NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM
REPORT 179

EVALUATING OPTIONS IN STATEWIDE TRANSPORTATION PLANNING/PROGRAMMING

ISSUES, TECHNIQUES, AND THEIR RELATIONSHIPS

TRANSPORTATION RESEARCH BOARD
NATIONAL RESEARCH COUNCIL

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RESEARCH SPONSORED BY THE AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS IN COOPERATION WITH THE FEDERAL HIGHWAY ADMINISTRATION

AREAS OF INTEREST:
- TRANSPORTATION ADMINISTRATION
- TRANSPORTATION FINANCE
- TRANSPORTATION ECONOMICS
- URBAN COMMUNITY VALUES
- URBAN TRANSPORTATION SYSTEMS

TRANSPORTATION RESEARCH BOARD
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WASHINGTON, D.C. 1977

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Systematic, well-designed research provides the most effective approach to the solution of many problems facing highway administrators and engineers. Often, highway problems are of local interest and can best be studied by highway departments individually or in cooperation with their state universities and others. However, the accelerating growth of highway transportation develops increasingly complex problems of wide interest to highway authorities. These problems are best studied through a coordinated program of cooperative research.

In recognition of these needs, the highway administrators of the American Association of State Highway and Transportation Officials initiated in 1962 an objective national highway research program employing modern scientific techniques. This program is supported on a continuing basis by funds from participating member states of the Association and it receives the full cooperation and support of the Federal Highway Administration, United States Department of Transportation.

The Transportation Research Board of the National Research Council was requested by the Association to administer the research program because of the Board's recognized objectivity and understanding of modern research practices. The Board is uniquely suited for this purpose as: it maintains an extensive committee structure from which authorities on any highway transportation subject may be drawn; it possesses avenues of communications and cooperation with federal, state, and local governmental agencies, universities, and industry; its relationship to its parent organization, the National Academy of Sciences, a private, nonprofit institution, is an insurance of objectivity; it maintains a full-time research correlation staff of specialists in highway transportation matters to bring the findings of research directly to those who are in a position to use them.

The program is developed on the basis of research needs identified by chief administrators of the highway and transportation departments and by committees of AASHTO. Each year, specific areas of research needs to be included in the program are proposed to the Academy and the Board by the American Association of State Highway and Transportation Officials. Research projects to fulfill these needs are defined by the Board, and qualified research agencies are selected from those that have submitted proposals. Administration and surveillance of research contracts are responsibilities of the Academy and its Transportation Research Board.

The needs for highway research are many, and the National Cooperative Highway Research Program can make significant contributions to the solution of highway transportation problems of mutual concern to many responsible groups. The program, however, is intended to complement rather than to substitute for or duplicate other highway research programs.

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FOREWORD

By Staff
Transportation
Research Board

This report will be of special interest to transportation planners and analysts having responsibility for providing information to decision makers on current policy, program, and project issues. The discussion of these issues as identified from interviews with numerous state officials will also be of interest to transportation administrators. Many sketch planning techniques have been developed by others to meet the specific needs of individual states or regions, but dissemination of the capabilities and availability of these techniques has been limited. In response to this need, this report (1) summarizes the key issues facing state planners, (2) identifies impacts resulting from alternative solutions to the issues, (3) describes available techniques to measure the impacts, and (4) reports data availability to apply the selected techniques. The requirements of all transportation modes are included for a wide range of impacts, such as environmental, social, economic, travel demand, legal, and financial. Major emphasis is given to the identification and description of operational techniques so that planners can determine which techniques have potential use in their agencies; guidance is provided to assist planners in obtaining more detailed information for selected techniques.

The TRB Conference on Statewide Transportation Planning held February 21-24, 1974 identified many research needs as described in *TRB Special Report 146*. The conference gave high priority to the identification and development of planning techniques that provide quick response to current issues and/or that provide a less detailed level of analysis than the more traditional time-consuming, costly planning activities. Sketch planning techniques will not replace traditional planning methods; rather, there is a continuing need for both types of techniques, depending on the required level of detail and available time for response. Limited planning funds, reductions in planning staffs, and the need for timely assessment of transportation alternatives highlight the need for sketch planning tools. NCHRP Project 8-18 was initiated to meet this need and the results of the first phase of research are reported herein.

This report provides an extensive summary of available techniques that are of interest to state and regional planners. The second phase of research, to be reported at a later date, is currently testing and documenting three high-priority techniques, as described in Appendix D. Because of the timeliness of the information developed during Phase I, the results of the two phases are being reported separately.

The techniques reported herein are at various stages of development and many have significant deficiencies. Related projects are under way to refine existing

techniques and to develop new ones to fill the identified gaps, but much additional research is needed. Specific research requirements are identified in Chapter Four.

Planning Environment International, A Division of Alan M. Voorhees and Associates, Inc., is conducting both phases of this research effort in association with System Design Concepts, Inc. Their findings in regard to current issues, impacts, and techniques are based on numerous interviews with federal, state, and regional officials throughout the United States and Canada.

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ACKNOWLEDGMENTS

The research reported herein was performed under NCHRP Project 8–18 by Planning Environmental International (PEI), a division of Alan M. Voorhees & Associates, Inc., and System Design Concepts, Inc. (SyDec). Planning Environmental International was the contractor for the study. The work undertaken by SyDec was under a subcontract with PEI.

The principal investigators for the project were Salvatore J. Bellomo, Vice President of PEI, and Joseph R. Stowers, Vice President of SyDec. The other authors of this report are: Jawaharlal J. Mehra, Senior Engineer/Operations Research Analyst with PEI; Harry S. Cohen, Transportation Planner/Operations Research Analyst; Michael P. Petersilia, Transportation Planner/Engineer; and Arlee T. Reno, Transportation Planner/Political Scientist with SyDec. Particular contributions on this project were provided by Beth I. French, Marsha S. Goldberg, and Sally Liff from PEI, and JoAnne Greiser, Kenneth Mowll, and Bonnie Back from SyDec.

Grateful acknowledgment is made to all the state and Federal agencies and individuals who contributed their time and effort in responding to interviews as well as reviewing the three technical memoranda that were produced during Phase I of this study.

EVALUATING OPTIONS IN STATEWIDE TRANSPORTATION PLANNING/PROGRAMMING

ISSUES, TECHNIQUES, AND THEIR RELATIONSHIPS

SUMMARY

This report documents the results of the work performed during Phase I of the NCHRP Project 8-18 entitled "Techniques for Evaluating Options in Statewide Transportation Planning/Programming." The research objective is to provide transportation planning methodologies that will be policy-sensitive and that will facilitate the testing and evaluation of options in a manner that will produce results timely for decision making. In Phase I, the major transportation issues and their information needs were identified. Techniques available to address these information needs were also identified and evaluated. Study designs were developed to test the high-priority techniques in selected states with the aid of procedural manuals to be developed during Phase II of this study.

