3. Vehicle-counting techniques (including vehicle occupancy).
4. Transit-usage counting or monitoring techniques.
5. Collection procedures for air origin-destination data.
6. Collection procedures for rail origin-destination data.
7. Study on the continuing data collection process.

Long Run

1. Environmental monitoring.
2. Travel behavior monitoring, including origin-destination updates, trip generation changes, trip purpose splits, modal choice, and peaking characteristics.
3. Monitoring of relation changes between urban development and transportation policies.
4. Traffic and physical system inventory by satellite.

Resource Paper

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The movement of goods and the provision of services by the transportation sector typically account for approximately 20 percent of the gross national product of this country each year. Problems in the transportation sector, such as a lack of facilities (for example, railroad cars) or of power (for example, crude oil and gasoline), will usually have serious repercussions throughout the economy. In the case of a lack of rail cars, the effect is relatively localized and the impact is limited to a small part of the economy; there is enough flexibility in the total transportation infrastructure to permit shifts to occur. The consequences of such facility shortages may be a difference of only a few cents in the cost of some goods. In the case of a lack of basic energy to drive the transport sector, it is clear that we are only just beginning to realize the implications for the economy and our way of life.

Partially in recognition of transport's importance to the economy and the interdependence of the modes of transport, modal agencies in many states have begun to shift to departments of transportation charged with a responsibility to plan for the total transport needs of the state. (By August 1973, 20 states had created departments of transportation, and 12 others were studying legislation to enhance the state's role in multimodal transportation.) Other factors have prompted this shift in responsibility and structure as well: changes in the values of the users of transport services and recognition that, although highways can provide extremely good service for most travelers, they can seriously disrupt urban areas and impose social costs that may well outweigh the benefits. Many states are, in fact, having considerable difficulty constructing any new highways, both in urban and rural areas, primarily because of environmental and social concerns. These problems will most certainly be compounded by fuel shortages.

Because of all these factors as well as the problems and the recent changes in institutional structure and funding, state transportation agencies must now consider a whole new set of options in maintaining and improving transportation services. The Environmental Protection Agency has proposed an impressive list of options as alternative ways to meet environmental standards in urban areas (3). These options range all the way from improved traffic flow programs through pricing and regulation to a restructuring of public transit services. Although not designed as such, they may turn out to be viable alternatives for easing the current energy crisis as well. Those options, listed below, are arranged in 3 groups according to the primary purpose intended to be achieved.

I Reduce motor vehicle-miles of travel
 A Transit operations
  1 Bus lanes on city streets
  2 Bus lanes on freeways
  3. One-way streets with two-way buses
  4 Park-ride, kiss-ride (A situation in which a passenger is driven to a public transportation terminal and dropped off has come to be called a kiss-ride)
  5 Service improvements and cost reductions
 B Regulation
  1. Parking bans
  2 Automobile-free zones
  3 Gasoline rationing
  4 Four-day, 40-hour week
  5 Congestion passes
 C Pricing policy
  1 Parking tax
  2 Road-user tax
  3 Gasoline tax
  4 Car pool incentives
II Increase efficiency of traffic flow
 A Freeways
  1. Reverse-lane operations
  2 Driver advisory displays
  3 Ramp control
  4. Interchange design
 B. Arterials
  1 Alignment
  2 Intersection widening
  3 Parking restrictions
  4 Signal progression
  5 Reversible lanes
  6 Reversible one-way streets
  7. Helicopter reports
 C Traffic improvements
  1 Traffic-responsive control
  2. One-way street operations
  3 Loading regulations
  4 Pedestrian control
  5 Traffic Operations Program to Increase Capacity and Safety (TOPICS)
 D Staggered work hours
III. Apply supplementary motor vehicle emission controls
 A Inspection and maintenance
 B. Idling restrictions
 C Retrofit of emission control devices
 D Conversion of gaseous fuels

As a first and continuing step in helping transportation planning to cope with the multitude of factors facing it, the Transportation Research Board (through NCHRP) and the U.S. Department of Transportation have sponsored a number of research projects that are designed to produce new multimodal planning techniques and procedures. They have also sponsored a number of conferences intended to summarize the state of the art and to produce recommendations for future research. Most of these conferences have been oriented to urban methodology and issues to date. The most recent were conferences on urban travel demand forecasting and citizen participation in transportation planning and air quality. In addition, one conference on state transportation issues in the seventies addressed the organizational and financial issues of states. This present conference is the first one aimed directly at discussing the full range of critical issues in statewide transportation planning.

The primary focus of this paper, which was prepared as a resource paper for Workshop 3A, is on passenger travel demand forecasting methodology, but it is obvious that priority programming, citizen participation, and a whole host of other issues strongly related to statewide transportation planning must be interrelated with the methodological issues of passenger travel forecasting. It should also be obvious that the list of issues for Workshop 3A is far too broad and far too encompassing to be addressed adequately by a single resource paper.

The purpose of this paper, therefore, is to present a brief survey of existing state methodologies, to discuss the desirable attributes of a statewide passenger planning and programming methodology, to outline a program of long-range research, and to identify what can be done immediately to improve the existing methodology available to state transportation agencies.

This paper has 5 major sections: (a) emerging issues facing statewide planning as background for methodology for statewide planning and programming; (b) existing methodology for statewide planning and programming; (c) proposed improvements to statewide planning and programming methodology; (d) continuing statewide planning process; and (e) summary and conclusions.

EMERGING ISSUES FOR STATEWIDE PLANNING

In response to changes in technology, demand, and most notably, societal attitudes and values, transportation planning has had to undergo during the past few years significant adjustment in the institutional structure and in the process and procedures used in planning. For example, many changes are now occurring in metropolitan transportation studies through the establishment of regional planning agencies (RPA), such as increased public participation and an emphasis on planning being done at the lowest possible local level. Massachusetts (5) is one example of an urbanized state where RPAs bear the major responsibility for preparing plans and setting priorities. California is also relying heavily on its 41 RPAs to produce the transportation plans that will be the basis for the 1976 state transportation plan; West Virginia, a predominately rural state, is also emphasizing regional agencies.

At the national level, federal funding procedures appear to be heading eventually toward multimodal funding, and there are new legal requirements for the consideration of social, economic, and environmental factors. Many states are in the process of preparing state multimodal transportation plans and developing state planning methodologies. [NCHRP Synthesis 15 (6) provides an overview of the methodologies used by various states up to 1972.]

Not surprising, there is a general feeling that the issues emerging at the state level are of an order of magnitude more complex than urban, regional, or perhaps even national issues. Based on the previously mentioned conferences, reports, and personal discussions with perople responsible for state planning, it appears that there will be considerable controversy over the appropriate methodology for statewide transportation planning simply because of the small amount of previous effort in this area and the paucity of data at the state level.

There are, however, additional reasons for the complexity that exists at the state level. The report of an earlier conference (4) summarized what that conference considered to be the major issues facing state transportation agencies in the next decade.

1. Organizational Issues Should a state organize functionally or modally? What is the role of commissions? Who has the responsibility for planning, for construction?
2. Intergovernmental Relations in Transportation How can problems with the U S Department of Transportation be resolved? What should be the relationship of states to local government?
3. State Regulation of Transportation Should the regulatory and planning functions be integrated? If not, how should they be coordinated?
4. State Financial Issues How are revenues to be raised? Should there be general or modal funds? How active a role should states have in mass transit?
5. Aviation What is the role of the state in financing, planning, and constructing airports and upgrading the overall air system and its access modes?
6. Highway Issues Who decides the role of highways in the seventies? How is coordination with other modes assured? How are they to be financed? How are

environmental concerns coped with?

7 Railroads How much role should states play in planning rail improvements? What about the issues of rail safety enforcement and rail-highway grade crossings, relationship with Amtrak, and the states' role in abandonment and relocation?

8 Multimodal Planning How is multimodal planning carried out? How is it different in a rural state versus an urban one? What is the effect of lack of multimodal funding?

Although these issues are significant and must be resolved, they are also fairly broad and encompassing. Some will be many years in debate; some may never be fully resolved. There are a number of methodological issues, however, that must be handled in the immediate future regardless of the resolution of the broader issues described above. Moreover, these are issues that can be addressed effectively and, if resolved, will support an agency's ability to deal with more complex policy level and organizational issues in a flexible manner.

The position of this paper is that there are 4 major emerging issues with which any methodology for statewide planning must deal. These are discussed in the remainder of this section.

Changing State Role in Transportation Decision-Making

Many states are beginning to identify a wide range of state interests that complement (and, in some cases, conflict with) previously established transportation interests. These include interests in land use, economic development, air quality, and energy conservation. For example, significant questions are now being raised by segments of the public and government concerning environmental quality and development patterns for the state as a whole. California (7) recently instituted a Coastal Zone Policy and is reconsidering the question of highway investments in general in its coastal area because of environmental concerns. Should the state initiate overall state goals as to environmental objectives and their relation to state transportation investment policy, or should it merely respond to crisis? Obviously, the state must take a much more active role in statewide land use (as well as transportation) planning and policy formulation if the critical environmental and developmental issues now being recognized are to be carefully considered. Although they are able to articulate statewide goals and objectives in general terms, the states must now move to define them operationally so as to identify and resolve conflicts. [Many states have defined their objectives in a simple and straightforward manner similar to the way in which urban studies defined their objectives in the early 1960s. Many others recognize the difficulties with such an approach and are attempting to define statewide objectives more flexibly (8).]

The changing role of transportation agencies will also involve the interaction, coordination, and resolution of conflicts among different functional planning agencies of the state. Departments of recreation, economic development, health, education, welfare, and even agriculture have significant stakes in the development patterns that will occur and the transportation investments that lead and in some cases follow those patterns. In some states, interaction and cooperation have already begun. In others, the state transportation department is aware of the organizations that exist, but understanding their functions, the available data sources, and how to coordinate them is only in a preliminary stage.

Furthermore, in many states the emergence of distinct regional variations in objectives has resulted in conflicts between state and region and among regions. For example, rural regions now want to control growth in some areas while urban regions still want access to rural areas in order to improve recreational opportunities. This requires a state transportation planning framework that recognizes the conflicts in goals and provides the process for resolving them. Moreover, it requires a process that recognizes the competition among regions, between regions and the state, and, in some cases, even between states for a limited set of resources.

Competition Among Modes

Modal competition exists in some form or other in all states. Even in the more rural states where the primary mode of passenger travel is by automobile, rail and trucks are in direct competition for goods movement. Because trucks must share the existing highway facilities and rely on the mobility provided by the highway network, ignoring this competition in planning facilities in terms of scale, location, and design standards leads to inefficient investments and perhaps even distortions in the transport sector.

In the more urbanized sections of the country, this competition is even more dramatic and is certain to be accentuated by environmental issues and fuel shortages. The issue is how to resolve the trade-offs that exist among modes. Given that some broad consensus can be reached in development objectives and that conflicts among regions and between regions and the state can be resolved, how should investments be made to effectively reinforce state and regional policy? What are the most efficient investment levels for each mode given an investment picture involving both public and private interests? What is the methodology required to help make those trade-offs?

Citizen and Community Participation

Citizen participation, community interaction, and public involvement are all synonymous with a much more participatory, grass-roots level of interaction between the public and the technical and political interests involved in making public investment decisions. A number of experiences in citizen participation at the local level have been extremely successful while others have not. [The Boston Transportation Planning Review (9) is one of the most elaborate and successful studies involving community participation to date. Atlanta (10) and New York City (11) have also had considerable success with citizen participation.]

At the state level, however, it is difficult to tie the effects of the issues being discussed to the interests of particular individuals or groups. Often the discussion of long-range resource allocations and policies is so abstract that many interest groups cannot understand why they should be concerned. [New York State (12) undertook a series of community interaction meetings that were thought to be extremely successful in getting both involvement and agreement.] As a result, major issues that might block the actual implementation of a project or program do not emerge until planning has progressed well beyond the state level. The challenge, therefore, is to develop a participatory and iterative process that can identify the critical statewide issues (e.g., land use control, economic development, and transportation level of service) that must be resolved in statewide planning and to actively stimulate the participation of interest groups in discussion of these issues (i.e., by making the effects of such policies as explicit as possible). Although implementation can never be fully assured at the state level, only through more effective participation can higher quality, responsive state policies emerge. The methodologies for statewide planning must recognize and encourage this kind of participation.

Equity

The final issue to be addressed by any statewide methodology is the equity and the distributional effects of investments. No longer can we evaluate alternatives in terms of "benefits to whomsoever they may accrue." [This was the general phrase used in federal legislation in the 1950s and incorporated in the traditional highway benefit-cost analysis procedures (13).] The distributional impacts do matter and will become increasingly important—truck versus rail interests, agricultural regions versus urban areas. (To date, most of the equity issues of regional significance have been ad hoc. For example, many states have handled regional equity problems by mandating that certain minimums be spent in each county or district whether or not there are projects high enough on the state priority list.) Different income groups within and between different geographical areas will become interested and want to know how their interests are being reflected. Moreover, the demands for statewide services will be different for different groups. What most certainly cannot be accomplished, which some have alluded to, is to construct a welfare function that collapses the values of these different groups and makes interpersonal aggregations. On the other hand, it is possible to develop a statewide technical planning and programming process that recognizes these equity issues and provides the political and policy level people and the affected public with enough information on distributional effects to enable them to make trade-offs and resolve conflicts. The issue of equity has considerable implications for the methodologies and models used for predicting demands, evaluating alternatives, and making programming decisions.

In addition to the 4 major issues cited above, a number of problems of a more procedural or mechanical nature must also be resolved before there can be an effective statewide planning process.

1. Should statewide planning focus on the long run and only concern itself with horizon or target-year plans some 20 to 30 years in the future? Or, to have credibility, must it be integrated with shorter run plans and actual programming decisions in a time-staged, sequential investment sense? There are significant trade-offs to consider in terms of cost and time of analysis versus relevance of the planning and programming process.
2. What is the appropriate level of detail required in the statewide planning effort? How does a statewide plan match the regional plan projections? How effective is a spider network at a relative abstract level of detail? How many zones should be used? A number of states are using 2 zone systems, one on the order of 1000 to 2000 zones and another on the order of 100 to 500 zones.
3. How is the overall state plan developed, and what is its relation to urban, regional, and corridor studies? Is the state plan merely a composite aggregate of regional plans?
4. What are the data requirements for statewide planning? What new types of data are required for the new models for predicting travel and economic and environmental impacts? What sample size is required for surveys? What mixture of screen-line counts, origin and destination surveys, and license plate surveys should be used?
5. What new tools are required for statewide analysis? What new tools are required to address the multimodal issues emerging at the state level? Where and when should we be using specialized, single-mode models? Should we have alternative levels of models for addressing different problem types?

