all probability a very imperfect one. The relocation of industries and residences takes time, and the nature of the fixed facilities associated with some industries may make them unusable for other occupants. It may therefore be necessary for an industry to completely amortize its present equipment before it can move to a new location because there is no market for the old facility. Transportation is obviously not the only factor of importance to the location of industry and individuals, but it is clearly one of the factors and could therefore be used as one force helping to establish a particular land use.

Our current transportation planning processes do not account for land use that changes in response to the transportation facilities provided. Although there are a number of studies and reports that acknowledge the fact that land use is shaped by accessibility, there are only a few urban transportation planning efforts that have explicitly incorporated this into the basic model structure in an operational way (5, 6, 7). Most of these treat land use in a one step, design-year fashion. Current procedures are more like those shown in Figure 2 (8). The steps indicated in this figure include

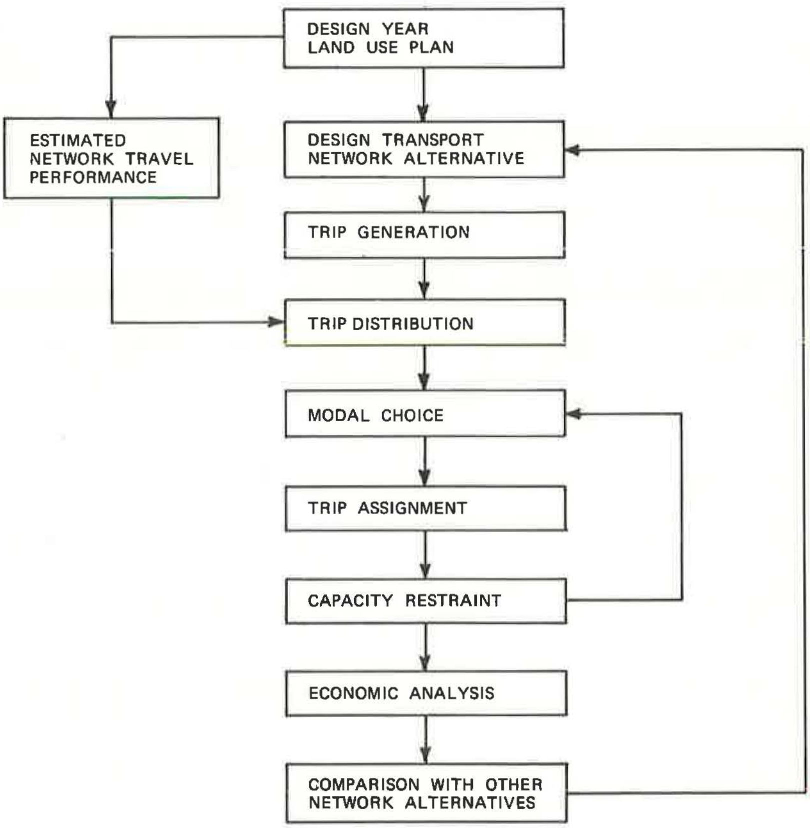

Figure 2. Simplified current transportation planning procedures.

land use forecasts typically for the design year, trip generation based on empirically determined generation rates found in current land uses, and trip attraction based on estimated network travel performance. This last step involves use of one of the traffic assignment models, such as the well-known gravity model or something equivalent. This is followed by modal choice, traffic assignment, and capacity restraint routines for most studies.

Although it is generally recognized that the capacity constraint portion of the assignment must be iterated until the traffic volumes assigned to each link remain fairly stable over several iterations, it is not generally appreciated that the same kind of iterative procedure must hold for the trip attraction portion of the assignment process. The gravity model must use as input the estimated network travel performance from point to point, sometimes known as "skim trees". Yet, there is usually no attempt made to check final travel performance on each link of the network with the estimated network travel performance used as input to the gravity model. Presumably if a different set of skim tree inputs were given to the gravity model, the assignments could turn out to be quite different. At present, good practice does not iterate until a consistent set of outputs has been achieved.

Another point on which the current procedures could be greatly improved is the elimination of the assumption that trip-making is independent of the level of traffic service provided. This is the direct consequence of separating trip generation and attraction. Models for accomplishing this improvement already exist (9) and could easily be incorporated into the existing structure. They would replace both trip generation and trip distribution models. They have the advantage of possessing behavioral parameters, thus obviating the need for separate calibration in every application. The inputs for such "econometric travel demand" models would be supplied by descriptions of land use on the one hand and travel performance on the other and, like the suggestion of the previous paragraph, should not be iterated until all outputs are consistent.

The concept of introducing a model to predict changes in land use arising from changes in accessibility into the procedure and running the model on a year-to-year basis complicates the process and to date has been untried in practice. Yet, this appears to be a logical next step.