A two-pronged approach was taken to identify major state-level issues and the techniques necessary to resolve them. An extensive body of literature was reviewed. The knowledge gained from this "static" source was then supplemented by field interviews with those persons currently active in statewide transportation planning and programming. The basic products obtained through this approach include:

1. An annotated bibliography of all reviewed literature.
2. A list of approximately 75 specific major issues.
3. A description of 144 techniques for providing information to address these issues, ranging from fully operational techniques that have been applied in one or more states to techniques from the literature that have not yet been field tested.
4. A list of generally available data items and their sources.

The list of issues was sorted into 11 major issue areas within which states make key transportation decisions. These 11 issue areas and actions that might result from decisions in each are:

1. *Revenue shortfall:*
   Undertake actions to cope with current or projected declines in revenues and/or increasing costs.
2. *Development of multimodal transportation policies, plans, and programs:*
   Recommend policy changes, multimodal plans or program approval; delete or add elements to existing plans and programs.
3. *Organization and management:*
   Specify responsibilities of units within Departments of Transportation; prepare or revise work schedules; coordinate activities of various units; obtain greater productivity in project planning and programming.
4. *Coordination with other state and regional programs:*
   Specify the responsibilities of Departments of Transportation and other state and regional agencies in overlapping areas; undertake actions that are synergistic or, at least, not counterproductive.
5. *Development of energy policy, plan, and program:*
   Undertake actions to reduce direct and indirect consumption of energy by transportation or to develop energy resources.

6. *Relationship between transportation improvements and developments:*
   Initiate transportation-related actions to promote or control development; initiate joint transportation/development actions.
7. *Major corridor improvements:*
   Conduct studies in corridors in which alternative major transportation improvements are to be developed and evaluated; prepare implementation program.
8. *Cost effectiveness in highway standards and maintenance:*
   Establish a policy on the standards to which various types of highways will be built and maintained; perform project improvements in a manner closely tailored to the specific problems; revise standards to reflect slower growth, more limited funding, and high costs of achieving uniformly high standards; apply construction funds to modest-scale reconstruction where most appropriate.
9. *Improvement/abandonment of rail service:*
   Determine action to take for individual rail lines and determine other actions to ensure feasibility of rail plan and to ameliorate possible adverse impacts.
10. *Funding of transit services and improvements:*
    Establish general policy on amount and distribution of funds and/or ad hoc decisions on funding individual transit operations and improvements.
11. *Airport capital improvements:*
    Establish general policy on amount and distribtuion of funds and possible environmental controls and standards and/or ad hoc decisions on these matters in relation to the individual airports; define state role and responsibility.

The information judged to be most important in addressing the major issue areas was grouped into seven fields of impact: (a) environmental, (b) social, (c) economic, (d) travel, (e) development, (f) legal/administrative/institutional/financial, and (g) plan and program evaluation. The same fields of impact (areas of concern) were used to classify techniques so that the identified information needs could be readily related to the available techniques.

Table S-1 gives a numerical accounting of the available techniques classified by field of impact, by scale of application, and by mode of application. Although a large number of techniques were classified in the environmental and travel fields, the majority of them, however, are applicable not at the state level but rather at the substate level. As expected, techniques applicable to the highway mode predominate because a greater amount of attention has been paid to this mode during the past several years.

These techniques were evaluated in terms of (a) their operational state, (b) the scale and mode of application, (c) the input data requirements, (d) the output information, and (e) the resource requirements. Data available for input to these techniques were identified for each of the seven fields of impact. The data items, their sources, and the level of detail at which the data are available were also identified. The techniques were further classified into three groups:

1. High-priority techniques.
2. Other fully operational techniques.
3. Nonoperational techniques requiring further development or testing.

TABLE S-1

SUMMARY OF AVAILABLE TECHNIQUES BY SCALE AND MODE OF APPLICATION

FIELD OF IMPACT	NUMBER OF APPLICABLE TECHNIQUES [a]	SCALE OF APPLICATION					MODE OF APPLICATION					
		MULTISTATE	STATE	SUBSTATE	CORRIDOR	PROJECT	HIGHWAY	TRANSIT	RAIL	AIR	GOODS MOVEMENT	NON-MODE-SPECIFIC
Environmental	37	3	16	34	13	7	20	6	5	5	3	12
Social	10	—	3	4	7	5	10	2	3	3	1	—
Economic	10	2	8	7	2	—	1	1	2	1	4	4
Travel	40	2	32	25	4	1	28	10	14	12	12	—
Development	9	1	4	5	4	1	7	6	—	1	—	2
Financial/legal/ institutional/ administrative	18	1	16	7	7	6	7	2	6	1	1	3
Plan and program evaluation	20	3	20	14	4	4	16	5	5	4	2	1
Total	144	12	99	96	41	24	89	32	35	27	23	21

[a] Horizontal rows do not add to total because techniques can apply to more than one scale or mode.

The operational techniques were identified and described in a summary form. References for each operational technique were cited where more detailed information could be found. The nonoperational techniques requiring further development and testing were also identified and described in a summary form.

The high-priority techniques were identified primarily on information needs, with some general consideration being given to such other criteria as transferability, probability of success, time, and costs required to perform the application.

The high-priority techniques were grouped into potential projects that might be undertaken in the Phase II effort. These projects would involve the application of one or more techniques that provide information to assist in resolving state-level plan and program issues. Twenty-one such projects were identified. Because sufficient funds are available to conduct only a small proportion of the projects identified for Phase II consideration, criteria were developed to evaluate the projects so that the highest ranking ones could be selected for testing in Phase II. The projects selected for testing are:

1. Highway user revenue forecasting and analysis techniques.
2. Priority programming methodology.
3. Statewide energy conservation forecasting techniques.

The Phase II effort will include the development of procedural manuals for test application of these techniques. After the testing, deficiencies in the techniques will be identified, and the manuals will be revised accordingly. New methodologies will be suggested as appropriate, depending on the importance of the deficiencies.

The remainder of the twenty-one projects are good candidates for further research by NCHRP, Federal, state, or other research agencies.

CHAPTER ONE

INTRODUCTION AND RESEARCH APPROACH

INTRODUCTION

Statewide transportation planning and programming is evolving rapidly, reflecting the major changes that are taking place both in the organizational framework and the nature of the issues that are being faced by states.