Conclusions

The tentative conclusion one reaches from considering all of these issues and how they have been handled to date is that considerable research, development, and implementation need to occur in a wide variety of areas of statewide planning. And even then there will be mistakes and we will have to revise and adapt our methods and techniques. For example, it is becoming clear to many states that existing UTP procedures are not sufficient, and perhaps not even appropriate in their present form, for statewide multimodal planning. It is also clear that the present interface between planning and programming is extremely weak. A set of criteria is needed, broader than the present set, to be used in determining multimodal needs and performing evaluation if statewide planning is to be effective. Overall, the information flow among state agencies on statewide planning has been extremely limited. Much better dissemination is needed of information about ongoing research and practical methods of citizen participation; economic, environmental, and travel prediction techniques; methods for integrating state and regional plans; and so on.

What Can Be Done?

The previous sections have painted a rather bleak picture of the existing situation faced by statewide planning organizations. The situation is not hopeless, however. A number of techniques that are or soon will be available at the urban level can be adapted to statewide planning. Fairly elaborate and useful new packages of systems planning tools in a number of states are already available for use by other states. The first requirement for state transportation agencies, therefore, is the development of a careful and deliberate strategy of improvements, both short and long run, that (a) integrates the methodology that can be adapted, (b) develops the research required to produce techniques and tools in the areas needing them, and (c) evolves a coordinated statewide modeling and analysis system useful for evaluating the transportation investment decisions facing us in the next few years. Moreover, what is required is a process that brings out the issues described above—modal trade-offs, spatial and interpersonal equity considerations, ecological and environmental impacts, and intersectoral trade-offs such as the effectiveness of transportation investment relative to health, education, welfare, recreation, and housing.

The presentation in this paper will outline the initial and immediate steps required to develop and implement the models and methodology necessary to support the identification and resolution of these issues.

EXISTING METHODOLOGY FOR STATEWIDE PLANNING AND PROGRAMMING

The previous section outlined what appear to be the major emerging problem areas at the statewide level from a very broad perspective. The intent of this section is to present a brief survey of the methodology currently used by states in resolving some of these issues, analyzing how successful it has been, and presenting the major deficiencies with this methodology. In part, the survey has focused on the methodology used by highway agencies, not by design but because multimodal concerns have only recently been incorporated in newly formed departments of transportation. Where possible, this section also reviews methodology that has been developed for multimodal analysis and could be used at the statewide level. The following section will then discuss revisions to this methodology to overcome these deficiencies, building on the framework that exists in many states and the techniques currently available. In all cases, the revisions are intended to allow the process to become more credible and policy-oriented by becoming a multimodal process.

Overview of the Planning and Programming Process

The following description is paraphrased from a report by Krecji (14, pp. 16-25). It is only a general summary of the components of and interface between planning and programming. A more detailed discussion of a particular state's planning and programming process and the interface and flow of information are given by Neumann (15).

Although each state has its own unique approach to planning and programming, there are some basic similarities and some major differences in how these functions are defined and how they are carried out. We will define these functions to be sure terms are understood, to specify the interface between them, and to serve as a background for the problems presented in the following sections.

Capital investment planning is one of a number of responsibilities of most transportation agencies. Its purpose is to determine desirable improvements to the existing transportation system. This includes improvements such as major capital additions to the existing network (safety improvements, new construction, operational improvements), maintenance improvements (resurfacing, continuing maintenance, spot improvements), and, in some instances, provision of assistance to other agencies (TOPICS, rail crossings, county assistance).

Investment planning, perhaps the most important function of a state transportation agency, generally consists of 6 major activities: fiscal planning, system planning studies, programming, budgeting, scheduling, and project development phases.

Fiscal planning is a broad term meant to include several subactivities: It involves forecasting of revenues and analyzing of alternative financing methods such as bonding or pay-as-you-go financing for highway improvements. As part of fiscal planning, the allocation of the burden (i.e., who pays the taxes among the users or nonusers) is determined. For example, among users, how much should truck travel pay compared to passenger automobile travel? Fiscal planning, also as defined here, must be concerned with the allocation of revenues. After revenues are collected, the decision must be made of how they are allocated both among different districts and among different functional classification systems such as a primary, secondary, or Interstate system. Fiscal planning, in addition, provides information and necessary input for the programming activity.

The second major activity of the investment process is referred to as systems planning or preliminary studies. This involves the generation or conception of projects and the collection of information on the impacts, uncertainties, relative community acceptance, and interdependencies of different candidate projects. It includes many of the more familiar activities that lead to the proposal of any project; needs studies, land use, economic activity shift, traffic flow modeling and simulation techniques, master plan development, urban planning recommendations, field inspections and inventories, and political suggestions. All these sources of projects are input to, and part of, system planning studies.

Programming then begins with a review of the information that has been prepared by fiscal planning and system planning. These basic data are used to prepare alternative programs of projects. (A program, as used here, is a collection of nonmutually-exclusive projects. Sometimes programs are divided into subgroups, each called a program, such as a construction program or a safety program. The word program as used here refers to the entire collection, i.e., the total investment program.) The emphasis is on programs because the purpose of programming is to oversee and plan for the entire spectrum of investment decisions made by the state transportation agency.

Once alternative programs are developed, they are evaluated as to their impacts and their relative desirability based on different priority criteria; generally indexes such as volume capacity ratios, safety rates, and sufficiency ratings are used. Programming is not completed, however, until the final priority of alternative projects is established; account is taken of not just project and network impact data (including community and environmental concerns) but also the distribution of projects over geographic areas and over time.

Programming also is involved with monitoring and updating a selected program while implementation proceeds until the next major programming cycle is reached.

The scheduling of projects occurs once a program has been adopted. After programming identifies in a normative fashion what, when, and where project development actions are to occur, scheduling determines whether it is actually possible to perform these actions in their relative priority order and within detailed constraints on money and manpower and suggests whether small changes are necessary to account for the manpower and work-load considerations. Scheduling is also responsible for developing time and manpower standards; it balances the work-load by developing a precise short-term timetable of subtasks for carrying out the adopted program.

Budgeting is similar to scheduling, but is concerned with the financial aspects. It includes financial accounting, preparing cost histories, and performing fiscal planning on a very short-term scale. Budgeting is also concerned with monitoring budget performance.

The activity called project development phases is the aggregation of the more familiar terms of project planning, such as location studies, environmental impact studies, design, right-of-way acquisition, and construction. Project development phases are obviously subsequent to scheduling and budgeting, for it is through these activities that the necessary resources, tentatively assigned to a particular project during programming, are actually allocated.

The relation between each of these 6 major activities of the investment process is shown in Figure 1 (14). The major sequences between the activities are indicated by the heavy lines and the feedback loops or iterations among the activities by the light lines.

The investment planning process shown in Figure 1 must be a continuous, iterative, and cyclical process, with each of the activities recurring at regular intervals. For example, needs studies occur every 2 to 4 years, traffic flow modeling is perhaps continuous, and the programming decision may occur every 1½ to 2 years. There are a number of institutional responsibilities for various elements of this overall process. For example, the state headquarters of a highway department or transportation agency is generally responsible for fiscal planning; district offices, for community interaction procedures; and either the district offices or headquarters, for conducting preliminary system planning studies such as needs studies and corridor and network analysis. The exact responsibilities and the methods and techniques used to carry out these functions will differ from state to state. No matter how the function is defined in any particular state, the process implies the need for a significant amount of information flow and participation. In many states the institutional structure and the flow of information have become even more complex, and the responsibilities have not yet been clearly articulated. For example, RPAs are now heavily involved in most if not all of these functions of planning and programming, which should reinforce (and may replace in some cases) the state's activities in these areas.

Because of their importance to the overall development of investment patterns, we have chosen to focus this paper on 2 key elements of the 6 activities: the system planning studies and the programming process. These 2 components are most strongly related (or should be) and have the most impact on the projects that actually get constructed.

Although the system planning studies and programming functions have not been entirely divorced from each other in state transportation agencies, their interface has been something less than desirable to date. As Neumann et al. state (16), "System plans have specified the total list of projects which could be considered without providing strong guidance for the scheduling and implementation of specific projects (i.e., priority setting and programming) with some disastrous results in implementation delays and revisions." In other words, these 2 functions should strongly reinforce each other and traditionally they have not. Therefore, although all 6 activities are obviously important to the investment planning process and all are strongly interrelated, we feel that the primary deficiencies (and the most promising areas for improvement) fall in the areas of system planning, the programming process, and the interface between them, as we will describe in the following sections.

Survey of the Existing System Planning Methodology

Relative to urban and regional studies, little concern has been devoted to statewide transportation studies and a smaller effort yet devoted to the documentation and dissemination of the studies that have been done. Some recent reports, however, have surveyed a number of studies and in some cases developed study designs of their own. Along with material collected by the author through correspondence and personal contact with a number of states, these serve as the major source for this section.

The 3 major sources of the methodology used by various states are a report by Hazen (17), a Carnegie-Mellon University and Pennsylvania State University (CM/PS) study (18), and an NCHRP report (6). An additional excellent reference on the techniques used by various states is a recent FHWA publication (19). In addition, material was obtained on Massachusetts, Michigan, Connecticut, New York, and California through other sources. The purpose of this section is not to repeat these surveys but to give a fairly broad categorization of the study methodologies. Readers are referred to each study for a more detailed comparison of approaches.

Existing statewide system planning studies (with an emphasis on passenger movements) can be classified into 4 basic categories: (a) no statewide model (traffic estimated by trends or growth factors); (b) statewide network simulation traffic models, including highway models only, modal models not integrated, and integrated multimodal models; (c) statewide travel model integrated with environmental impact (air quality, noise) models; and (d) statewide travel model integrated with land use, economic, and other impact models.

No Statewide Model

In a large number of states, "statewide" studies are confined to traditional surveys on a link-by-link basis in order to establish a need for improvements. [An excellent summary description of this process is contained in the CM/PS study (18).] Surveys include highway inventories, road-life studies, traffic surveys, highway classification studies, motor vehicle use studies, and fiscal studies. Data obtained from these surveys and projections of traffic flows are used in a continuing study of highway needs, which identifies and evaluates future projects of highest priority (18, p. 93).

The most obvious and major problems with this approach, aside from the lack of a similar methodology for other modes, are that (a) links are not considered as part of an interconnected network and (b) needs are determined in terms of user consequences only (usually a level-of-service condition or safety deficiency) and without regard to budget constraints for the network as a whole or for regions. (More will be said about this deficiency in the section on programming.)

Statewide Network Simulation Traffic Model

A great many states have converted or are in the process of converting from the preceding category to this category. Within this category, there are 3 types of approaches.

Highway Simulation Model

This approach is most typically used by highway departments that have attempted to adapt the traditional UTP sequential procedure of trip generation, distribution, modal split, and assignment to a statewide level. (For purposes of this paper, we assume that the reader has some familiarity with these procedures and their differences.) Although each of the approaches in this category have similarities, there are some significant differences in terms of number of trip purposes, type of model (for example, trip distribution might use either a gravity model or the Fratar method), calibration method type of base-year trip table, assignment method, and so on. Both the CM/PS studies (18) and the NCHRP study (6) contain more elaborate discussions of these approaches. Table 1, which is taken from the NCHRP report (6), gives a summary of the methods employed by 8 of 10 states contacted in 1972.

The major points to emphasize concerning these studies are that (a) they are not multimodal; (b) they are used as long-range forecasting techniques (15 to 30 years in general); and (c) historically, they have had little impact on actual programming decisions of which links get built when.

It is interesting to note that a recurring problem for a great many, if not all of these studies, is the trouble encountered in trying to reproduce statewide flows by matching screen-line counts or trying to match counts produced by regional studies. The magnitude of this problem depends, of course, on the level of aggregation in terms of number of zones and its effect on numbers of intercity versus intracity trips, the degree of disaggregation in terms of number of trip purposes, and so on. Table 2 gives some additional comparative information on the differences among the simulation approaches taken in a number of states.

Modal Models Not Integrated

A limited number of states have, or are planning to have, simulation models for modes other than highways. Michigan expects to have statewide models operational

Figure 1. Transportation investment planning process.

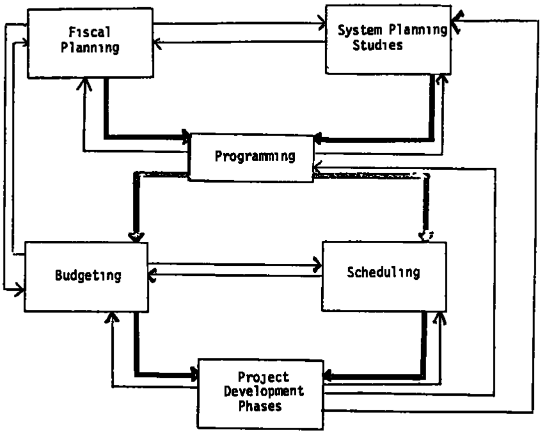


Table 1. Statewide transportation simulation models.

State	Simulate Trips Over Statewide Network	Base-Year Trip Table	Future Trip Table: Trip-End Generation	Future Trip Table: Trip Distribution	Assignment to Statewide Network: Spider	Assignment to Statewide Network: Free	Assignment to Statewide Network: Capacitated	Assignment to Statewide Network: Multimodal
Rhode Island	Yes	O and D	Regression equations	Gravity		X		No
California		O and D and synthesis	Regression	Gravity		X		No
New York	No	Combined O and D and synthesis	Regression (population and employment)	Gravity or opportunity			X	No
Pennsylvania	Yes	Screen line and synthesis	Growth factors	Fratar		X		No
Iowa	Yes	Screen line	Population	Fratar		X		No
Wisconsin	Yes	Screen line and synthesis	Growth factors	Fratar		X		No
Minnesota	Yes	Screen line	Regression on population	Fratar	X	X		No
Connecticut	Yes	1 percent O and D	Regression	Gravity				
New Jersey								
Florida								No
Washington	No	—	—	—	—	—	—	No
Wyoming	No	?	?	Fratar	?	?	?	No

Table 2. Statewide planning models.

State	Date	Population	Number of Zones in Model System	Number of Miles of Highway	Area (square miles)	Cost (dollars)
Connecticut	1963	2,500,000 (in 1960)	1,177 856	9,100	5,009	1 million
California	1968	18,602,000	1,450	14,215 + feeder roads	158,693	
Massachusetts	1973	5,348,000	Not available		8,257	
Pennsylvania	1971	11,520,000	163 passenger 15 to 40 freight		45,333	
Rhode Island		920,000	550	1,600	1,214	1 million
Michigan	1973	8,218,000	2,300 547		58,216	
Wisconsin	1964-1967	4,144,000	643	14,484	56,154	

for a number of different modes by the middle of 1974, but there is limited documentation for these models as yet. California, in addition to its 2-level statewide highway model, has an air travel simulation model. Connecticut has developed goods movement models for railroad and truck as well as special recreational travel demand models (17).