For me, the implications for urban transportation planning models are quite clear. First, we must have models that show how the entire urban area will grow over time in response to changes in the transportation system. The models must link together the urban economy, the land use, the travel patterns, and their influence on the future location of industry and residences. The overall structure of the model would be somewhat as shown in Figure 3. Here, the overall operation of the model shown would occur once during every period of time simulated. Thus, if the time increments were years, the entire process would be run for every year of a simulation. The status of both transport network and land use would be maintained internally and updated yearly as exogenous changes were introduced.

The comprehensive nature of such models must not deter us from their exploration. The models may turn out to involve as much effort on the housing market portion of the model as in the transportation portion. The nature of the spatial competition for land and between industries must also be involved. It will be impossible to have practical planning results available from the first uses of such models to meet specific planning deadlines. It therefore appears that it would be unwise to organize model-building efforts in such a fashion that they would be called on to produce detailed planning studies for actual implementation in the real world as a prime responsibility. This unfortunately is what happened to the Penn-Jersey study, in which many of the scientific aspects of that work had to be neglected and eventually abandoned (10). At the same time practical planning was severely shortchanged and much criticism was lodged against the overall study for that reason. It will, however, be crucial to have these studies directly associated with real cities and with real decision-makers.

Although the models proposed here are meant to be comprehensive, everything cannot be done with the same set of models. Each set must be relatively policy-specific. Because the subject of interest here is transportation, these models must be transportation-specific. That is, they must include those aspects that bear directly

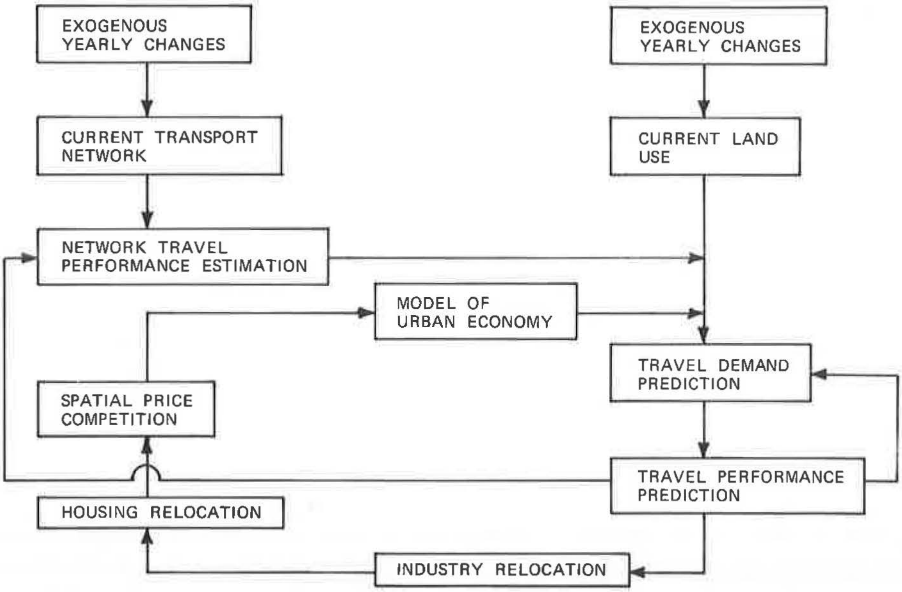

Figure 3. Simplified proposed urban growth model for use in transportation planning.

on transportation planning, but must necessarily ignore other aspects that may be of broader policy interest, e. g., the social aspects of the ghettos.

Examples of the type of models that I am proposing are suggested by both the Harvard work in Colombia and the Northeast Corridor Study. Both use integrated economic and transport models. Both involve multimodal multiattribute transport networks. Both embody the concept of a system that grows over time with feedbacks from one time period to the next. The elements of the Colombian model were so tightly interconnected that it was possible to make 10-year runs in the computer without manual intervention. Both studies, however, are concerned with interregional travel, location, and spatial equilibria instead of the more difficult process within the urban area.

SYSTEM EVALUATION

A common misconception is that the desirability of a transportation plan can be determined by comparing flows on alternative designs using the output of the transportation simulation models. If, in fact, the only changes in the entire system under evaluation were those in the transport system, there would be some measure of truth in this approach (11). However, if the total environment in which the transportation system is functioning is allowed to change with industry and residence relocations, changes in the trip-making propensity of the public, and shifts in the nature of the urban economy, then there can be trade-offs in which higher transportation costs are traded for lower costs somewhere else in the system. In this case it is no longer possible to treat transportation as a separate entity, if in fact it ever was.

In fact, the purpose of the transport system will always be found outside the system itself. The transport system can be used to promote more efficient production, to allow easier access to goods and services by individuals, or to create a more pleasant environment. Increases in any of these goals cannot be measured on the transport system alone. This was obvious from the start in the case of the Colombian study, and evaluation in terms of the state of the economy were substituted for the more conventional cost-benefit studies, although comparisons between the two approaches were illuminating (12). This was also recognized in the corridor project, and studies of comparative evaluation strategy were undertaken (13).