The characteristics of plans and programs at the state level are extremely diverse. They vary widely in terms of (a) how they are formulated (level of detail and comprehensiveness of the evaluation process), (b) timing of the process (frequency of updating and length of forecast or planning period), and (c) range of programs included.

The statewide transportation planning and programming process and methodology must have the flexibility to accommodate this diversity. Methods are needed that are practical tools and that provide quick responses, without necessarily providing the detail or level of accuracy that have typically been required in plan and program evaluation in the past.

Many of the techniques used in statewide transportation planning and programming have been borrowed directly from urban transportation planning, highway-needs studies, or from project planning. Often these techniques are inappropriate conceptually, are too demanding of time and data, or are not flexible enough to deal with the broader range of options being considered. On the other hand, newer techniques that have been substituted often suffer from insufficient conceptual development, lack of validation, incompleteness in terms of the system effects considered, or in terms of data needed to effectively use the techniques.

When suitable techniques are available, they often have not been adequately documented for use by other states. Little previous effort has been devoted to explaining and demonstrating how new techniques can be used to address a range of critical, contemporary, statewide policy questions.

Most states do not have any comprehensive work program for putting the state resources to work developing and applying needed techniques.

RESEARCH OBJECTIVE

The objective of this research is to provide transportation planning methodologies that will be policy-sensitive and that will facilitate the testing and evaluation of options in a manner that will produce timely results for decision making. The focus is on reasonable cost, sketch planning-type techniques applicable to important issues in statewide transportation planning and programming.*

* Sketch planning techniques are defined as tools that can provide approximate measures of impacts and comparative evaluation of alternative transportation plans and programs quickly and inexpensively, using commonly available data.

RESEARCH APPROACH

A two-phase approach was developed to meet the research objective. Phase I of this study included the following tasks:

1. Identify and classify major transportation issues facing decision-makers at the statewide level.
2. Identify and categorize data and methodologies to meet the needs identified in Task 1.
3. Evaluate and document methodologies most likely to provide early usefulness.
4. Develop a study design to test high-priority methodologies.

In Phase II, draft procedural manuals will be developed for the high-priority methodologies and will be tested in a few states. Based on the results of field testing, the procedural manuals will be revised and, where appropriate, recommendations for further work will be made.

ORGANIZATION OF THE REPORT

This report documents the work performed during Phase I of the research effort. Chapter Two contains a summary of pertinent research findings relating to the identification of major state-level issues and the techniques and data available to address these issues. For example, Figure 1 shows the general framework for identifying and resolving state-level transportation issues. Figure 2 summarizes the information important to states (those in which interviews were conducted) in addressing major issues. The information typically needed to help decision-makers in each issue area is summarized for each type of impact in Figure 3. This visualization has been prepared so that information needs identified for each issue area can be more precisely related to technique requirements. The techniques are categorized and described in summary form in Tables 1 through 7. Table 8 presents the data availability for these techniques. The table includes the source and level of detail for the identified data items. Tables 9 through 19 show information needs for each issue area and the techniques by field of impact to satisfy them. Chapter Three discusses the applications of the Phase I research findings with respect to the techniques available to address state-level information needs and the evaluation of candidate projects for Phase II, given in Table 20. Chapter Four presents the conclusions of Phase I of this research effort and the research directions for Phase II.

The appendixes provide supporting material for the research findings. Appendix A presents the process that was followed for identifying the state-level issues and tech-

niques. An annotated bibliography is presented in Appendix B. Appendix C elaborates on the information judged to be most important in addressing the major issues in each of the thirteen interview states. Appendix D includes documentation of high-priority techniques and identification of reference sources for all operational techniques. The criteria for evaluation of techniques are included in Appendix E.

CHAPTER TWO

RESEARCH FINDINGS

The general framework for identifying and resolving state-level transportation issues is shown in Figure 1. The diagram attempts to portray all of the basic steps that ideally should be involved in all major transportation decision processes, whether part of an annual planning and programming process or the result of particular problems that arise in an unscheduled manner (Fig. 1, Step I). Before a decision can be made, certain information is needed by decision-makers in order to address the issues (Fig. 1, Step V). The information requirements for major statewide transportation issues are described in the first section of this chapter.

Techniques are needed to provide the information to assist in evaluation prior to resolution of the issues (Fig. 1, Step III). The techniques that were identified in this research are described in the second section of this chapter. These techniques require some data to be input before information can be obtained from them. The data items, which are generally available, and the sources from which these data can be obtained are described in the third section of this chapter. In the fourth section, the linkage of available techniques to the state-level information needs is described. This will assist the user in the selection of techniques to provide information for guiding decision making in any issue area. The next step was to define and evaluate potential projects that might be undertaken in the Phase II effort. This is described in the fifth section of this chapter.