Integrated Multimodal Models

To the best of our knowledge, no state has as yet developed or used an integrated multimodal model for statewide planning. However, a number of states have carried out multimodal study designs [California (20) and Pennsylvania (18) are examples], and California is currently considering utilizing one or more of a number of on-the-shelf multimodal computer packages including DODOTRANS (21) and STAR systems (22).

DODOTRANS, developed during the Northeast Corridor study (23) in the late 1960s, can incorporate multiple modes and integrated direct demand functions (simultaneously predicting generation, distribution, and mode split). The STAR system, first developed for studies in California, also has multimodal capabilities, has been tested extensively, and will soon be available for distribution through the Transportation Systems Center of the U.S. Department of Transportation. Both will be described further in the following section on proposed improvements to planning procedures at the statewide level.

Statewide Travel Model Integrated With Environmental Impact Models

Most states have begun to develop environmental impact models in conjunction with a network simulation model. The emphasis to date has been on the development of air quality and noise impact models because of the legal requirements for meeting environmental standards. The most obvious problem with most of these approaches is the previous lack of work in these areas. This is extremely virgin territory compared to the travel forecasting methods available, and how accurate these techniques are is not yet clear. An interesting question being raised by some state agencies is, What good are air quality impact models (even at the state level) if we are concerned with reducing truck volumes from 6.5 to 4.5 percent to achieve air quality standards when the forecasting methods for truck volumes are producing forecasts on the order of 10 percent of passenger volume with an error of at least ±50 percent?

Nonetheless, Michigan (24), California, and a number of other states have developed both air quality and noise models that should be useful at least for order-of-magnitude estimates. Clearly, our knowledge in these areas can only be termed elementary at best, and the accuracy of the methods is subject to question.

One interesting set of models, which was developed for FHWA by Harvard University and is called the TASSIM model (25), has incorporated the FHWA travel prediction package (including a multipath assignment technique), fairly simple moving and point source emission models, and a simple dispersion model to predict the impacts of various air quality policies. (The model to date has been developed by using a spider network on a 122-zone system in the Boston region.) The interesting feature about this study is that the research team compared a variety of emission and dispersion models currently available for predicting air quality before deciding on the basic features of their approach. They concluded that, in general, the simpler models available give results at least as good as those of the more complex methods and are significantly easier to calibrate and use. [A second study by Darling (26) also contains a general state-of-the art survey on computer models for transportation-generated air pollution.]

Statewide Travel Model Integrated With Land Use, Economic, and Other Impact Models

Few states have attempted to integrate travel forecasting methodology with more comprehensive land use and economic impact models. Connecticut is one state that has developed operational models and used them in a statewide study; Pennsylvania and California have developed elaborate study designs but as yet have not begun to make these studies operational.

Connecticut

The Connecticut Interregional Planning Program (CIPP) is a unique study, having developed and used a number of economic and land use models in conjunction with a traditional set of transport simulation models (17, 18, 27). It is also unique because 2 state agencies, the highway department and the state development commission (already in the midst of a land use study), cooperated and developed an integrated transport recreational and land use plan. (The cost of the study was $1 million over a period of 3 years. This cost was much less than it otherwise might have been because existing data were available. The study also was apparently extended in 1971.)

The model system, shown in Figure 2, consists of (a) an economic base model, which produced an industrial accounts model for determining employment in basic industry and dependent employment in related service industries; (b) a land use distribution model, which takes the aggregate of population and employment predicted by the economic base model and disaggregates these by subareas (in addition, a simultaneous equation system allocates land uses by the 4 sectors of manufacturing, service, unique location, and population); (c) recreational activities and recreational travel models, which respectively describe the per capita demand for outdoor recreation by 5 categories in the state and by towns and predict the manner in which this demand would be allocated between towns and outdoor recreational locations; and (d) transport submodels of the traditional 4-step UTP approach for both passenger and freight.

California

In 1965, the California Division of Highways had a study performed (20) that describes a series of transportation demand, population, economic input-output, land use, and evaluation submodels that operate over time and permit feedback between the transport sector and other sectors of the economy. The estimated cost for development and implementation was $6 to $9 million over a period of approximately 4½ years. To date, however, the model system has not been implemented. The California Division of Highways has, however, recently developed a highway simulation model, as described earlier, based on the traditional UTP process.

Pennsylvania

Pennsylvania had a study performed (18) that also laid out a comprehensive framework for planning multimodal transportation systems. This study is also unique in a number of respects. First, the study design proposed to develop a comprehensive data collection effort and modeling framework consisting of 4 major submodels, as shown in Figure 3 (18). The model is multimodal, however, only in terms of different modes (automobile, truck, bus) that use the highway system. No attempt is made to model the rail mode and its flows because of (a) the interstate nature of the flows that extend beyond Pennsylvania's boundaries and (b) a basic lack of data. The model system consists of a passenger demand model for one purpose, used with an adapted FHWA assignment procedure operating on an abstract network. According to the report (18, p. 370), "The three distinct modes of auto, truck and bus are assigned separately, although the route choice patterns of the latter two modes depend upon the route patterns determined

Figure 2. Phases and model system of the Connecticut Interregional Planning Program.

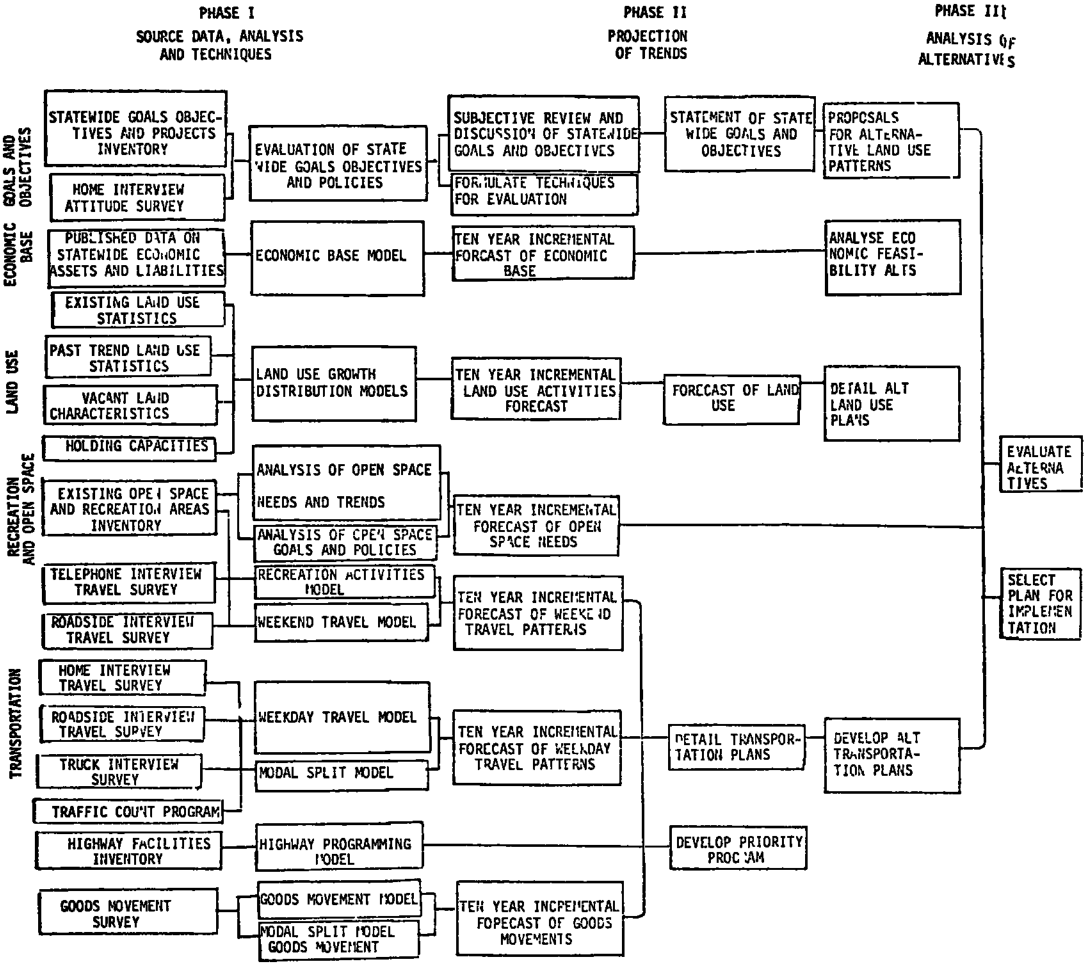
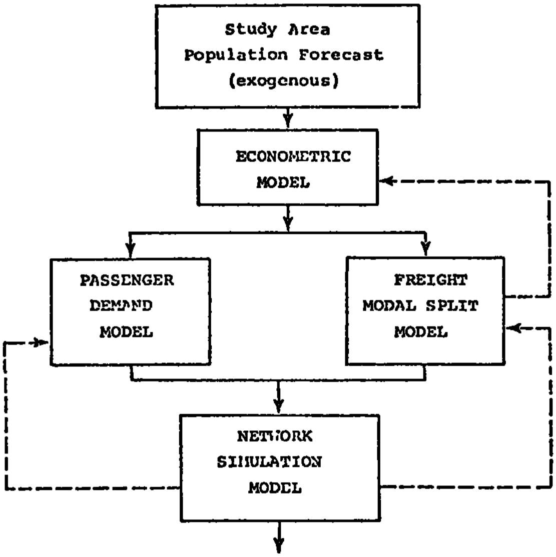


Figure 3. Forecasting model system.



for the auto mode." [An abstract mode or Baumol-Quandt model (28) similar to one conceived during the Northeast Corridor study is proposed as the basic demand model for both freight and passenger flows. It has the advantages of requiring limited data and being able to predict the demand for new modes. However, a number of studies have shown the model to possess some undesirable features in certain instances (29). It most certainly will have biased estimates if developed for only 1 trip purpose as proposed. The study recognizes the need for a more disaggregate model, but rejects the approach because of the lack of availability of substantial passenger flow data. A later section in this paper discusses data requirements for stochastic disaggregate models that may help to eliminate this problem.]

The freight modal-split model is also based on the abstract-mode model approach, but incorporates different variables and a revised procedure for applying it to the regions under study. It has the same advantages as the passenger model in terms of computational use and calibration, but it has the major disadvantage of being unable to differentiate the effects of commodity type on the modal-split decision.

Finally, the econometric model is a fairly complex input-output model of an interindustry, interregional type that captures the flows of commodities between regions and sectors and is sensitive to transport policy.

The passenger model is proposed to operate at the 163-zone level; the freight model, limited by data availability and the economic input-output model, will operate at the 15- to 40-zone level. Freight demands and supplies will require further disaggregation by subzones before assignment can occur.

The major advantages of the techniques proposed by this study design over those of the Connecticut study are that (a) it has recognized the multimodal nature of demands and is using the direct demand approach; (b) it also recognizes that passenger and freight traffic use the same facilities and is, in effect, a multimodal assignment process (although capacity restraint is not proposed); and (c) it has included an economic input-output model in order to predict the interzonal interindustry flow of goods by commodity class.

Its major disadvantages are that (a) it uses an aggregate passenger demand model with only 1 trip purpose; (b) it is oriented solely to some future target-year system and endorses the master plan concept (therefore, it is not recursive in nature and cannot capture intertemporal effects); and (c) it estimates the cost of development of the modal system, including data collection at $7.2 million over a period of 5 years.

Other Studies

In addition to the previous studies and study designs, there are several studies worthy of mention, which, although not designed to be used at the statewide level, are somewhat unique in the transport field and have resulted in a number of spin-offs and developments in research that may in fact change our ability to predict by at least an order of magnitude.

The first study is the Northeast Corridor study (23), conducted during the 1963-1968 period. Out of this study came almost all of the current direct demand modeling efforts, including the SARC-Kraft model (30), the Baumol-Quandt model (28), and the McLynn model (31). In addition, a number of multimodal model systems were developed such as the Mitre multimodal transportation model (32), the STAR system (22), and the DODOTRANS system (21). The study even took some preliminary steps toward incorporating stochastic disaggregate approaches (33).

The second study worthy of discussion is generally referred to as the Harvard-Brookings study (34), developed in the 1964-1968 period for a cost of approximately $0.5 million. It consists of (a) a macroeconomic model, which models industries, government, and private investments and commodity flows over time, and (b) a transport model or submodels of rail, highway, water, and pipeline. It operates recursively over yearly periods; the transport model possesses the ability to be disaggregated by seasons if necessary to capture seasonal effects.

Although the original Harvard-Brookings model was the first of its kind to integrate economic input-output models with a transport model, as well as passenger and freight models for modal split and assignment, it still had some shortcomings (for example, links were not capacity restrained). Recent improvements to the transport model have eliminated most of these shortcomings, and the whole study stands as a classic in the field of transportation planning because of its interaction and feedback with the economy as a whole (35).

Problems With the Existing System Planning Methodology

The discussion in preceding sections leads to the identification of some fairly obvious but critical problems with the current methodology. Some less obvious problems are even more critical if we are to successfully develop, implement, and use statewide models. These problems fall into 5 major categories (in no particular order): traditional UTP-related process, behavioral demand prediction models, long-range planning and its relevance to programming, activity-shift models, and existing data.