The fact is that the external effects are extremely difficult to measure and to evaluate. For example, it appears that one of the benefits of increased freeways is to allow industry to move to low-cost, more efficient, one-story plants with easily available parking. Families have been motivated to move to the suburbs to achieve the amenities of more open space and individual housing. Likewise, commerical retailers have found that one-story shopping plazas with easily provided parking are also more efficient than the downtown location. Although we have yet to measure these savings in a careful way, they are undoubtedly partly the product of improved transportation.

Finally, the whole question of environmental quality is becoming increasingly more important as our society grows in affluence and complexity. In the same fashion that a family may choose to use its income to secure a home with special amenities, as opposed to one that provides housing at the most economical level, so may an urban population decide that it wishes to have an environment that is somewhat nicer or one that emphasizes characteristics different from those in other urban areas. At the moment we do not have sufficient mechanisms whereby this kind of public decision can be made. Nevertheless, it is clear that the transportation system offers one of the most powerful tools for shaping the urban environment from an aesthetic point of view.

One of the problems in this regard is that at the moment transportation planning authorities are not delegated responsibility for planning the total environment of the city. Rather, they are charged only with the responsibility for providing an efficient transportation system. Legally, they probably could be found guilty of manipulating the transportation system to produce a given form of land use. Although this appears to be a legitimate goal, it is certainly not the intent of the legislation under which most transportation planning authorities are currently working.

Our society could decide (and portions of it have) that the noise, pollution, and frantic activity involved in urban living are just not worth the benefits received, and they could revert to a somewhat more aboriginal existence. The alternative is to seek to improve the quality of urban existence. In this endeavor, the transportation system is likely to play a major role. Urban growth models will be indispensable to this type of planning. These models will be used to find how to grow the city in a more environmentally acceptable way. The problem may be akin more to gardening than to engineering.

ACCURACY OF RESULTS

Current planning models produce an exceptionally large amount of output. The traffic flows for every major link in the system are typically produced, including turning movements for each intersection. These flows are frequently factored to give peak hour and off-peak hour volumes as well. Because these figures are produced for the design year, they are invariably used by the designing authority to help size the facilities being designed. For planning new freeways, these figures are frequently used to determine the number of lanes, the placement of ramps, and the timing of traffic signal devices. Although most planning authorities recognize that these figures are not sufficiently accurate to be used in this fashion, there are no alternative figures, and it is difficult to admonish the design engineers that these figures should not be used.

In spite of the fact that these are the only figures available, there are major distinctions between the planning models and the real world. Within the planning models there are no traffic queues. Within the real world queues, both traveling and stationary, are perhaps one of the most noticeable aspects of an urban transportation system. When a traveler arrives at a constricting point, it is necessary for him to wait his turn before using that portion of the facility. There is, to use the words of the hydraulic engineer, "ponding in the system". Current planning models do not involve system dynamics, and relatively little work has been expended on developing them.

My general feeling is that limited use should be made of the output of the planning models, if they are used at all. It would be far better if the facilities were designed from the point of view of maintaining consistency for the using volumes. If, for example, the input to a particular road segment is metered, then all flows downstream can use this figure as an upper bound on flows, unless it is anticipated that the input constraint will someday be eliminated. Conversely, by metering inputs, we can guarantee travelers a given level of service in this section. Adequate thought must be given to these effects of backup and ponding during the design phase.

For use in design, it would be extremely beneficial to have models that were dynamic in time over very short time increments, perhaps as short as 2 to 5 minutes. These models should treat subareas or corridors of the transport system, not the entire network. They should show the places where queues will build, their lengths and dispersal times, and queuing statistics such as the average holding time and maximum holding time. Instead of developing these models for design, we have concentrated on building large networks. We talk now of networks with 10,000 or more links. Such networks are extremely difficult to work with, from the standpoint of both computer time and programming, as well as in the data collection and use phase.

It is extremely doubtful that using such large networks does much for us in the way of planning. A great deal of effort is required to define the network and all the inputs, yet the principal planning on design effort is being directed toward only a few links in the overall network. An infinite number of technical difficulties manage to keep us from focusing sufficiently on these critical links. It would, in my estimation, be more productive to redirect the time and effort spent on working with large networks to working on smaller networks treated in a dynamic fashion.

It is possible to develop simulation programs that handle traffic flow in a time-dynamic sense. These programs would simulate the behavior of traffic flowing over street systems or freeways in which queue formation and dispersal could be studied and design alternatives explored. Of necessity, the programs would involve considerably more detailed input in geometric design and in terms of signal timing, parking, and off-highway interference. Nevertheless, the exercise would be extremely beneficial for both freeway designers and transport system analysts. Although there have been a few good starts toward the solution to this problem, nothing really practical has resulted to date.