STATE-LEVEL ISSUES AND INFORMATION NEEDS

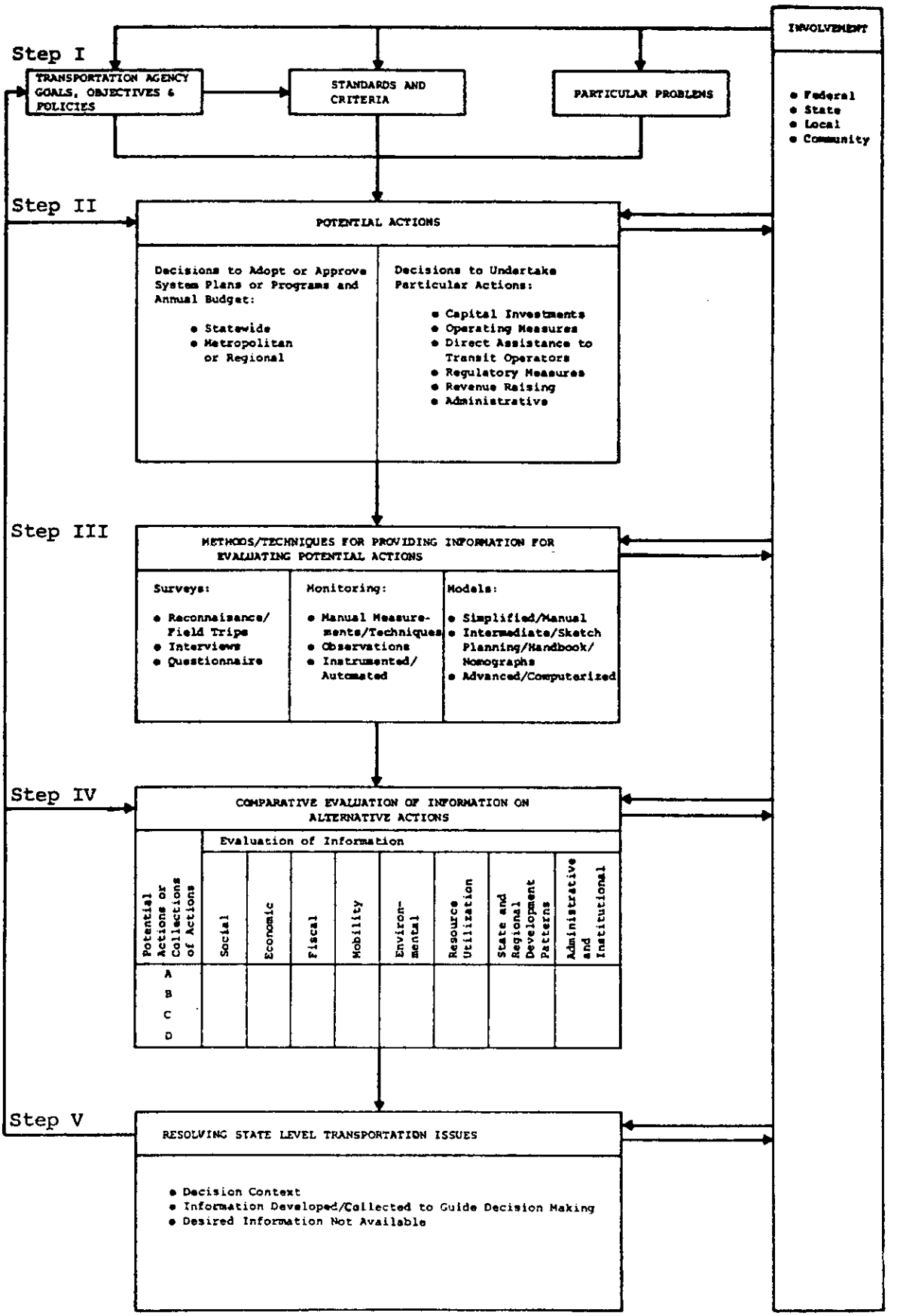
A sound understanding of the major issues facing decision-makers at the state level is essential to achieve the general objective of this research, which is to provide transportation planning methodologies that will be policy-sensitive and will allow the testing and evaluation of options in a fashion that will produce timely results for decision making. Toward this purpose, interviews (more than 100) were conducted to obtain the views and experience of a wide variety of knowledgeable people regarding the transportation issues facing the states and the role that information and techniques actually play in decisions relating to these issues. The interview process is described in Appendix A. The literature search performed during the study, including the literature references alluded to during the interview process, resulted in an annotated bibliography, which is presented in Appendix B.

As a first step in attempting to generalize across states, issues identified for individual states were sorted into like groups. The list of issues fell rather naturally into eleven issue areas. The first seven of these issue areas are generally multimodal, and the latter four are mode-specific. They are listed together with an indication of the actions that might result from decisions made in each issue area:

1. *Revenue shortfall:*
   Undertake actions to cope with current or projected declines in revenues and/or increasing costs.
2. *Development of multimodal transportation policies, plans, and programs:*
   Recommend policy changes, multimodal plan or program approval; delete or add elements to existing plans and programs.
3. *Organization and management:*
   Specify responsibilities of units within Departments of Transportation; prepare or revise work schedules; coordinate activities of various units; obtain greater productivity in project planning.
4. *Coordination with other state and regional programs:*
   Specify the responsibilities of Departments of Transportation and other state and regional agencies in overlapping areas; undertake actions which are synergistic or at least not counterproductive.
5. *Development of energy policy, plan, and program:*
   Actions undertaken to reduce direct and indirect consumption of energy by transportation or to develop energy resources.
6. *Relationship between transportation improvements and development:*
   Transportation-related actions to promote or control development; joint transportation/development actions.
7. *Major corridor improvements:*
   Conduct studies in which alternative major transportation improvements are to be developed and evaluated; prepare implementation program.

FIGURE 1

FRAMEWORK FOR IDENTIFYING AND RESOLVING STATE-LEVEL TRANSPORTATION ISSUES



8. *Cost effectiveness in highway standards and maintenance:*

Establish a policy on the standards to which various types of highways will be built and maintained; perform project improvements in a manner closely tailored to the specific problem; revise standards to reflect slower growth, more limited funding, and high costs of achieving uniformly high standards; apply construction funds to modest-scale reconstruction where appropriate.

9. *Improvement/abandonment of rail service:*

Decisions on individual lines and decisions on other actions to ensure feasibility of rail plan and to ameliorate possible adverse impacts.

10. *Funding of transit services and improvements:*

General policy on amount and distribution of funds and/or ad hoc decisions on funding individual transit operations and improvements.

11. *Airport capital improvements:*

General policy on amount and distribution of funds and possible environmental controls and standards and/or ad hoc decisions on these matters in relation to individual airports; definition of state role and responsibility.

The list is not intended as a comprehensive statement of all the issue areas in which transportation decisions are made. Rather, it is the product of an attempt to identify those areas in which information needs are most critical because of the importance of the decisions as well as the lack of generally established techniques for developing needed information.

Figure 2 shows in summarized manner the information judged to be most important in addressing the major issues in each state. In some cases, certain states are developing this information or have initiated studies to develop this information. In other cases, states have identified the need but have no work plans to develop the information. A scan down the column for each issue area shows the type of information that is useful in making decisions in the issue area. The column also shows the extent to which states share the need for particular types of information. The fact that less than 25 percent of the boxes in Figure 2 are empty indicates that states face common problems, many of them being relatively new areas for which planning resources (data and methods) have not yet been developed.

An unpublished report,* "Overview of Statewide Transportation Decision Making Process," contains a more detailed discussion of the material presented in Figure 2. In presenting experiences from individual states for each issue area, an attempt was made to focus on specific decisions that states made in the recent past or will have to make in the near future. A number of examples are cited where states found individual techniques to be particularly useful in guiding decisions. Also cited are instances in which states perceive a need for information to guide decisions although the techniques necessary to generate this information are not currently available to them.

Figure 2 also shows that a large proportion of the states' information needs can be attributed to very few events or actions:

1. Concerning revenue shortfall, costs have been increasing at a faster rate than the revenues available for project implementation.
2. New federal requirements for the development of metropolitan area Transportation Improvement Programs (TIP).
3. Delays in expediting individual projects due to environmental impact procedures.
4. Increased concern for the mobility needs of those who are transit-dependent.
5. Federal requirements for state aviation system planning as a precondition for airport improvement grants.
6. The Regional Rail Reorganization Act of 1973 that required state rail plans as a precondition for federal operating subsidies.
7. The Energy Policy and Conservation Act that requires state energy conservation plans as a precondition for Federal Energy Administration (FEA) grants to aid in implementing energy conservation actions.