Traditional UTP Process

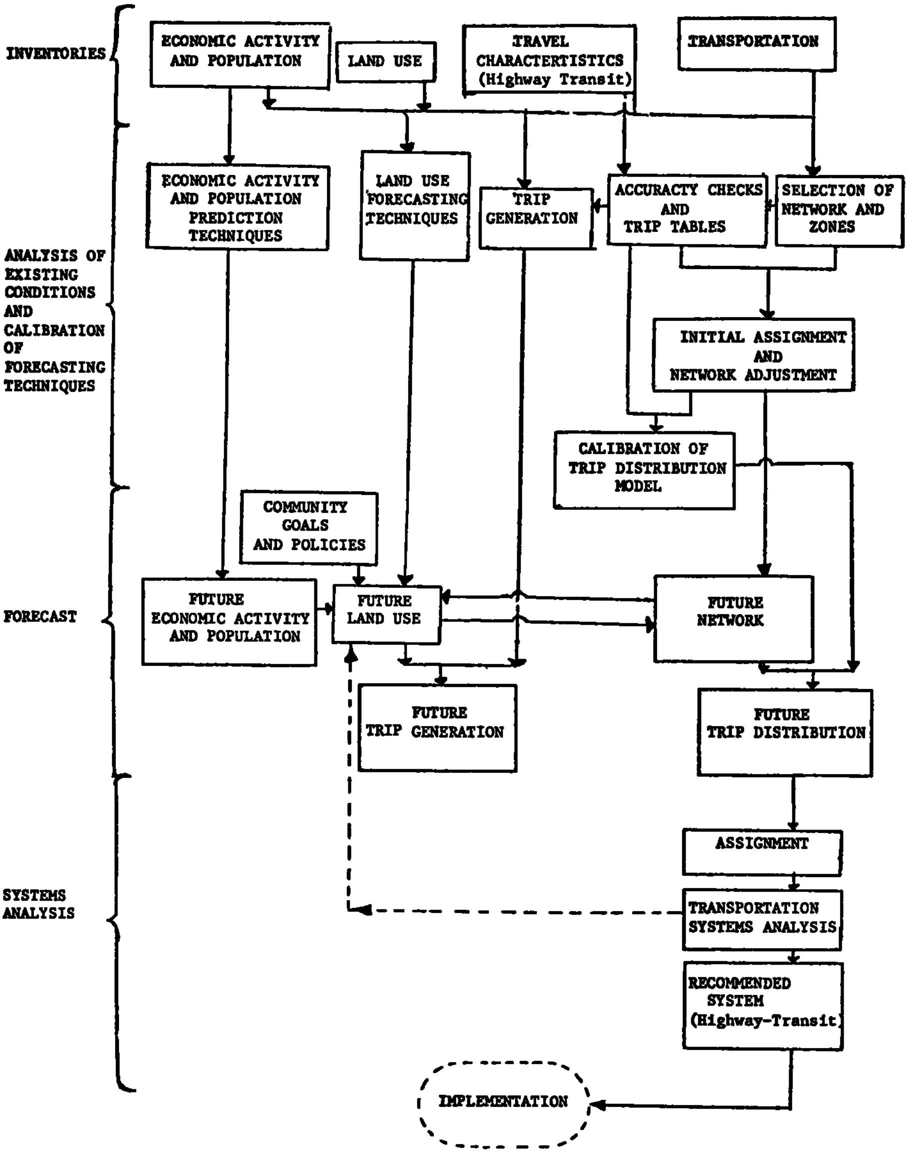
One of the most frequently asked questions concerning statewide modeling is whether the UTP methodology is appropriate. Can we simply adapt existing techniques that have been so extensively used in so many urban and metropolitan studies (and apparently not very successfully)? Before answering this question, however, we must first ask how effective the UTP approach has been for urban studies. What are its critical shortcomings? If it has some, and they can be improved, can it then be applied at the statewide level?

Criticism of the current methodology has been well documented. Roberts (36), Manheim (37), Domencich (38), Boyce, Day, and McDonald (39), and others have all presented succinct and effective discussions of the weaknesses of the current set of models. In the past, to criticize the present set of models has been far easier than to offer constructive proposals for improvement. To make a significant improvement in existing techniques and their ability to make short-run forecasts now appears to be possible by implementing a number of research advances that have occurred during the past few years. (This is discussed further in a later section on proposed improvements.) In addition, the UTP process can be changed to make it more consistent with behavioral theory. [In fact, the suggestion has been made that the UTP process is just a special case of a more general process and that it can be useful for special problems (37). In addition, UMTAs new multimodal package, soon to be available, provides the option of using the traditional sequential approach or a more direct approach (40).] An alternative methodology for demand modeling is now gaining wide acceptance and is certainly worth considering as a statewide modeling tool, given the track record of the existing UTP process.

The following general summary of the UTP process, shown in Figure 4, is taken from the paper by Roberts (36):

> Although the diagram [in Figure 4] cannot be considered to be a complete statement of the details of the UTP process, I think it is fairly representative of the basic thinking underlying the process The four basic steps, trip generation, trip distribution, modal split, and traffic assignment, are shown Economic activity and land use are essentially projected into the future without feedback from the transportation system though feedback to future land use is shown here with a dotted line, indicating that "though we now know there should be interconnections they have not been routinely implemented to date " Trips are "generated" without concern for the supply of transportation or its effect on the level of service offered Trip distribution is typically constrained by its "calibration" to maintain the existing trip length distribution whether or not the network can support it or the land uses have changed to accomodate it And, neither generation nor distribution is typically brought into the equilibration process with network flows Finally, the "future system" or target year approach is indicated as the recommended approach

Figure 4. Urban travel forecasting process.



These general shortcomings described by Roberts can be elaborated on (we should stress the fact that most of these criticisms also apply to those existing statewide models that have been implemented and were described in the previous section).

1. The level-of-service attributes used should be as complete as necessary to adequately predict traveler behavior. For example, in addition to travel time, variables such as cost, frequency of service, time reliability, number of transfers, and privacy should be included if empirical evidence or theory or both indicate that these are important determinants of trip-making behavior. Recent studies have indicated that there is a wide range of service attributes that are important in both the urban and intercity case (42, 43). The CM/PS (18) and California study designs (20) described earlier also reflect this approach.

2. Each level-of-service variable should enter into every step, including trip generation. This is axiomatic unless there is an indication in a specific situation that some step is, in fact, independent of level of service for all market segments. For example, the generation of work trips may be relatively independent of the level of service provided. For most trips, this will not be true. For example, it is hard to believe that recreational travel at the state level is insensitive to the level of service provided. In terms of fuel shortages, there is no way to accurately reflect the effect of changes in gasoline prices on recreational trips during the summer because cost (as a level-of-service variable) is not incorporated in most trip generation equations (for example, those for recreational travel equations). In addition, the same attributes of service level should influence each step. For example, rail fares, automobile parking charges, and service frequencies should influence not only modal split but also assignment, generation, and distribution.

3. The level-of-service variables must be disaggregated into their component elements by trip segment. A level-of-service variable has components that are experienced and perceived differently over different segments of a trip. Recent studies, for example, have shown that trip-makers value time at 25 to 60 percent of their wage rate and wait time as much as 3 times more heavily than they do travel time (44, 45). Although to disaggregate travel time into walk time, wait time, line-haul time, transfer time, parking time, time variability, interarrival time, and schedule delay may not be necessary in all cases (as some studies have done), to consider level-of-service variables at a disaggregate enough level to capture those aspects of trip-making behavior that are important at the statewide level is nonetheless important.

4. The process should calculate a valid equilibrium of supply and demand. In practice, there is almost no feedback in the present system of models. For example, the travel times that are used as inputs for modal split, distribution, and even generation should be the same as those that are output as results from assignment. If necessary, iteration from assignment back to generation, distribution, and so on should be carried out to obtain this equilibrium. A number of states still have not recognized that in the assignment phase capacities are limited and that, in the real world, there is a certain equalization of impedances over alternative paths in a network. We recognize that, for most statewide systems, capacity will not prove to be a problem. But without capacity restraint, the few bottlenecks that do exist in the system and the way in which travelers react to them will not be clearly articulated. Moreover, if networks are to be compared in any way, generally some improved network in the future is compared with the existing system loaded with future travelers. The existing system loaded with future travelers may well show many links in the system with some congestion problems, but only if link supply is represented as having some finite capacity.

5. The levels of service of all modes should influence demand for any given mode. Changes in the level of service of a given mode (e.g., a change in the congestion on highway or rail networks or a change in fares) should, in general, affect not only the demand for that mode but also the demand for other modes. That is, there should be provision for explicit cross elasticities of demand with respect to level of service on competing modes. Recent evidence has shown this to be true at the urban area level (42), at the intercity level in the Northeast Corridor (43, 46), and at the state level in California (28). Therefore, when we change the magnitude of a level-of-service variable, say, cost (for example, in terms of price of gasoline), not only would we expect automobile travel to decrease but also we would expect the demand for competing modes to increase.

6. The estimation procedures should be statistically valid and reproducible. The use of regression for generating trips and matching trip length frequency distributions for trip distribution may produce "best fits" for generation equations and, in terms of matching trip length frequency distributions, for trip distribution models. However, there are serious doubts as to whether we are actually reproducing (or simulating) real world flows, as some statewide planners have recognized (47).

Careful examination of the traditional approach indicates it violates each of these conditions. As a consequence, serious questions can be raised about the biases and limitations of the flow predictions resulting from use of the models in their traditional forms at both the urban and statewide levels.

Thus, although there are some counterarguments for the value of the current approach, enough empirical evidence is apparently available from recent studies to indicate that there are serious problems with the process at the urban level and this holds true for most, if not all, statewide approaches as well.

Behavioral Demand Prediction Models

In his paper on travel demand forecasting, Roberts (36, p. 58) states:

> The most obvious problem with the models is that they are not policy responsive That is, they are not designed to answer the questions posed by a particular agency or to understand the response of the system to particular controls held by that agency The urban transportation system in a large metropolitan area is rarely under the control of a single authority but is typically jointly controlled by a variety of transportation agencies and an equally larger number of non-transportation agencies One cannot overly criticize the designers of the models for failing to identify a particular decision-maker The major problem here, however, is that the current model design does not properly reflect the trip making response of the system to changes made in the system itself As [Domencich (38)] points out, the models are non behavioral and noncausal as well.

Roberts indicates that the most important change to the UTP procedures, certainly more important than incorporating level of service at every step or having feedback between every step of the process, is the fact that the models should be based on a theory of how consumers react behaviorally to a changed set of conditions. There are 2 aspects to the behavioral nature of models.

Causal Versus Correlative Models

The most important characteristic that a demand model should have is that it be causal rather than correlative. Causal models are based on a theory of observed behavior and can be used to predict changes in one variable (demand) if another variable changes (for example, level of service). In this case $D = f(L)$ can be said to be a causal model (although perhaps not correctly specified). Correlative models may be of the form $D = f(L)$ as well, but do not necessarily describe a causal effect. A simple example in transportation is the trip generation models that hypothesize trips generated in the following form:

$$T_i = f(AO_i,\ P_i,\ DCBD_i,\ \ldots)$$

where

T_i = trips generated in zone i,
AO_i = automobile ownership in zone i,
P_i = population in zone i, and
$DCBD_i$ = distance from the CBD to zone i.

Obviously, automobile ownership levels will influence trip generation—the more automobiles owned, the more trips expected. Similar arguments hold for population and other variables. On the other hand, although trips are generally correlated with distance from the CBD, no one can argue that distance from the CBD influences the rate of trip generation. Some other factor—income, life-style, stage in life cycle—that influences both location choice and trip generation is responsible for the correlation between trip generation and distance from the CBD. It is important to emphasize the relation between causality and usefulness for predicting the effect of policy changes. Correlative models cannot capture the response to policy change, whereas causal models are structured to do so.

In transportation, the wide variety of models fall into these 2 classifications, and it is difficult to determine when a model is causal and when it is simply correlative. In general, the traditional UTP approach has tended more toward the correlative end of the spectrum, and the direct and disaggregate stochastic models (discussed in the next section) generally tend toward the causal end. [Most UTP approaches use some causal, some correlative variables in trip generation, only travel time in trip distribution, and a number of variables in modal split, and, again, only travel time in the assignment process. Thus, they generally ignore out-of-pocket cost, safety, reliability, comfort, and convenience, which can be considered to be behaviorally related to trip generation, distribution, modal split, and assignment (48).]

Aggregate Versus Disaggregate Models

The second important characteristic of a demand model concerns whether it is based on aggregate or disaggregate data. [Fleet and Robertson (49) show that using aggregate data only captures 20 percent of the variation (between zones) in trip making; 80 percent of the variation that occurs within zones is lost. This is one of the major reasons models cannot be transferred from one geographical area to another: The model is zone-size dependent, and different areas have different zonal breakdowns.] Aggregate models are calibrated on zonal averages (average zonal income, average interzonal trip time). Disaggregate models are based on individual data items (i.e., the demand for travel for each individual is a function of that individual's or household's income, age, sex, stage in life cycle, and automobile ownership level). The traditional UTP approach has by and large used aggregate models.

Long-Range Planning and Its Relevance to Programming

The third major shortcoming of the traditional planning methodology and perhaps the most important for statewide planning is the extremely weak ties that have existed with the programming process. The existing planning techniques are generally used only to provide volume estimates for the location or design engineer. In only a relatively few cases have systems planning techniques been considered a vital part of determining priorities and the programming process. (More will be said on this in the next section.)

Activity Shift Models

The fourth major shortcoming of the traditional approaches at the state level has been an inability to develop acceptable longer run activity shift models—models that predict economic activities such as manufacturing, retail sales, and wholesale trade as well as population and land use shifts over longer periods of time. These models are essential for successfully testing alternative transport policies and their impact on the economy. There are a few notable exceptions, however, but these models are generally correlative in nature and are unlikely to be useful in testing the implications of policy decisions. Recent efforts (50) with disaggregate techniques have incorporated automobile ownership as a dependent variable (as opposed to an exogenous prediction) in a series of simultaneous equations that predict automobile ownership, generation, and modal split. There is also a strong possibility that these techniques can be extended to include the residential location decision as well (51).

Clearly, the development of activity shift models is an area to which significant effort was devoted in the 1960s for metropolitan studies with little success. However, without these kinds of models (economic input-output models, population projection techniques), the usefulness of our basic transport models will be severely questioned. It is time for serious effort to be devoted to collecting the data required and testing alternative models.

Existing Data

And, finally, one of the major problems of all studies—urban, regional, and statewide—is the lack of an appropriate data base for calibrating models. A number of studies have apparently made the mistake of almost exclusively relying on previously collected data. In many cases, data bases have been constructed without fully knowing what models those data were intended for. In urban studies, fully 60 percent of the cost of a study can usually be attributed to data collection and processing costs. It is in this area that careful design and collection can afford high savings. In addition, as will be described subsequently, the stochastic disaggregate models have the potential for reducing these costs significantly while providing a greater probability of transferability of results.

There is no way around the effort required for data collection, however; we cannot construct models of behavior without having an adequate data base. NCHRP Synthesis 15 (6) discusses the data problems connected with statewide studies (screen line versus home interview, origin-destination versus license-plate surveys), and that discussion will not be repeated here.

As discussed in the CM/PS study (18), one of the major problems in data collection is that of obtaining freight flow and activity system data. These problems almost dwarf the existing passenger data needs.

Existing Programming Methodology

The techniques for statewide programming and determination of priorities employed by the states do not have as much variation from state to state as the modeling and forecasting techniques described in the previous sections, although the overall process of programming does have some differences. Programming is an extremely complicated process that involves more than simply assigning priorities to improvement projects. According to Krecji (14), the term programming refers to "the process of integrating project priorities with fiscal plans to develop a strategy of project development sequences to be tentatively performed with a certain future time period." Programming, therefore, is the conversion of long-term general transportation system improvement plans into realistic short-term work programs. To be effective, it must be capable of addressing 5 major issues.