Experience with the transport networks involved in the Northeast Corridor Project suggests that we will have some problems in extricating the corridor of interest from the larger network. One approach to handling this problem is to use a spider network covering the overall system within which important systems interactions occur and superimposing the detailed network within the area of most intense interest. By this device the trade-offs between the system of interest and the remainder of the environment can be captured while preserving a manageable-sized system overall. Other techniques will have to be evolved for detailing some systems components while allowing others to remain only grossly defined. With more experience this will become easier.

Using these techniques, we can concentrate more of our attention on the planning phase and the design phase as separate endeavors. It should be possible to redirect some of the efforts of the planning phase from overconcern with the very large networks we are presently using to smaller networks studied in a more comprehensive manner. This would allow room in the broader scale planning effort to concentrate on such topics as sequencing over time, land use, and industry location as an explicit part of the planning process.

CITIZEN PARTICIPATION

The problem with trying to involve more citizen participation in the planning process is that there are at present too many actors controlling too many control variables. From a model-building point of view the number of combinations of alternatives is extremely large. To have a group of uninformed citizens entering into the process, each with his own set of biases and without the right organizational mechanism for incorporating suggestions, appears to be inviting chaos. For planning purposes it would be far simpler if decisions could be centralized.

There is no denying that increasing the number of participants in a decision makes the decision that much more difficult to achieve. Yet, it is also clear that planning is a sociopolitical process. Changing the transport system in the real world will undoubtedly affect some people more and some less, some adversely and some beneficially. The silent (and only slightly affected) majority has a stake in the planning process, but so does the highly vocal minority that is being affected in a major way.

It is important to recognize that the people who are displaced by a transportation facility improvement are compensated for their inconvenience, although the compensation is in many instances less than the damage, particularly for the old and the poor. The loss of housing does pose a threat to many. Families that can least afford it may be affected in an adverse way and marginal businesses may be closed. The people who are left behind, however, are frequently affected adversely without compensation. Although it is difficult to provide adequate compensation in all cases, in the interest of equality some kind of compensation should be arranged for this group. Although larger payments to affected parties may be in order, even more important is a sensitivity on the part of planning officials to the effects that transportation changes can bring.

To be useful at all in a broadly participatory planning process, the planning models we devise must be able to trace the incidence of benefits within the system. It will not be enough to know the total net benefits of a particular plan; we must know that one group will be net losers while others realize a net gain. Only then will it be possible to design adequate compensation schemes and to preview the political repercussions of various courses of action. This proved to be true in the Colombian study in terms of trade-offs between both regions and industries. I would therefore argue that instead of a reduction in planning models, it will be necessary to increase the scope and usefulness of these models and that they will be applied more and more to study the sociopolitical consequences of an improvement or change to the transport system.

In summary, then, urban growth models of the type I have advocated appear to be a useful addition to our planning repertory. Having appropriate facts at hand may not make political decision-making any easier but, by the same token, it is unlikely to affect it in an adverse manner. By clarifying the complete set of consequences that will result from a transportation improvement, we can improve public confidence in the planning process.

CHALLENGES FOR URBAN TRANSPORTATION PLANNING

Urban transportation planning has come a long way from the days of the Fratar model, but it still has a long way to go if it is to contribute to the solution of the major problems in our cities. The next decade promises to be the era of the city. It is clear that this is where the major growth in our economy will lie. Money for urban development may eventually be forthcoming. Even then, however, there will never be a time when efficiency and economy can be ignored. The planning model and the computer will be immensely useful if we have developed the needed models and if we understand their use.

The greatest challenges to effectively performing our role as urban transportation planners are, therefore, as follows:

1. Recognizing that current urban transportation planning has stagnated in the building of new models and is failing to adequately address the pressing model-building issues of the current time;
2. Admitting that, although today's models are useful, they could be made more useful if we restructure them to eliminate the hidden assumptions outlined in this paper;
3. Recognizing that future models must be based on a true desire to understand the urban growth phenomenon (this may require subordination of transportation until its role is better defined);
4. Developing future planning models that are dynamic over time and that incorporate submodels of industry and residential location along with models of the urban economy;
5. Ensuring that our preoccupation with models does not hinder our search for new technology and ways to apply it and realizing that new technology can solve our problems only if we understand what its full impact will be on the urban growth process; and

6. Seeking more effective ways in which the planning process can be integrated with decision-making and allow grass-roots participation.

The challenge to urban transportation planning is a challenge to how effectively we can utilize the model-building capability we are slowly acquiring, the computing power we have developed, and the understanding of the nature and purpose of planning we have discovered to explore the possibilities that the technology of the future holds for the city.

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