Revenue shortfall has particularly affected highway planning because it has hit the highway mode harder than other modes. In the past, when available revenues were more in line with needs, highway segments were routinely designed and maintained to pre-established, uniform high standards. However, due to the recent shortage of revenues, states have found it increasingly necessary to revise standards downward or to deviate from standards on an ad hoc basis.

Revenue shortfall has also increased the need for techniques to compare plans and programs based upon alternative financial assumptions. This need is particularly important in the context of developing multimodal policies, plans, and programs. Several states have developed statewide plan alternatives, which differ significantly in the amount of resources required for implementation. These plans have been compared in terms of the number and type of new transportation facilities to be constructed and in terms of expenditures for operations (e.g., transit assistance, maintenance). However, states have found it difficult to describe (in terms understandable to legislators, other public officials, and the general public) the different impacts of alternative plans and/or programs on the various affected user and nonuser groups.

New federal TIP requirements mean that much of the information previously developed to aid in programming must be reoriented to suit the needs for information of metropolitan planning organizations. This includes more emphasis on less-capital-intensive projects and on analyzing tradeoffs among modes in solving particular transportation problems in a metropolitan area. Another possible consequence of the new TIP requirements is more emphasis by states on the development of aggregate indicators of regional transportation service to guide the allocation of funds among regions.

Delays in expediting projects due to environmental review procedures have led states to seek better information on environmental problems early in the planning process. Early identification of projects with potentially serious adverse environmental impacts allows states to adjust project planning procedures in order to anticipate these problems or to drop such projects from further consideration.

* This report is available from University Microfilms, Int'l., 300 N. Zeeb Rd., Ann Arbor, Michigan 48106.

FIGURE 2

INFORMATION IMPORTANT TO STATES IN ADDRESSING MAJOR ISSUES

	MULTIMODAL ISSUES				
STATE	REVENUE SHORTFALL	DEVELOPMENT OF MULTIMODAL TRANSPORTATION POLICIES, PLANS AND PROGRAMS	ORGANIZATION AND MANAGEMENT	COORDINATION WITH OTHER STATE AND REGIONAL PROGRAMS	DEVELOPMENT OF ENERGY POLICY, PLAN, AND PROGRAM
California	Must convincingly demonstrate that mobility will suffer, facilities will deteriorate and key sectors (e.g., agriculture) will be badly hurt.	Simplicity in organization and presentation of information; need to deal with wider range of issues (e.g., regulation, more on low-cost alternatives).	Formal review of purpose of all planning activities with emphasis on use in programming.	Some standardization of information from all regulation planning programs (e.g., land use, definition of alternatives).	Need to build credibility in showing how limited the tradeoff is between transit and auto use.
Connecticut	Benefit assessment in most comprehensive socio-economic terms to compete with all other programs for general revenues.	Establish well-founded standards, assess benefits comprehensively and integrate with other state and regulation plans.	Annual publication of schedules in Plan; Project Status Review Committee uses CPM and looks at all factors.		
Georgia	Information on benefits of completing planned highways at a faster pace than allowed for by fuel tax. Have to get general funds from legislature.	Basis to facilitate consistency in transport policies emanating from various state agencies.		A need to reconcile the factors for priority setting among DOT, state budget office, regulation planning agency and others concerned.	
Illinois	Justify change in priorities from elaborate new construction to maintenance and rehabilitation. Focus on more cost effective solutions to transportation problems.	Focus on tradeoffs among modes. Develop programs for different funding levels. Develop criteria for each program category.	Need information to guide annual priority programming and project management (e.g., cash flow, project status).	Improve local input to state planning and programming; focus urbanized area on transport problem solving instead of federal requirements.	Determine relative energy efficiency of modes, possible fuel savings, modal tradeoffs. Identify state energy reserves and ensure accessibility.
Kentucky	Project descriptions, costs and other project related data are necessary for the legislature. Show coal-haul road maintenance needs.	Dept. would like a long-range highway plan to set program priorities, and measurements of benefits and costs to identify tradeoffs among improvements to different modes.	Data to justify DOT priorities in urbanized areas.	Need to show state-level requirements and benefits in the TIP process to be done by MPO's.	
Maryland	Impacts of not building or postponing highway construction and of deferred maintenance.	Need criteria and measures of effectiveness to develop and evaluate plan alternatives and to set program priorities.	Need closer link between units that set plan priorities and unit that prepares program.	Need measures of effectiveness for different modes to use in TIP process (e.g., travel, land use, energy, economic benefits.	Impacts of plan elements on energy consumption.
Massachusetts		Need techniques to identify tradeoffs between highway projects in different parts of the state.	Need better link between highway planning and programming.		

	MODE-SPECIFIC ISSUES				
RELATIONSHIP BETWEEN TRANSPORTATION IMPROVEMENTS AND DEVELOPMENT	MAJOR CORRIDOR IMPROVEMENTS	COST EFFECTIVENESS IN HIGHWAY STANDARDS AND MAINTENANCE	IMPROVEMENT/ ABANDONMENT OF RAIL SERVICE	FUNDING OF TRANSIT SERVICES AND IMPROVEMENTS	AIRPORT CAPITAL IMPROVEMENTS
Auto dependency of most development; dependency of major industries on highway mobility, port access.	Capital and operating costs, capacities, levels of service, system usage, available financing. Ability to answer questions is key.	Show limits of what can be achieved by low-cost improvements, pricing, regulation.		Complete alternatives analysis for guideway proposals in major urban areas; need for some UMTA funding guidelines for state.	Need to define more clearly the state's role; need to show that it is less effective to use state funds for operations and maintenance.
Dependency of industry on rail access and reliability.	Rail travel time, costs, reliability to major sources and markets.	Continue to improve effectiveness of project conception prior to programming thru Program Concept Team.	Transportation cost savings; benefit/cost ratio; other economic benefits to industries and communities.	Establish well-founded basic level of service standards sensitive to socio-economic needs.	Effectiveness of personal rapid transit at state-owned airport.
				Need to assess viability of transit in small cities and rural areas; need guidelines.	Environmental, economic, and development impacts of alternative sites for second capital airport.
Assess effects of continued rail service or abandonment and airport access/levels of service on local area development potential.	Reassess new freeway needs given projected drop in revenues. Identify possible lower-scale, more cost-effective improvements.	Use pavement condition, accident rates, traffic geometrics to identify transportation problems and improvement projects.	Develop model for examining freight flows in terms which bear upon investment decisions/ subsidies.	Assess cost effectiveness of rehabilitating versus rebuilding transit structures. Identify management and rural transit needs.	Determine appropriate level of involvement of state versus local areas in airport development, funding, setting priorities.
Economic importance of coal-haul road maintenance to mining.		Long-range economic impacts of deferred maintenance; revised sufficiency rating system.	Need data on operating costs, basic technology and overall economics of railroads moving in Kentucky.		
Need data to illustrate costs of not limiting access to primary highways and benefits of doing so.		Need information to justify relaxing design standards without losing federal funds. Need priority-setting technique for maintenance projects.	Information on avoidable costs of providing commuter rail service. State is concerned about commuter rail fares.	Need information to help determine appropriate level of transit funding for metropolitan areas.	
		Need information to justify reduced design standards. Show importance of federal aid for minor reconstruction.	Need system for monitoring existing rail freight and passenger services. Need techniques to forecast rail freight and passenger movements.	Need techniques to determine public transportation needs and appropriate supply in small urban areas of state.	