1. Multiple and conflicting policy objectives. There are usually different objectives at state, regional, and local levels. Even at one level there exists a diversity of interest groups with varying objectives. The role of planning and programming is to articulate the trade-offs among conflicting objectives. In addition, it should be capable of addressing the distributional elements of a program in terms of equity—among regions and among socioeconomic groups.
2. Multiple impacts. Related to the issue of multiple and conflicting objectives is the fact that programs and individual projects have multiple attributes or impacts involving economic, environmental, and social concerns. The programming process must be capable of coping with a multitude of impacts—some quantifiable, some qualitative—in determining desirable programs.
3. Interdependencies among projects. The programming process should also be able to account for project interdependencies. Project dependency implies that building one project requires, or eliminates, the need for another. Network dependencies arise from the interconnectedness of links in a network. Budget interdependencies exist simply because a dollar spent on one project means less resources available for other projects.
4. A complex organizational structure and a broader, more participatory decision process. The fourth factor that influences programming is the organizational structure of the state and the fact that many people will be involved in helping determine priorities through a participatory process. In addition, the planning and implementation (programming) functions are often the responsibility of different agencies. Program-

ming, therefore, must be structured and yet be flexible enough to allow many iterations and to integrate comments from people both within and outside the agency. It must be designed to be a cyclical, iterative, and participatory process.

5. A dynamic and uncertain environment. Programming decisions must recognize the inherent uncertainties associated with impact assessments. Changes occur in technology, in community values and social concerns, and in funding. In light of these uncertainties, programs must be flexible enough to respond to changing conditions without massive recycling of all projects and planning efforts.

The programming methodology currently available for handling these 5 factors is in an extremely embryonic stage. Most procedures to account for these factors are either subjective or nonexistent. To date, most states have based highway improvement priorities on the traditional sufficiency rating method and have ignored most of these basic factors except in an ad hoc manner. [According to surveys by General Analytics, Inc., and Comsis Corporation (52), Krecji (14), and the author, General Analytics and Comsis Corporation actually categorize the priority setting procedures into 4 major categories: sufficiency ratings, quasi-economic analysis, benefit-cost, and macro or micro economic theories. To this list should be added a fifth category, best called the pure judgment approach in which decisions have been made on a periodic basis by a group of highly knowledgeable staff who have little quantitative input, except funding constraints and what is in the pipeline and can be built.]

The sufficiency rating scheme has evolved from procedures first proposed in 1939. It is a numerical procedure that assigns points to various road attributes (such as road condition, safety, and service) according to their comparison with a standard. Although the variables and point-weighting scheme may vary from state to state, the procedure is essentially the same.

There are some exceptions, however. A few states are studying ways of including social and environmental factors. California has incorporated this approach, and uses in addition a weighted sum of the 3 direct measures of safety benefits, capacity adequacy, and time-delay savings index. Pennsylvania apparently is the only state using a strict benefit-cost analysis. Massachusetts is in the process of implementing a similar benefit-cost procedure using the Highway User Investment Study (53), a computer package developed at the federal level for estimating benefit measures, and a simplified programming procedure that accounts for different functional class budget limits, geographical area minimums, and overall total budget minimums. It is currently being tested statewide and in a selected RPA for its usefulness in a participatory framework.

California is beginning to incorporate budget constraints and multiple alternatives (as will be described subsequently) and, in a few instances, has developed alternative contingency programs for a district as a hedge against the possibility that a key project in one program would not be approved.

Problems With the Existing Programming Procedures and Processes

There are a number of problems evident from a survey of the existing programming procedures and of the programming process itself. The most obvious symptom that a problem exists is that the process is simply not working, based on the huge backlog of proposed highway improvements in each of the several highway systems in most states. The process just has not been able to effectively address the 5 factors described above. The second is that environmental impact statements are taking excessively long periods of time and costing enormous amounts of money to develop; but, more important, they are probably occurring too late in the process. The result is that programming does not have much relevance to what is getting built. These problems can be attributed to the following factors:

1. Budget constraints have not been recognized early enough in the process. Developing "needs" lists and then, after each district has submitted a needs list, apply-

ing a cutoff budget level result in too many facilities with excess capacity that may not actually be required for years and, most important, may never get built. As will be described subsequently, California planners have recognized this and are rescaling (or, in their terms, rescoping) their programs with the budget constraint in mind, trading off level of service on specific links for network connectivity and accessibility. In other words, they are opting for a smaller scale, a more integrated network than for larger, unconnected facilities with no hope for completion. In most cases, they are also discovering that the smaller scale facility is beneficial from a benefit-cost as well as an environmental point of view.

2. Multiple (mutually exclusive) alternatives have not been incorporated into the tentative programs. This is closely related to the first problem area. If only because of the budget constraint (54), there are dependencies among projects because a dollar spent on one project cannot be spent elsewhere. In addition, the existence of project or network dependencies means that adoption of one program may preclude others and make feasible others. The traditional approach of deciding early in the process the size or scale of a project based on level-of-service standards precludes the development of smaller facilities that may have other attributes that are more important (environmental impacts, for example) in terms of acceptance by the community. California again is also now considering alternative scales and stagings of projects that allow greater flexibility in selection and that can provide needed service now while freeing up scarce resources for projects elsewhere.

3. An emphasis has been placed on user benefit measures, with political, environmental, and social concerns incorporated as an after-the-fact ad hoc adjustment to the program. Most states have focused on safety, service, maintenance, and capacity adequacy factors as the primary determinants of a highway's need and its ranking in a program. The traditional concept of "needs" must be reevaluated and broadened to include nonuser impacts such as the community and social need for transportation service. Moreover, the needs concept must be expanded to include other modes of transportation.

4. Uncertainty has been ignored. Priorities and programs have been determined in many cases without effectively incorporating factors of uncertainty. In cases where it has been included, it has been unstructured and ad hoc. We cannot eliminate uncertainty, but we can learn to recognize it and plan our alternatives more flexibly and in a more adaptive manner to cope with it.

5. The process has not been a flexible, iterative, participatory process. The typical programming process of most highway or state transportation agencies during the past several years can be characterized by 3 factors: (a) leaning toward fairly precise, definable indexes or priority measures of improvement; (b) priority measures oriented toward the highway user; and (c) extremely low participation and understanding by the public as to the priority setting process.

In addition, one of the purposes of programming has been to maximize the use of available funds within a specified time period, to put down as many miles of highway as possible. The pressure in some cases has been to favor quick and easy-to-finish projects over alternatives that may be more desirable but are more complex and require more time and effort to complete. [Neumann and Pecknold (55) developed a case study that shows that projects selected in one region of a state had very low benefit-cost ratios because of the difficulty in getting a major freeway design accepted by the community.]

Most important, however, what has been missing from the programming process are the necessary ties to the planning process itself. Clearly, both functional areas are to blame; but, with new techniques becoming available in both areas to make each more credible, the next step is the integration and coordination to provide a more effective statewide planning and programming process.

PROPOSED IMPROVEMENTS TO STATEWIDE PLANNING AND PROGRAMMING METHODOLOGY

Although a comprehensive methodology for statewide planning and programming will require considerable time and effort to develop and implement, there are a number of areas where improvements can be made relatively quickly and easily that will enable us to respond immediately to the emerging multimodal investment, environmental, and energy issues. In addition, there are areas of research of a longer range nature that should be undertaken now to ensure the continuation of improvements in the future. These short- and long-run areas of improvement are divided below into improvements to the planning methodology and improvements to the overall programming process.

The first section on improvements to analysis systems emphasizes short-range incremental modifications to existing systems. It would be incomplete if it did not point out the limitations of this approach.

At the time most currently used systems were created, there was no way to anticipate either future developments in analysis techniques or future demands that would be placed on analysis systems. In software, as well as in transportation systems, there is a trade-off between efficiency and flexibility, and because the need for analysis flexibility was not foreseen, the systems were designed for maximum efficiency at the expense of flexibility. This means that there is some point beyond which it becomes impossible or highly cost-ineffective to incrementally change existing systems.

When this happens, states are inevitably going to have to obtain new analysis systems if they wish to remain abreast of the latest transportation planning procedures. And when new systems are being considered, states would do well to reevaluate the efficiency and flexibility trade-off. Systems that maximize efficiency at the expense of flexibility perform limited analyses (cheaply) and are difficult to upgrade. Systems that sacrifice some efficiency for increased flexibility may be slightly more expensive to run, but they can perform much better analyses and are much easier to upgrade when this becomes necessary. We are learning some of the costs of ignoring flexibility when we design transportation systems; identical lessons hold in the case of analysis systems.

Improvements to Travel Forecasting and Impact-Prediction Techniques

Improvements to planning techniques can be subdivided into short-range and long-range work areas. The priority, time, and costs are given in Table 3.

Short-Range Improvements

The 6 specific areas of improvement of a short-range nature are (a) incrementally adjust existing network equilibrium model systems to be internally consistent, (b) begin the development of simplified policy-sensitive (behavioral) analysis tools, (c) begin the development of specialized disaggregate (stochastic) demand models, (d) incorporate on-the-shelf (environmental, economic, and other) impact-prediction techniques, (e) employ one of the available on-the-shelf multimodal model systems and initiate prototype studies on a subregional or substate scale, and (f) initiate research on other specialized modal problems.

1. Incrementally adjust existing model systems to be internally consistent.

In recent years, transportation research has made great advances in the area of travel forecasting. A number of new techniques and variations on old techniques have been developed, many of which should be added to the repertoire of state planning agencies. However, to incorporate all these new methods at once would require a large-scale software development effort, something which because of high cost and risk, states are better off avoiding at the present time. Instead, a set of changes can be identified that, when incrementally added to existing state modeling packages, will

Table 3. Priority, time, and cost of proposed improvement to methodology.

Improvement	Priority	Time (months)	Cost (dollars)
Short range			
Incrementally adjust existing model systems to be internally consistent	High	12 to 36	75,000 to 150,000
Begin development of simplified policy-sensitive (behavioral) analysis tasks	High	12 to 18	50,000 to 150,000
Begin development of specialized disaggregate (stochastic) demand models[a]	High	6 to 12	50,000 to 100,000
Incorporate on-the-shelf (environmental, economic, and other) impact-prediction techniques			
Employ available on-the-shelf multimodal model system and initiate prototype studies on subregional or substate level	High	12 to 24	50,000 to 150,000
Initiate research on other specialized modal problems	Low	6 to 12	25,000 to 50,000
Long range			
Conduct study to determine states' overall modeling requirements	High	12 to 36	500,000 to 2,000,000
Develop long-run activity-system models to predict economic impacts, land use distribution, and other impacts	Medium to high	24 to 36	Variable

Note All of these estimates are extremely preliminary They are intended as an order of magnitude comparison of tasks The actual time and costs will depend on the current system in use and the abilities of the professionals performing the work They are also in terms of in house dollars at a state agency valued at $50,000 per man year, including direct and overhead charges

[a]This approach has a very high potential for application in different parts of a state, reducing the costs of data collection and calibration even further

result in an internally consistent flow-prediction methodology at low cost and risk.

The set of changes required can be divided into changes to demand modeling methodology, changes to supply modeling methodology, and changes to equilibration methodology.

Manheim (37) has shown the formal equivalence of internally consistent sequential aggregate UTP type of demand models with simultaneous aggregate models such as those of Baumol-Quandt and SARC-Kraft, when the latter are used in a 1-step approach to equilibrium. However, most UTP models used in practice can be shown to be internally inconsistent, which means in effect that planners are postulating that trip-makers use totally different criteria at different stages in their trip-making decisions. We can, therefore, maintain the sequential form of our models, but must make them internally consistent by (a) including the same level-of-service variables at each step in the process (unless it can definitely be shown that some variables are not considered by trip-makers at a given step) and (b) iterating the models so that all steps use the same level-of-service values. In many systems, for example, the travel-time value used to perform trip distribution is totally different from the value used for traffic assignment. Such a situation can never result in a valid equilibrium.

As a first step in modifying the supply modeling capabilities of current planning packages, networks should be coded as 1-way links having generalized supply functions that can capture the degradations in level-of-service due to high traffic volumes. This will allow the assignment phase to more realistically model congestion and directional effects. Although most of the network at the statewide level will not be congested, there will be portions that can be classed as bottlenecks. Assignment without capacity restraint only points up a few of these sections, whereas use of capacity restraint will ensure that all bottlenecks are identified (and correctly) and will more realistically simulate the way in which traffic distributes itself over the network. If capacity is not important, the assignment process with capacity restraint will take only slightly longer than it now does without it.

No amount of improvement to the demand and supply modeling capabilities of an analysis system will result in computation of a valid equilibrium if the equilibration technique itself is inconsistent. Deep understanding of equilibration techniques has come only recently, however (56), and few systems have valid equilibration routines. The next few years will probably see more of these developed. In view of this, it seems most reasonable to wait until such routines are more widely available, but to explicitly plan now for a future changeover to a valid equilibration technique. (In fact, the problems with such a changeover will probably be less substantial than the problems incurred in simply changing to consistent demand model formulations.)

2. Begin the development of simplified policy-sensitive (behavioral) analysis tools.

A system that computes a valid equilibrium of supply and demand may be of no use to planners if it does not permit them to investigate a broad range of policy options, including low-capital and institutional alternatives. For example, what would be the effect on statewide transportation of staggered work hours and a 4-day work week? What would be the effect of changing regulations on motor carrier and rail movements? Although considerable resources would be required to develop a network equilibrium system that could tackle such broad questions efficiently, it is possible to begin addressing these questions immediately by making some modifications to existing systems and to use them as policy analysis tools.

It is not clear, in fact, that a sophisticated network supply-demand-equilibrium system is the most appropriate tool for evaluating broad policy questions as described above. Certainly, policy-sensitive network equilibrium procedures will be required for answering many questions about the impacts of specific investments, for exploring regional and state equity issues, and for determining actual program priorities. But many questions of a broad policy nature simply do not require the full-blown network equilibrium procedures.

Simplified policy-sensitive analysis tools have been used effectively in a number of studies in urban areas and promise to be useful at the statewide level as well. For example, the original SARC-Kraft model (43), developed to predict intercity flows, was adopted to the urban situation and used in a simplified manner to predict the impact of a city-specific and nationwide free-fare transit policy (57). The original model formulation was adapted to the urban area problems; Boston data were used. For example, the original level-of-service variables of time and cost were disaggregated into line-haul and access times for both the transit and auto demand functions. This permitted an investigation of the impact of improvements to the access segment of the transit system as an alternative to a free-fare policy.

A second example of the development of simplified, policy-sensitive analysis tools is contained in a report (58) of a study that involved the development of a simplified methodology called a pivot-point analysis procedure. This procedure is used to predict the impact on revenues of service modifications to a fixed-route, local bus system that is experiencing serious deficits. The term pivot-point refers to the procedure of using existing empirically derived elasticities and "pivoting" about these elasticities to determine the change in demand for small changes in services. The procedure includes simplified policy-sensitive service-reduction and service-elimination models that were applied to several case studies in a large metropolitan area.