FIGURE 2

INFORMATION IMPORTANT TO STATES IN ADDRESSING MAJOR ISSUES (continued)

	MULTIMODAL ISSUES				
STATE	REVENUE SHORTFALL	DEVELOPMENT OF MULTIMODAL TRANSPORTATION POLICIES, PLANS AND PROGRAMS	ORGANIZATION AND MANAGEMENT	COORDINATION WITH OTHER STATE AND REGIONAL PROGRAMS	DEVELOPMENT OF ENERGY POLICY, PLAN, AND PROGRAM
Michigan	Huge shortfall projected for "needed" improvements to highways over next 20 years; need to show importance of needed improvements.	Need a long-range highway plan to set program priorities. Need measures of benefits and costs to make tradeoff among modes.			
New York	How to assess the consequences of not meeting identified needs; economic effects in particular.	More planning should focus on contingencies and how they might be dealt with rather than focusing on a single future.	Anticipate hurdles to project implementation; identify social and environmental impacts early in planning process.	Regional and subregional impacts (social, environmental, economic) of candidate projects to guide TIP process.	
Oregon	Show general economic benefits to stake claim for use of general revenues; need more cost-effective standards and criteria for programs.	Have format and process for policy analysis; need more certainty on federal funding; need to give Legislature more information on short-range policy and program.	Detailed step-by-step procedures to divide up planning and programming functions among units. Use CPM for highway project scheduling.	Need state plan information for forecasts and environmental constraints; need to assist others in planmaking; need input of locals thru hearings.	Uncertainty of national conditions and effects of policies and trends on revenues.
Pennsylvania	Social, economic, and environmental impacts of variations in highway funding levels and mechanisms.	Identification and assessment of intermodal alternatives for freight currently moved by rail (e.g., truck on flatcar).	Current approach is to keep modes separate, interested in multimodal approach for the future.		
Utah	Continue to develop projects which are supported by legislation to get general revenue; maximum multiyear program benefits.	Uncertainty on resource development projects. Have good over-all program data and sufficiency ratings. Use of general revenue creates uncertainty in funding.	Have computerized project management system which provides detailed, up-to-date status information at project and program levels.	Environmental issues raised on resource development projects.	Location and costs of access roads to serve resource development projects. Need state plan guidance.
West Virginia	Show problems associated with reduced funding levels for highways in terms understandable to the legislature and lay public.	How to evaluate/recommend reasonable subsidies for modes which compete (e.g., competition of pipeline, truck, rail for coal movement).	Not a DOT; need information on extent to which actions may be synergistic, counterproductive, or neutral in relation to other modes.	Role of transportation system in promoting economy, health care, education, and tourism.	Impacts of action alternatives in responding to future gasoline shortages.

States are becoming increasingly involved in efforts to improve public transportation in rural and small urban areas. This involvement includes providing technical assistance and, in many cases, financial assistance to municipalities and transit operators. Several states are attempting to establish statewide standards for public transportation. Transit planning for rural and small urban areas requires better information on the mobility needs of those who are transit-dependent and on the revenue potential as well as the cost of new transit services.

	MODE-SPECIFIC ISSUES				
RELATIONSHIP BETWEEN TRANSPORTATION IMPROVEMENTS AND DEVELOPMENT	MAJOR CORRIDOR IMPROVEMENTS	COST EFFECTIVENESS IN HIGHWAY STANDARDS AND MAINTENANCE	IMPROVEMENT/ ABANDONMENT OF RAIL SERVICE	FUNDING OF TRANSIT SERVICES AND IMPROVEMENTS	AIRPORT CAPITAL IMPROVEMENTS
			Uncertain about level of rail passenger service to provide. Effects of rail passenger improvements on highway travel.	Need information to determine appropriate transit supply and funding level in different areas of state.	
Role of transportation actions as a catalyst for change in underdeveloped or declining areas.	Economic and development impacts; indirect economic effects such as impacts on commodity prices.	Condition and usage data for highway segments and bridges; impacts of various levels of maintenance expenditure at state level.	Primary and secondary impacts of rail abandonment; effect of rail service improvements on ridership.	Revenue and operating cost for alternative levels of fare and service; productivity measures; fare/service/income data to assess equity.	Need statewide framework for assessing cost effectiveness of improvements in various regions.
See "Coordination with Other State and Regional Programs."	Operating deficits of added rail passenger service, need intercity O-D data for highway and rail demand analysis.	Highway user costs for various design standards; costs of reconstruction in various areas and conditions. Legal responsibility.	See "Major Corridor Improvements."	Show needs of transit-dependents in small cities; need better operating cost data for contracting and monitoring of demonstrations.	Need to define state's role; need traffic counts at uncontrolled airports. Use demand forecasts and cost effectiveness index for priorities.
Impact of actions on development and mechanisms for controlling land use—particularly at highway intersections and airports.	Economic, social, and environmental impacts on adjacent and nearby areas.	Cost to users of not improving road is estimated for resurfacing and reconstruction projects to aid in determining priorities.	Impacts at community level; secondary economic effects; financial effects on rail corporations.	Evaluation of existing services (including socio-economic characteristics of users; potential demand; system requirements and financing.	Ability to meet demand. Impacts on access system, land use, economy, environment, funding requirements.
See previous two comments for Utah.	Route analysis studies done by planning provide good general environmental information on alternatives prior to project planning.	Accident experience, road condition, traffic, and geometrics used to define problem-specific design concepts.	No issue now, but new federal legislation will cause railroads to want help. Need to define state interest, economic criteria, cost analysis methods.	Analyze needs of transit-dependents; provide technical assistance for rural transit services.	Plan without program is worthless. Need to work on implementable program with legislature.
Transportation-related impacts of siting plans for health care facilities, other state facilities.	Highway travel demand on weekends, effects of alternative toll facilities and pricing schemes on travel demand, revenue, and socio-economic impacts.	Need to assess highway design standards and maintenance standards in economic terms, assess equity of taxes and tolls.	Economic impacts of rail abandonment.	Funding availabilities and interrelationships among FHWA, UMTA, HEW.	