The advantages of both these studies (and of simplified policy tools in general) are that (a) they do not rely on a large, cumbersome, and expensive model system to evaluate policies, (b) they are relatively easy to operate and understand (moreover, a large number of variations in policy can be tested very quickly), and (c) they are valuable in giving insights into how the large-scale network equilibrium procedures should be modified to become more policy sensitive as well. [In the free transit study (57), the demand model was developed as a simplified policy analysis tool but could also be used directly as the demand model in a network equilibrium package. In the local bus service modification procedures (58), the procedures were developed primarily as policy analysis tools to test a wide range of service changes and their impact on the overall system in a preliminary way.]

Simplified policy-sensitive analysis tools of this type are also required for statewide-level planning and should have high priority for development.

3. Begin the development of specialized disaggregate (stochastic) demand models.

The third major improvement to planning methods (which appears to be extremely applicable to statewide problems) is the area of stochastic disaggregate demand models. There is evidence that the use of disaggregate data can reduce the aggregation bias present in most traditional aggregate models as described earlier. Calibrating models on aggregated data results in biased parameter estimates, misleading goodness-of-fit measures, and tremendous loss of information about travel behavior.

There have been significant advances made in the state of the art of travel forecasting in the area of stochastic disaggregate behavioral models in the past few years. [A recent HRB report (1) presents an excellent summary of the state of the art and problems facing demand modeling efforts. Lave (59) has developed a simple binary-choice modal-split model. Charles River Associates (60) and Ben-Akiva (61) have shown how to extend this to include generation, distribution, and modal split as well as the time of day.]

First, these models are stochastic because they give a probability of an individual's choosing one alternative from among several available alternatives. This is represented by $P_i(a/A)$, the probability that individual i will select alternative a from the set of alternatives A. This has been recently extended from simple modal-split models to cover all aspects of the travel decision (including choice of frequency, choice of mode, choice of destination, and choice of route) represented by the probability that individual i will take one or more trips, mode m, destination d, and route r or $P_i(f, m, d, r)$. [Because of the large number of possible combinations of choices in a simultaneous mode of this type, the number of variables and the number of interactions among variables become complex. This can be resolved by reducing the attributes a traveler is assumed to consider and by reducing the destinations to reasonable numbers. An alternative method would be to calibrate a series of sequential models much like the UTP process (but internally consistent with the L vector in every step), which would then have the form of a series of conditional, sequential, probability models:

$$P_i(f) . P_i(d|f) . p(m|f, d) . P_i(r|f, d, m)$$

This requires a stronger assumption about how a traveler makes his decision, however. If this decision is unknown a priori, the simultaneous model is the most unbiased method to employ.

Second, the models are disaggregate because they use disaggregate (individual or household) data and predict an individual's trip-making behavior.

The advantages of developing stochastic disaggregate methods appear to be significant if we can accept existing evidence to date.

a. They are more behavioral in nature because demand is now based on individual data. Variables such as age, sex, stage in life cycle, income, and number of automobiles, are included for each individual or household and not on a zonal aggregate basis, where variables such as the average stage in life cycle are not meaningful.

b. They have the potential for reducing data collection costs significantly because we now only require a very limited sample (relative to the data requirements of aggregate models). Preliminary estimates by disaggregate demand modeling experts are that, of the current data set of 25,000 households collected for a traditional urban study, a maximum of only 5,000 household observations are needed for calibration. This represents a reduction factor of 4 or 5 in sample size requirements. The reason for this reduction is that we are now working with individuals at a more detailed behavioral level. Therefore, fewer data are needed to capture the essential differences among travelers. Even given that the cost per sample may increase from the current value of $20 to $30 per household (a factor of 2 to 3 is estimated) because of increased information requirements, the savings in collection and processing costs can be fairly significant. (Additional information is required on variables such as sex and age, and for each individual on the values of the level-of-service vector for competing modes.) Attributing this increase in cost to the model approach is somewhat misleading because the model is a multimodal model and is designed to predict all demand interactions simultaneously, similar to the aggregate direct demand models, such as the SARC-Kraft, Baumol-Quandt, and McLynn models. A fairer comparison would be between data requirements for aggregate and disaggregate multimodal demand models.

c. The model parameters (which show the sensitivity of demand to changes in the socioeconomic characteristics of the trip-maker, the attractiveness of the possible destinations, and the level-of-service variables) have a much higher likelihood of transferability from one geographical area to another. The underlying hypothesis, for which there is some (as yet inconclusive) evidence is that individuals with the same traits, i.e., same economic background, same age, same sex, same income level, same stage in family cycle, same number of cars, and so on, will react in a similar manner. In other words, most of the problems with transferring aggregate models (such as the UTP models) from one region to another have to do with problems caused by different zonal aggregations and the inherent biases associated with them. If this proves to be correct, the costs of data collection will be reduced even further because data sets need not be collected in total for every new problem area.

The only major problem apparent with disaggregate models has been the problem that arises when one wants to use them for prediction. The independent variables must be forecast before the dependent variable (demand) can be predicted. In aggregate models, this implies forecasting future average zonal variables, such as income. In the disaggregate case, to forecast each individual change in the independent variables will be virtually impossible. This, therefore, requires the development of an aggregate model based on the disaggregate model. In the short run, a number of heuristic techniques can be employed, such as use of Monte Carlo techniques or stratification. Research is currently under way on the most practical methods for solving the aggregation problem (62).

One additional advantage of collecting information and calibrating disaggregate models at the individual or household level is that, once calibrated, the model is independent of the size of the zonal system used for forecasting. In other words, the disaggregate model can be used for any size zone system by aggregating to that level, whereas an aggregate model is limited to the same level (or higher) zone size that it was calibrated on.

The problems with this task of developing stochastic disaggregate models for state travel will be primarily with designing the data collection effort. The calibration method used most frequently is the maximum likelihood procedure for a multimodal logit model (63). This package exists and is operational in California, at M.I.T., and at a number of other places. In addition, some states may already have usable data sets. California, for example, appears to have 1 or 2 potentially good data sets available already from other sources and is considering developing this type of modeling approach for recreational travel. As a first step, the state should develop a disaggregate stochastic model for a specific kind of trip purpose, perhaps the recreational trip, if data are available or can be collected easily enough. From there, once the initial steps have been worked out, the model can be extended to other trip purposes and market segments for analyzing statewide travel, either for the policy-sensitive analysis tools or for use in network equilibrium procedures.

4. Incorporate on-the-shelf (environmental, economic, and other) impact-prediction techniques.

In addition to improvements in the travel forecasting methodology, there are a variety of techniques that have become available in the past few years (and in some cases, just the past few months) that can be useful as immediate procedures for predicting impacts at the statewide level. Two of the most important areas of impact prediction appear to be air quality and noise pollution models for urbanized states. An HRB report (3) describes the general problem and available techniques up to 1972. Since that time, many states have incorporated air-pollutant emission and dispersion models and in some cases noise pollution models. California (64) is such a state. Michigan currently has air and noise models operating in conjunction with travel simulation models only at the large zone (547) level but hopes to expand this system to the small zone (2300) level some time in the near future (24).

Two model systems worthy of consideration (described earlier) are the ones developed by Ingram (25) in 1972 as a response to a need for models to predict air and noise pollution in conjunction with a travel simulation system and the STAR system (22).

This area of modeling is changing so rapidly and there has been so little investigation relative to the traffic flow modeling procedures that it is difficult to summarize exactly the accomplishments of each state or to propose a comprehensive set of improvements in this area. In addition, a wide variety of other impact models are also required, and the extent of their usefulness in the statewide modeling effort would be just conjecture at this point, although it is fairly certain that some models will be extremely useful. Economic development and social-impact prediction techniques are 2 areas that would seem to be high priority areas for research and development.

A recent study (65) contains a fairly comprehensive first attempt at a survey and evaluation of available impact-prediction techniques. The study has also attempted to classify these techniques with respect to their usefulness at the system, corridor, and project levels as well as to estimate their relative costs of use. The impact prediction (or resource) models cataloged in this study include models to predict impacts such as direct cost and revenues; noise, air, water, and visual pollution; energy requirements; system changes; community disruption; and other important effects. The total list of potential impact prediction models is given in Table 4. This study further describes the details of existing impact models, and it and NCHRP Report 133 (66) are recommended for a review of specific techniques. The selection of specific techniques for each impact type will have to be based on each state's specific requirements and available resources. Obviously, the priority placed on impact techniques will vary from state to state. In addition, as in the demand modeling efforts described in earlier paragraphs, there may be a need for a variety of techniques for any one impact type, some simplified procedures for analyzing broad policy-oriented issues, and some for detailed, network-oriented models to be used in conjunction with the network simulation methods.

Clearly, much further work needs to be done in the whole impact-prediction area before the appropriate models for statewide modeling can be determined. In addition to the basic research required in each of the areas of impact prediction, there should be some effort directed toward determining the appropriate level of detail for each specific model. Many impact-prediction models now require detailed inputs that are simply not available at the planning or programming stages.

In the short run, existing procedures [e.g., SRI method under development in California (64) and Darling (26)] should be compared for their effectiveness and cost and a decision made as to the most appropriate technique for each state. A reasonable strategy to follow in the development of all of these methods in order to reduce the risk and cost involved would be the testing of the selected procedures in terms of data requirements, cost of operation, effectiveness, and so on on a substate level before they are fully developed at the state level.

5. Employ one of the available on-the-shelf multimodal model systems and initiate prototype studies on a subregional or substate scale.

In parallel with steps 1 through 4, states can immediately upgrade their multimodal analysis capabilities by obtaining one (or more) of the existing multimodal analysis packages currently available. The STAR system (22) developed by the Rand Corporation has been tested extensively by the Transportation Systems Center of the U.S. Department of Transportation and will be available soon on request. It was designed for use as an intercity multimodal model and used for a California corridor. The package is based on models and programs developed during the original Northeast Corridor study. In addition to having demand and network simulation models, the system has models for the prediction of other impacts, such as energy requirements, emission levels, ground-mode noise, air noise, and costs.

The DODOTRANS system (21), also developed during the Northeast Corridor study, is a multimodal analysis and evaluation package that has a considerable amount of flexibility. (In addition, ongoing research at M.I.T. will produce a first version of an updated system during 1974 that is designed to add a significant number of capabilities.) DODOTRANS (a) allows alternative demand and modal-split formulations of the direct demand model type; (b) has an assignment phase that can be used in an all-or-nothing assignment mode without capacity restraint or in an incremental (equilibrium) mode with demands competing over all links and all modes simultaneously; (c) is designed originally as an evaluation tool to allow comparison of alternative

Table 4. Impact prediction techniques.

Technique	Level of Planning[a]			Usage Costs		
	System	Corridor	Project	Low	Moderate	High
Environmental and conservation						
Air pollution						
Emission factor models	X	X			X	
Dispersion models	X	X	X		X	
APRAC-1A diffusion model	X	X	O			X
Rollback model	X	X		X		
Box model	X	X		X		
Noise pollution						
Comparative studies			X		X	
Estimating equations		O	X		X	
Computer models			X			X
Noise-land use surveys	X	X	X		X	
Physical models			X			X
Nomographs		O	X	X		
Ecosystem						
Natural resource inventory	X	X	O	—[b]	—[b]	—[b]
Bioassays		O	X		X	
Ecological relations	O	O	X		X	
Ecological models	X	X	X			X
Aesthetics						
Index of visual intrusion			X		X	
Photographic studies			X		X	
Physical models			X		X	
Vibration						
Comparative studies			X		X	
Water resources						
Chloride estimates			X	X		
Comparative studies		O	X		X	
Meteorological dispersion models		X	X		X	
Historic preservation						
Historic resource inventory	X	X	X	—[b]	—[b]	—[b]
Induced economic						
Employment and economic activity						
Economic base studies	X	X	O			X
Correlative studies	X	X			X	
Input-output models	X					X
Highway usage indicators	X	X		X		
Econometric models	X	X			X	
Business dislocation studies			X		X	
Simulation models	X	O	O			X
Tax base change						
Right-of-way assessment	X	X	X		X	
Community						
Housing displacement						
Residential density method	X	X		X		
Housing studies	X	X	X	—[b]	—[b]	—[b]
Environmental capacity						
Annoyance index	O	O	X		X	
Community disruption						
Neighborhood social interaction index		X	X		X	
Residential linkages		X	X			X
Mobility index		X	X		X	
Social capacity indicators		X			X	
Transportation service						
Accessibility						
Accessibility indexes	X	X	O		X	
Accessibility graphs	X	X	O		X	
Isochronal maps	X	X	X		X	
Mobility for special groups	—[c]	—[c]	—[c]	—[c]	—[c]	—[c]
Pedestrian mobility	—[c]	—[c]	—[c]	—[c]	—[c]	—[c]
Exposure to CO						
CO model	O	O	X		X	
View from the road						
Land		O	X		X	
Visual values		X	X			X
Activity distribution						
Land use						
Correlative studies	X	X	X		X	
Index of development pressure	X	X	X		X	
Urban development models	X	X	O			X
Population						
Econometric models	X	X			X	
Urban development models	X	X	O			X
Direct costs						
Right-of-way						
Rules of thumb for right-of-way	X	X	O	X		
RMC model	X	X	O	X		
Construction costs						
Cost models	X	X		X		
Operating costs	X	X	X		X	

[a] X = best level of planning for using technique, and O = other levels of planning for which technique is applicable
[b] Depends on level of detail
[c] No specific techniques exist

networks with alternative measures of performance as specified by the user; and (d) is based on a problem-oriented free format language that is extremely user-oriented and easily learned.

In addition, there are a number of other candidates for use as on-the-shelf computer packages for statewide planning. A computer package developed by the Aerospace Corporation for intercity multimodal travel simulation and evaluation is proprietary but available (67, 68). UMTA is developing a multimodal system that is oriented to the urban scene, but may be useful for statewide modeling. Its capabilities are being greatly expanded as part of a 3-year effort that has been under way for 2 years (40).

It is strongly recommended that states that do not have a statewide model now consider going directly to one of these packages, or packages available from other states, and evaluate each in terms such as data requirements, modes considered, and effectiveness. This evaluation should then lead to a test of one or more packages on a substate, regional, or corridor problem. States that already have developed statewide (unimodal) models may want to explore the possibilities of these packages on a small-scale study as well, while adapting their existing packages as suggested in task 1 of this section. Many of the components of the existing packages can be used in a modular fashion. Therefore, what may occur is a merging of approaches rather than complete abandonment of one system in favor of another.

6. Initiate research on other specialized modal problems.

Some effort should be devoted to specialized modal problems, such as air and ports, that will require models not included in the existing packages. For example, California's air simulation model that focuses on airport access and location is not suitable for incorporation in some of the packages, but still may be a useful model in some instances. There are also a number of port simulation models (69) that could be used by those states concerned with port development and its impact on the rest of the transportation system.

Long-Range Improvements

Some long-range improvement efforts are appropriate at the federal level, and other research may be done by one or more of the large states or through joint studies between the states. These are clearly long-range only in terms of the amount of money and time involved in developing the procedures and in implementing a workable system—not in terms of the need for the research. Some states may consider themselves advanced enough to implement these recommendations much sooner.

This need for long-run research is divided into 2 parts. The first recommendation is for a study at the federal level of the overall requirements for states in terms of modeling methodologies. The second is for development of specialized models and procedures to be used in conjunction with the short-run changes described above.

7. Conduct a study to determine the states' overall modeling requirements.

A comprehensive study should be carried out at the federal level, much like the studies performed for Pennsylvania (18) and for California (20), that determine existing capabilities for a wide variety of states, requirements for planning and programming methodologies, and a staged strategy of improvements and a program of research. This study should focus on the methodology required for the 6 major areas given in Table 4. Some of the requirements in these categories will be fairly straightforward to satisfy. Most of the discussion in this paper has been primarily about transportation service.

Other areas have not been emphasized in this paper and will require considerable long-run research before techniques can be developed. The purpose of this study would be to identify the models and methodology available (in much more detail than was possible in this paper), the costs and accuracy of each, and how they should interface with the overall programming process.

In addition to being a long-run program of research, the study should identify the most immediate improvements for states with quite different geographical and institutional structure. Hazen (17) summarized 4 typical studies that have already been undertaken; their characteristics and costs are given in Table 5. The output of the study proposed here would be similar to Hazen's summary but would also include a study design for each type of state and emphasize models to be used for its particular problems.

8. Develop long-run activity-system models to predict economic impacts, land use distribution, and other impacts.

Specialized research needs to be undertaken immediately that focuses on implementing modeling methodologies that currently exist. The purpose of this research would be to focus on existing techniques in specific areas [for example, existing land use methods such as EMPIRIC (70), PLUM (71), and NBER (72)] and to identify the strengths and weaknesses of each approach, the costs to implement and run, and the specific situations in which the models would be useful. Clearly, this research would overlap somewhat with recommendation 7, but it is intended to be complementary to it and to focus on improvements using existing methodologies rather than on development of new techniques.

These techniques have been alluded to previously and have been discussed in part by the resource paper on goods movement in this report. They are essential to both passenger and goods movement methodology if any significant changes are proposed for any state. They include the areas mentioned in the previous recommendation and given in detail in Table 4. The areas that could be adapted most quickly and appear significant to statewide planning are economic models (economic base techniques, input-output models, regional econometric multiplier studies), population models (econometric, urban development models), and urban land use models (activity simulation models, econometric models).

The costs for developing or adapting these models will vary in each state because of size, availability of data, and so on and by the amount of effort devoted to each technique. For example, as Schiff (66) points out, simple economic base models will cost a lot less than a complete macroeconomic input-output model, but may be a first and reasonable step for a state to take.

Improvements to Programming Methodology

Although historically there has been some research on technical programming procedures, until recently there has been very little on the process of programming and the inclusion of nontechnical or nonquantifiable factors (52, 53). Certainly programming has received far less attention than the demand modeling tools and techniques, but there is some evidence of a growing interest in this area. [California has recently implemented a planning, programming, and budgeting system (73) and has recently explored an approach to include nonquantifiable factors as well.]

By and large, a study is significantly needed into both the procedures and the process to be used for matching proposed projects with available resources. Most important, much of the awareness of social values and environmental concerns must be incorporated in the overall programming activity. In fact, the recent FHWA guidelines (implicitly) require this approach (74).

Five general proposed improvements to the methodology of programming of transportation improvements correspond roughly to the problem areas identified in an earlier section. Although some of these will require considerable research before they can be effectively implemented, they must be recognized and introduced into the process immediately.

1. Introduce a realistic budget constraint early in the process.

This should reduce the number of projects being studied in great detail and put each link in perspective with other parts of the system. Introducing budget constraints early in the process will let systems studies focus on realistic networks that are interconnected and provide a reasonable level of service during the planning period. Moreover, this will allow RPAs to understand what is reasonable to expect from the state in terms of funding and to make their priority decisions and trade-offs accordingly. To develop plans in the absence of budget constraints and then to proceed down a list of projects that have been ranked until the budget is exhausted will result in projects that are too large, unconnected, and cost-ineffective.

The priority is high. (These tasks do not lend themselves to cost estimates or time-frame estimates as the planning models do.)

2. Incorporate multiple (mutually exclusive) alternatives with a range of impacts.

In conjunction with the previous recommendation, alternatives should be broadened to include multiple scales (2, 4, 6 lanes with provision for staging) that have a range of economic, community, and environmental impacts.

Multiple alternatives will allow decision-makers to have a more flexible set of alternatives and, therefore, to broaden their choices. An example of the advantages of this procedure recently occurred in Massachusetts. A particular region, completely opposed to a previously proposed highway alternative, reversed its position after observing the impacts of alternatives and the results that would occur if the improvements took place. Developing multiple alternatives allowed the state to gain credibility and acceptance of a need for transportation service.

More important, developing mutually exclusive alternatives is essential for the programming process if constraints on the overall budget are to be effectively considered. The program selected without recognition being given to budget constraints or the inclusion of mutually exclusive alternatives will, in general, be completely different and less effective than one that does. [Juster (54) recently demonstrated the importance of incorporating budget constraints, mutually exclusive alternatives, and a whole host of other constraints in a state's programming process.]

The priority is medium to high.

3. Expand the criteria for determining priorities to include social and environmental concerns.

Currently the criteria have been limited to user measures in either a sufficiency rating or economic analysis scheme. Although there has been some preliminary work done in some states on other measures, there is a significant need for research into specific criteria for the programming process.

A recent NCHRP study (75) established a framework to permit simultaneous evaluation of highway and transit improvements, with interchangeable measures of benefits and costs. This study is an important first step in performing multimodal analysis and, eventually, programming of investments on a multimodal basis with a reasonable and comparable set of criteria.

The priority is high.

4. Incorporate factors of uncertainty.

The first step, of course, is to recognize uncertainty and learn to live with it—uncertainty in demand, in technology, and in community values. The second step is to try to account for uncertainty in a more analytic and systematic way. Recent case studies in California (55) and Mexico (76) have demonstrated 2 time-staging approaches to handling uncertainty. The California Division of Highways has in the past developed 2 contingency plans for one district just in case the preferred program was halted.

The priority is medium to high.

5. Develop a flexible, interactive, and participatory programming process.

Research is needed into the overall programming process itself. Besides the analytic techniques for developing economic, environmental, and social criteria, the process of programming must be viewed as cyclical, iterative, and participatory with many different interest groups being involved in making up actual investment programs.

Thus, research is required on the actual decision-making process and structure: Who are the relevant decision-makers, and how should their views be accounted for when projects are selected for funding? How workable are the procedures? How understandable are they to laymen? How should information flow among various levels of interest groups? This problem is a result of the increased reliance on the UTP process, inputs from RPAs without a well-defined programming process, regulations in the Federal-Aid Highway Act of 1973, and EPA guidelines. The problem now manifests itself in connection with projects that are generally considered to be advanced enough to be out of the systems planning phase. But this is just a transitory situation while the new guidelines and regulations are taking effect, with pipeline projects caught in the middle. Eventually the systems planning phase will bear the greatest responsibility for meeting the new decision-making regulations. The research needed is in the development of the overall process, with the key decision points, the decision-makers, and their level of interaction identified at each point. This research should produce primarily a document that interprets the morass of regulations that have hit the states. It should collect all the new regulations from federal and state agencies and show where they overlap or conflict and where ambiguities need to be worked out. In addition, it should produce a much-needed framework to encompass the remaining research needs.

This research should be a first step before the more theoretical issues in systems planning and programming are considered because there is a need to show where, within a defined and accepted programming framework, the specific evaluation criteria, techniques, and processes fit in. Moreover, this research should go a long way in helping to define the problem of evaluation for alternative programs and clarify the situation so that research into the other areas is simpler and easier to define. Discussing an accepted programming framework, no matter how flexible or rigid, as long as decision points and decision-makers are explicitly defined, will make the remaining research less ambiguous and more relevant to state transportation planners and also to researchers. Currently, some states are faced with the problem of wanting to open up the programming process to all interested groups but are simply unsure of how to meet all the regulations in a coordinated and manageable process.

The priority is high.

CONTINUING STATEWIDE PLANNING PROCESS

The preceding sections have described the existing methodology of statewide planning and programming and have proposed incremental improvements to this methodology. That discussion has been primarily from a modeling or technique point of view—what models and techniques are in use or are needed to predict travel, economic, environmental, and social impacts. The purpose of this section is to discuss what are felt to be extremely important additional methodological issues—how the tools and techniques will be used. This will be explored from the following 2 points of view: (a) master planning versus the strategic, time-staged investment approach and (b) citizen participation at the statewide level.

Master Planning Versus the Strategic, Time-Staged Investment Approach

Nearly all urban, regional, and statewide system planning studies can be characterized as concerned with the development of long-range (15 to 30 years) plans with little or no emphasis on implementation strategies; i.e., given a long-range master plan, little effort is generally devoted to the question of how do we get from here to there. To a large degree, this lack of relevance to short-run programming decisions has been the single most impressive failure of the traditional studies. The legislatively mandated long-run state master plans for highways have produced an impressive system of interstate and state highway systems unparalleled in the world. In many states, however, many parts of the state system are experiencing serious setbacks, and there is a real question whether the system will ever be completed. (Boston's inner belt is one example; components of the Los Angeles system of highways are another.)

The reasons for these setbacks are fairly obvious and well-known: environmental and ecological concerns, spiraling costs, lack of funds, and so on. Most of the parts of state and interstate systems were constructed to fairly elaborate standards, in some cases with capacity that will not be needed for as many as 10 or 15 years. In addition, they were constructed around bottleneck situations in response to existing congestion problems. It is probably safe to say that system planning in general has played little part (other than providing design volumes) in determining which parts of the system were needed most and when they were needed; most of the decisions have been made without a consideration of network connectivity, accessibility to different geographical areas, and overall system effects of networks.

In what may turn out to be a classic study in the highway field, California has just recently completed a pilot project in the San Francisco region (and is planning to extend this to other regions in the near future) that has recognized that the regional plan will not be completed for the reasons cited above, but primarily because of reasons of negative environmental impacts and a limited budget. Besides considering traditional user benefit measures, volume-capacity ratios, and safety benefits as criteria for improvement, planners also evaluated connectivity, mobility, and flexibility of network structure, as alluded to in earlier sections. In addition, they are reevaluating all components of the system including the scale of projects (4, 6, and 8 lanes), time-staging of links (building 4 now and adding 2 later), and procuring right-of-way ahead of time in what they term a "rescoping" process. Not surprising, they are finding that many projects, from a benefit-cost ratio viewpoint, were entirely overdesigned; i.e., the smaller projects are most cost effective. Moreover, by also considering a more realistic funding picture for highways in the next few years, they are able to determine a good network plan from many possible alternative plans, one that has a reasonable chance of getting built (each scale of project has a different level of environmental and community impact) and is reasonable from an integrated highway network service point of view. This is the beginning step of the philosophy of planning we are advocating here that considers implementation strategies, time-staging, and integration of long-range master plans with short-term immediate investments.

The CM/PS study (18, p. 165) also addresses the issue of master planning versus a time-staged planning approach and, although recognizing the problems with the master plan concept, advocates its use on the grounds that

> 1. They are after a broadly defined, long-run sketch solution to the statewide problem upon which lower echelons of decision-making can amplify.
> 2. Interspatial interactions are much more important at the statewide level than intertemporal interactions between components of the transportation system. Practically all urban, regional, and state transportation planning efforts have been predicated on this assumption. Not only have past planning efforts deemed it infeasible to consider the time dimension simultaneously with the analysis of spatial interactions, but the few attempts at developing a meaningful model of the staging problem itself have proved infeasible.

We agree in part with the first reason: Long-run sketch planning (and the accompanying methodology) is useful to make trade-offs and preliminary decisions as to scale of systems or mode and so on. But this is only a part of the statewide planning methodology. Therefore, we do not agree that it should be left for others to amplify or that a time-staged strategic approach is infeasible. [The Harvard-Brookings model (34), for example, was applied effectively to an area with approximately the same population but 3 times the size of California with both a macroeconomic (input-output) model and multimodal transport model. It was able to develop and test alternative staging strategies very effectively. The need for the Boston Transportation Planning Review (BTPR) is a classic example of what is wrong with the master plan concept. The BTPR represents a reasonable, practical attempt to evaluate staging strategies at the ubran area level, although the staff perhaps was limited by time and money in what it could accomplish. In fact, it attempted to resolve the problems of a master plan approach that has left part of the system unbuilt.]

The advantages of the "traditional" master plan are obvious.

1. It is a broad, encompassing plan that is easy to understand and to visually display. It also allows trade-offs to be made and decisions on technologies that have long-term implications.
2. It is required by law to obtain funding.
3. It provides (or should do so at least) for the consideration of network interactions and for the development of an integrated coordinated network in the long run.
4. Most important, it theoretically allows other sectors of the economy and the public to make their locational and investment decisions with a degree of certainty, both in the private and public sectors.

But there are a number of disadvantages as well.

1. Although system plans are useful for determining the implications of complex systems, they have had little, if any, relevance to actual short-term programming decisions. Links are conceived at the project level and "aggregated" into networks to be tested. There has been little emphasis on network connectivity.
2. They generally fail to recognize realistic budget constraints. This has resulted in fairly large systems that, in general, are never completed.
3. Because of the long-range nature of the master plan, they cannot effectively cope with the uncertainty that exists in the future with respect to demands, technology, or even goals, objectives, and community values. How can we possibly say what is a desirable plan 20 to 30 years from now?

In fact, reliance on the master plan and the emphasis on long-range planning is exactly what has caused urban planning efforts to lose their credibility. It is imperative, therefore, that the planning groups, be they statewide, urban, or regional, recognize the intertemporal nature of investments and integrate their time-staged plans more effectively with the actual programming process if we are to have an impact on transportation investments at a state level.

Neumann and Pecknold (77, ch. 2) have proposed a strategic, time-staged approach to statewide planning. The following discussion is based on that work.

The change in approach for statewide planning is not proposed as a hard-and-fast, well-developed methodology to be followed but rather more of a change in the philosophy of planning. Activities of statewide systems and project planning should not be considered as sequential activities. Statewide system planning should not precede project planning, but provide a framework within which project decisions can be made. It serves to mediate between and coordinate ongoing project studies. Statewide system planning, therefore, would assign resources and priorities periodically among the ongoing subarea or regional studies and project planning processes. Project planning results would influence decisions about the overall system, not just vice versa. And because project studies influence system planning, they must be carefully coordinated with system planning in a cyclical, continuing manner.