Airport planning in individual states is heavily oriented toward the inclusion of individual airports in the National Airport System Plan. In statewide aviation system planning, primary information needs involve the coordination of forecasts and plans for individual airports. Specifically, a framework is needed in which improvements can be compared with respect to their cost and effects.

The primary focus of most state rail planning programs has been on determining which branch lines are threatened with abandonment and justifying which of those should be

preserved under the Final System Plan prepared in accordance with the Regional Rail Reorganization Act of 1973. State information needs include an accepted system for collecting reliable information from firms potentially affected by the plan and a methodology for evaluating the broad social and economic consequences of line abandonment versus continuation. There is a need to disseminate among all states basic information on rail system planning including basic rail technology information, typical cost factors, methods of analysis, and advice based on experience in dealing with the railroads on data collection, cost allocation, and negotiations.

In complying with the Energy Policy and Conservation Act's requirements that each state prepare energy conservation plans as a prerequisite for FEA grants, states need information on existing energy resources in order to ensure access to these resources. Additionally, information is needed on the relative energy efficiency of modes, possible fuel savings resulting from a shift in mode, and the possible impacts of energy plan elements on consumption and on state revenues.

The preceding paragraphs have discussed information needs arising from specific events or actions. In addition to these more specific needs, there is an important general need for better data on the condition and performance of all modes of transportation.

Examples include the type of data found in annual reports of transit operators: vehicle miles operated by type of system, revenue passengers carried, revenue, and operating cost data. Similar data can be obtained from transportation operators in other modes. Other data-monitoring sources are the state Departments of Employment Security for data on employment and other economic indicators in transportation and related sectors.

In the past, the type of monitoring data collected by state transportation agencies has been generally limited to those portions of the system directly owned and operated by them, with concern primarily for physical condition and traffic volume data for the state highway system.

One important factor that is often overlooked is the need to evaluate the effects of public sector transportation programs on the private sector.

More attention should be directed to monitoring conditions in the private sector, in particular to the economic health of industry rather than to data needs for physical system planning, as is the case for systems operated by the public sector. Typical data needs in the private sector areas might include such measures as unemployment, profitability, failure rates, new firm formations, and other indicators of the health of competition in the transportation field.

The indicators used to monitor conditions and performances for all modes of transportation should be selected to cover those aspects for which issues can be anticipated, based on current trends and past experience. Techniques will be required which provide estimates of a variety of transportation indicators based on parametric relationships and fairly readily available data from other sources.

A familiar example of this approach exists in the use of traffic count data for relatively few days and locations, combined with parametric values on seasonal and other time distributions as well as classifications of routes, to obtain complete annual flow maps. Somewhat analogous approaches to system monitoring are being developed or can be developed using data and relationships in a number of areas of growing policy concern, such as energy consumption and air quality, and for modes other than highways.

Unfortunately, no comprehensive monitoring system of this type is available or under development in any of the states visited. However, elements of such a system are contained in Maryland's Statewide Transportation Work Program and in the techniques used by Maryland in preparing its "Systems Planning Report."

SURVEY OF STATE-LEVEL TECHNIQUES

Techniques have been defined, for the purposes of this study, as "the operational and emerging tools that are capable of producing information that may be of assistance in resolving state-level transportation planning and programming issues." Such techniques now range from monitoring and surveys to the application of sophisticated computer models. Although the focus of the study is on existing sketch planning-type techniques, the framework developed also includes traditional analytical techniques. These techniques can be applied at various levels ranging from project level to multiple state and national levels. Emphasis was placed on techniques that can be applied at a systems or state level with corridor level a close second. Some project-level and multistate- or national-level methodologies showing promise for adaptation at the state level have also been included in the analysis. Methodologies arising from urban studies that could be adapted for statewide purposes were also reviewed.

The search process, described fully in Appendix A, resulted in the identification of 144 techniques. The techniques are given in Tables 1 through 7 and are classified according to their major fields of impact (or areas of concern): (a) environmental, (b) social, (c) economic, (d) travel, (e) development, (f) legal/administrative/institutional/financial, and (g) plan and program evaluation, each of which is further discussed. Descriptions of the techniques are in terms of (a) author of the technique, (b) its scale of application, (c) its mode of application, (d) its technical status, (e) its data availability, (f) its output information, and (g) time and cost of its application.

Environmental Field

The thirty-seven techniques in this grouping are those that estimate the impacts of the potential actions on the physical environment. The environmental field is divided into the subgroups of (a) air quality, (b) water, (c) noise pollution, (d) energy, and (e) natural environment. The methodologies applicable to each subgroup are given in Table 1, Sections (a) through (e). The number of methodologies identified in each subgroup ranged from a low of 3 concerning water quality impact to a high of 13 for air pollution impact.

Social Field

Ten methodologies to estimate the social impacts of alternative actions were estimated and are summarized in

Table 2. Most of these methods are applicable at the corridor level. Four out of the ten methods are applicable at the regional level.

Economic Field

Table 3 gives ten techniques for predicting economic impacts. One of these methods—the input/output analysis—has been used in various forms for obtaining the dollar value of interindustry transactions. All the methods identified can be applied at the state or substate levels.

Travel Field

Over fifty travel estimation techniques were identified during the search process. Those analyzed are given in Table 4. The majority of the methods listed are applicable at the state and/or substate levels. With regard to mode of application, the methodologies for highway mode predominate, as expected, in contrast to the other modes, which are relatively evenly balanced.

Development Field

The techniques in this grouping include land-use and activity allocation models. Given alternative actions, these methods predict the development patterns in a region. The nine methods identified are given in Table 5. Most of these methods have been applied for the highway or transit modes at the state or substate (mostly urban) level. However, the basic input required is a level of service measure, and it is possible that rail and air modes can also be used in the analysis.