The time-staged, strategic approach explicitly recognizes that transportation plans are not implemented instantaneously as a "one-shot" system, but rather in a series of stages in which benefits and costs are quite different at each stage. At each stage, demands and activities in terms of locational decisions of industry and population can change. The "plans" to be evaluated now become alternative strategies of investment over time. For example, the 20-year time horizon might be divided into 5-year stages. Each stage of a particular implementation strategy might include construction of a number of highway links or rail options, operating and policy changes, and different

Table 5. Classes of statewide transportation studies.

Characteristics	Purpose	Procedures
Statewide traffic model $100,000 or less 6 to 18 months	To do system simulation by using the computer in order to better understand how the system operates, and to undertake functional classification and general planning purposes	Zones and network are selected and coded by using standard procedures Models for trip generation and distribution are kept simple Usually, there is no trip purpose breakdown, 1 but no more than 3 independent socioeconomic variables and minimum O-D data are utilized
Statewide highway transportation study $100,000 to $500,000 (usually over $200,000) 15 to 30 months 6 to 12 people	To develop an intermediate priced traffic model based on C-D sample design, to obtain information on trip generation and trip length, to evaluate alternative highway networks, to develop a state highway plan	O-D sampling for internal trips is accomplished by multiple screen-line roadside interviewing, stratified cluster sample of homes, telephone interviewing, or some comparable procedure Models are developed by trip purpose, usually 3 to 5 for automobiles and 1 to 2 for trucks Comparisons and calibration are made against ADT volumes Development of alternatives includes functional classification, scheme development, and testing
Comprehensive statewide transportation study $500,000 to $1,500,000 24 to 48 months 10 to 25 people	To develop on a statewide or regional basis the comprehensive transportation planning process, to simulate person movements by mode of transportation, to evaluate alternate modes and networks, to develop a state transportation plan	Elements and procedures are similar to those of the comprehensive urban transportation studies Interviews are sufficient to develop a trip table of interzonal person movements Studies include an economic base model and land use model Within budget limitations, goods movement is obtained and projected
Integrated statewide transportation study Over $1,500,000 36 to 60 months 15 to 50 people	To apply the latest techniques in systems analysis and operations research to statewide transportation planning, to study the complete system of person and goods movement from origin to destination, to evaluate alternate sets of policies in regard to the transportation system, to develop a state transportation program	The procedures incorporate the latest techniques in systems analysis and operations research - Detailed person and goods movement from origin to destination is studied, emphasis is on transfer and terminal points The models are iterative with a feedback to account for results of different transportation policies

Figure 5. Implementation strategy approach to system planning.

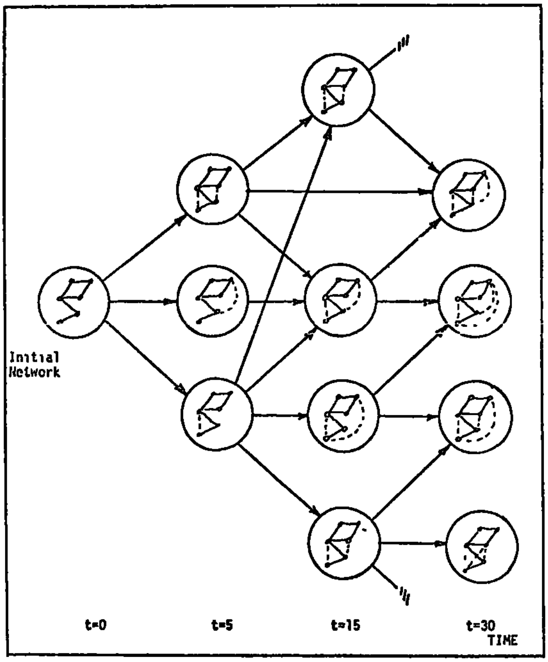


Table 6. Community interaction techniques.

Information Gathering	Information Distribution	Interaction	Special Purpose
Existing sources Compiled statistics Descriptive information Working with local officials Monitoring new developments Analyzing plans, programs, and reports Monitoring mass media Newspapers Radio and television Other Field work Surveys	Announcements and study information Posters, billboards, and signs Mail notices Newspapers Legal notices Advertisements News articles Feature columns and articles News releases Letters to the editor Radio and television Announcements News coverage Talk shows and community-oriented programs Documentaries Private media Displays, maps, models	Small group meetings Working meetings Workshops Hearings and other large public meetings Field offices Public information centers Advisory committees, steering committees, other groups	Referenda Technical assistance Mediation and arbitration Ombudsman Charette

studies. No particular "end state" need be identified initially as a target system. The benefits of such an approach are that, during implementation of the first stage, the subsequent stages in a strategy could be revised or updated in light of new information or changes that have occurred (Fig. 5).

One of the primary benefits of this approach is that it recognizes that many significant decisions affecting a system plan are in reality going to be postponed until project environmental impact and corridor and initial route studies are under way or completed. The mode, scale, specific alignment, and indeed even the existence of a particular facility may therefore be determined in later phases of planning. System plans can account for the possibility of a number of possible outcomes from these later studies.

Developing different sequences of actions on facility improvements places emphasis on what choices are available during the planning time in the future. The different sequences can also explicitly recognize uncertainty regarding a number of factors by evaluating the impacts of a number of potential outcomes from project negotiations or impact studies. Thus, implementation strategies provide a convenient framework for relating statewide system and project planning and programming by focusing on both short-term programming decisions and longer range plans.

Although the resources available for system planning will restrict the number of sequences and uncertainties that can be considered, attention need not be limited to one sequence over time. Implementation strategies most certainly cannot be developed for every possible event that may occur in the future, but they can represent what appear today to be the major choices facing the decision-making process.

The role of statewide system planning in the context of alternative implementation programs is to carefully anticipate the choice issues that must be resolved as planning continues and devise tentative sequences of improvements based on the potential outcomes from these choices. As new information is gathered, new options will be added while others will be dropped from consideration. In some cases, the uncertainty may be so great that one will need demonstration programs to test the response to new systems.

In summary, statewide system and project planning and programming must be integrated so that the "go—no go" decision to implement a project or a particular design will not disrupt the ability to allocate funds smoothly to other high priority projects. Focusing on implementation strategies will allow and encourage a state transportation agency to anticipate modifications so that, when they occur, they do not result in lost time.

Obviously, both the master plan and a plan based on time-staged strategies can be altered in future periods in response to changes. Neither irrevocably commits a region to one sequence of implementations over time. The 2 essential differences between the approaches lie in how initial decisions are made and in the flexibility provided to revise the plan over time. Initial decisions with the master plan aim at 1 target-year system. Although the master plan can be revised, many alternatives are foreclosed prematurely when 1 target network is focused on. The time-staged strategic approach, on the other hand, considers a number of improvement sequences as initial decisions are being made and is able to address questions of uncertainty explicitly. By anticipating the changes that may occur and a range of the choices available in the future, this approach explicitly requires periodic evaluations and revisions and ongoing coordination with project studies. The cost for such an approach may be higher than straightforward master planning, but the precedent has been set (34); and the chances of being able to implement realistic transportation investment programs will be considerably greater.

Citizen and Community Participation at the State Level

A second failure of the traditional UTP studies has been the lack of effective community involvement. Certainly, the most significant change to occur in the past 20 years in the transportation field is the factor of citizen or community participation. The public is demanding a more active role in planning and decision-making at all levels.

It has received the most attention in urban areas, and participatory planning is now required by law. Any conclusions concerning the kind of impact that community involvement has had on transportation decisions, however, can only be tentative at the current time. It certainly has worked effectively in some, but not all, cases. Community interaction is a communication and participation process involving information flow between the transportation agency and other agencies, officials, interest groups, and the general public. Its success has been limited where the information flow did not occur or was not sufficient or involved the wrong groups. To be sure, the techniques and procedures for effective community participation have still to be refined and, in some cases, are still to be developed. Nonetheless, changing attitudes have made it essential that the choices represented by transportation investment decisions be understood by all groups affected by those choices.

The NCHRP study (77) has produced a guide to effective community interaction for transportation investment decisions. It has also identified some 34 techniques to help in carrying out effective community interaction (Table 6).

The NCHRP report also points out that participation must take place in an environment of community and technical interaction. The community can aid in (a) determining goals and objectives, (b) identifying alternative transportation policies and projects, (c) identifying the impacts of concern to them, and (d) evaluating the impacts of the various alternatives. The technical team provides expertise in alternative development and impact prediction within the constraints of its limited planning resources. Through an iterative process of alternative development, evaluation, and refinement, key choices for decision-makers are identified and presented as a means of ensuring well-informed, responsive decisions. Clearly, this kind of involvement will significantly affect the methodology required for both planning and programming.

Both the NCHRP study (77) and the HRB report (2) articulate the objectives, the current approaches, and the effectiveness of citizen participation. To summarize effectively all of the information contained in these 2 documents would be difficult. However, 3 major points from these studies have a major impact on the methodology of statewide planning and programming and reinforce what we have been advocating in earlier sections.

> The transportation process is not now designed to answer questions that citizens often ask. The participants in the process identify and examine all reasonable alternatives and their consequences to assist the appropriate decision-makers in choosing the course that they believe to be needed and that they feel will best serve the needs and objectives of the community.

This implies the need for a planning and programming process that can identify and quickly evaluate many different transport options, focusing on not just a level-of-service need but on socioeconomic, environmental, and transportation service needs. It also implies a process that is open, flexible, and easy to use and has credibility with the public. (Although we do not expect laymen to fully understand technical procedures, they should be aware of the assumptions, biases, and limitations of the procedures. Certainly, local transportation people in RPAs and even politicians will be more than ever questioning the procedures in use in the future.)

> The most common impediment to citizens' involvement at the (statewide) systems stage is that it deals with problems that will occur too far in the future and citizens do not see how their own current interests are affected.

One approach to increasing this involvement will be to relate long-range state plans to shorter range programming decisions through the time-staging approach and to apply realistic budget constraints described in the previous section.

> Criteria for evaluation should include efficiency, equity, service, environmental protection, policy compatibility, future options, legality, and community goals and values. [Citizens should] also be involved in determining priorities in implementation schedules and have op-

portunity each year to assist in reviewing these priorities

This reemphasizes the continuing role of citizen participation and statewide planning, the need for ties between longer range plans and programs, and the necessity of broadening the criteria for determining priorities.

One good example of the relation between citizen participation and the technical tools used to evaluate alternatives is the Boston Transportation Planning Review (9). The major accomplishments of this very elaborate effort at citizen participation are fairly well-known and are soon to be published (2). But one shortcoming not documented, aside from the fact that the study was too short and had too little money for what it was trying to accomplish, was that the technical tools of the study were not entirely adequate. The forecasting tools were based on traditional UTP techniques and were not capable of responding to the many unique multimodal alternatives suggested by citizen groups themselves. Nor was the study able to respond as quickly as it would have liked. This example is not unique to the BTPR study. This fact and the objectives laid out by Gakenheimer (79) and summarized here have methodological implications for the overall analysis environment provided to carry out statewide planning and programming alluded to throughout this paper. Improving the procedures of both planning and programming should lead both to more effective community participation and to more effective transportation decisions.

SUMMARY AND CONCLUSIONS

The proposed methodology for statewide planning and programming described in this paper will not be easy to develop. It will require a significant amount of research, the testing of hypotheses, and the collection of new kinds and types of data. In some cases, it will also require a period of exploratory testing of new and as yet unproven techniques and methods. For example, economic activity simulation models (such as input-output techniques) and land use models have been used in only a small number of instances with only limited success (for a variety of understandable reasons) and in fewer instances yet in connection with a transport model. Nonetheless, to avoid developing these procedures is to ignore the interactions of the many different sectors of the economy and its influence on the flow of goods and location of population and employment.

Although the amount of needed research is substantial, this area of investigation represents a fascinating challenge to professionals interested and involved in transportation planning. In the short run, there is a significant amount that can be done to improve the methodology of statewide planning and programming. Existing procedures can be adapted from urban and regional studies. For example, although stochastic disaggregate demand models for short-run forecasting have still not been incorporated in the traditional urban studies, they have been used in many special studies in urban areas and, at least in one case, in an intercity study. They appear to be a significant improvement over the traditional methods of the UTP techniques in terms of (a) their behavioral nature and relevance to policy changes, (b) the costs of data collection, and (c) their potential for transferability of results from one state to another.

In many cases, we will not have the right kinds or amounts of data for these models. Fortunately, there is a growing body of evidence on elasticities in urban areas, and the beginnings of that kind of evidence at the state level as well. These results can be used in many studies involving incremental changes (such as the pivot-point analysis technique described earlier) while the newer and more elaborate techniques are being developed. In other cases, we will simply have to carry out the studies by collecting new data and constructing the models.

We are not recommending that those states with a significant amount invested in the traditional methods immediately switch to a whole new methodology. The proposed approach is a phased strategy of incremental improvements to the existing procedures. At the same time, states should seek, first, to improve the overall multimodal capability using existing packages and, second, to develop the longer run, more complex activity shift methods needed to properly evaluate the many different transport investment alternatives at the state level.

Moreover, not all states will require as elaborate a methodology as the large states with significant multimodal concerns. Each state will have to evolve its own set of procedures and ways of performing multimodal analysis. Cooperation among states has been extremely good in the past, and some already have indicated a willingness to make programs and models available to other states. It would probably be extremely beneficial to develop a pilot study in one or more different kinds of states in order to actually determine the methodology and data required to do effective statewide planning.

In summary, the recommendation of this paper is the development of a flexible analysis environment for each state and a variety of multimodal modeling tools, some general, others specialized, that have the capacity to predict travel, environmental and economic impacts, and trade-offs and equity issues for a wide variety of spatially and temporally different investment programs. These investment programs must include short-run, low-capital highway options (such as those shown in Fig. 1), low-capital transit or para-transit alternatives, and the more traditional longer range capital-intensive investments. In addition, we are also recommending a more strategic planning approach than has been used in the past; staging strategies are to be evaluated not only for economic and environmental impacts but also for the flexibility to adapt to a wide variety of conditions that may evolve in the future. This approach then should provide for a more positive influence in the actual programming and implementation process inherent in statewide planning. It also will allow for flexibility to interact with regional plans in an interactive, participatory, and iterative manner.

The effort required to develop and implement much of this statewide multimodal methodology will not be inconsequential. However, the potential payoffs from more efficient, well-planned, and integrated transportation systems are enormous, given the amounts of money we have been spending on transportation to date.

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