Legal/Administrative/Institutional/Financial Field

Eighteen methods were identified in this grouping and are given in Table 6. However, the majority of these methods are for financial analysis. The scale of application of these methods is at the state level and covers all the modes.

Plan and Program Evaluation Field

The techniques included in this grouping are those that assist in plan and program evaluation and/or assign priorities to improvements. A total of twenty methodologies were identified in this group, as given in Table 7, the majority of them being applicable at the state level. The highway mode predominates, showing a lack of techniques for multimodal priority setting.

Detailed documentation of these techniques is presented in Appendix D. In particular, Table D-1 lists the fully operational techniques with bibliographical references in which additional, more detailed information can be found.

STATE-LEVEL DATA AVAILABILITY

Data, for the purposes of this study, are defined as the basic information used as input for techniques to provide the necessary information for resolving state-level transportation planning and programming issues. Data may be obtained from existing sources, such as the Census Bureau for socioeconomic data, or from surveys such as the origin-destination (O-D) survey for travel information. This section presents a description of the data available from various sources.

To make this data availability survey compatible with the data requirements for techniques, data must also be classified according to the pertinent major fields as before.

The data availability for each of these seven major fields is given in Table 8. The table includes the source for the data item as well as the scale for which the data are available. This was developed based on the literature review and interviews with persons currently involved in transportation planning and programming and may not be an all-inclusive list. The following discussion describes the data availability for each of the major fields.

Environmental Field

This grouping includes data on such items as natural environment, air and weather systems, water and water quality, noise levels, and energy consumption rate. In the case of air quality and noise pollution, federal standards have been established for monitoring purposes. In many cases, states have set standards for air quality control more stringent than those for other areas. These standards are accessible to the public. The U.S. Environmental Protection Agency (EPA) has several publications documenting the emission rates and noise-generation levels for all kinds of vehicles. Air quality monitoring stations located in air quality maintenance areas provide information on background pollutant levels. Data on water and water quality are available through the U.S. Geological Survey (USGS), the U.S. Department of Agriculture (USDA), and the U.S. Army Corps of Engineers. Data on soils, geology, mineral resources, and related elements may be obtained from USGS and USDA. The Bureau of Outdoor Recreation provides information on recreational resources and visitation to recreational areas.

Social Field

This field requires data on population and household characteristics including age, sex, occupation, driving status, household income, car ownership, and movers (people who moved from their place of residence in the last five years). The data in this grouping are easily obtained from the U.S. Bureau of the Census (census of population and census of housing) at all levels ranging from national to census tracts. The Bureau of the Census has published, at irregular intervals, projections of total population by age groups at the state level. The population projections at the Standard Metropolitan Statistical Areas (SMSA's) are available from the Bureau of Economic Analysis (BEA).

Economic Field

Economic data provide information on area economy and economic activity and include such items as employment by type and location, labor forces, payrolls by industry type, earnings by industry type, operating costs of transportation modes, capital costs, maintenance costs, car ownership, and regional exports. The major source of this information is the U.S. Bureau of the Census (censuses of population,

TABLE 1

DESCRIPTION OF TECHNIQUES APPLICABLE TO THE ENVIRONMENTAL FIELD

METHOD/TECHNIQUE	AUTHOR OR REFERENCE TO ANN. BIBLIOG.[a]	SCALE OF APPLICATION					MODE					TECHNICAL STATUS	DATA AVAIL-ABILITY[c]	OUTPUT INFORMATION	TIME AND COST OF AP-PLICATION[d]
		MULTI-STATE	STATE	SUB-STATE[b]	CORRI-DOR	PROJ-ECT	HIGH-WAY	TRAN-SIT	RAIL	AIR	GOODS MOVE-MENT				
a. Air															
1. Emissions Forecasting	*89*		x[e]	x	x		x	x	x	x	x	Applied ex-tensively.	High	Emissions by vehicle type.	Low
2. APRAC-1A	*93*			x	x	x	x	x				Applied ex-tensively.	Medium	Isopleths, frequency distribu-tions and concentration for carbon monoxide.	Medium
3. Proportional Model	EPA; *90*		o[e]	x	x							Applied ex-tensively.	High	Air quality for pollutants of interest.	Low
4. Gaussian Diffusion	DBT; *86, 95, 101, 105*			x	x	x	x					Applied in various forms.	Low	Air quality.	Medium
5. Larsen's Model	RIL; *90*			x								Applied ex-tensively.	High	Air quality estimates related to ambient air quality standards.	Low
6. Air Pollution Simulation	ERT		o	x	x		x					Field tested in Washing-ton, D.C.	Low	Air quality.	Medium
7. Airport Impact Methodology	ANL			x	x					x		Field tested at St. Louis Airport.	High	Emissions for pollutants of interest.	Medium
8. Emissions Projection Methodology	ERT		o	x			x					Applied in Hackensack Meadowlands.	High	Total emissions for a land-use plan.	Low
9. Air Quality for Urban and Industrial Plan-ning (AQUIP)	*96*			x			x					Applied in Hackensack Meadowlands.	Low	Pollutant concentration levels, isopleths of air quality, and grid emissions.	High
10. Michigan Air Pollution Model	*42a*		x	x			x					Applied in Nw. Mich.	Medium	Emissions per square mile.	Medium
11. Air Transportation Impact Model (ATIM)	JK			x						x		Ongoing refinement.	Medium	Air quality by pollutant, con-centration, and location.	Medium
12. Land-Use-Based Air Quality Projection System	EJC			x								Ongoing refinement.	Low	Air quality based on land use.	Medium
13. Environmental Im-pact of Policies	*80*	x	x						x			Applied to USRA System Plan.	Medium	Potential environmental con-sequences of policies.	Medium
b. Water															
1. Water Quality Model	HSI			x								Unknown.	High	Concentration of pollutants.	Low
2. Urban Storm Water Runoff Model	*111*			x								Validated, applied.	Medium	Quantity, quality, pollito-graph and land surface erosion analysis.	Medium
3. Storm Water Man-agement Model	Univ. of Fla. et al.; *114*			x								Validated, applied.	Medium	Runoff hydrograph, pollito-graph, flow and quality receiving water effects.	High
c. Noise															
1. Noise Nomographs	*109*			o	o	x	x					Applied, validated.	High	Noise level in dBA.	Low
2. Annoyance Rating Scale for Wheel & Rail Noise	TSC			x	x				x			Unknown.	High	Scale for rating annoyance.	Low
3. Highway Noise Prediction Model	*106*			x	x	x	x					Applied extensively.	Low	Energy mean level for re-ceivers, noise levels, and percentile levels.	Medium

4. SAPOLLUT	*83*		o	x			x					Applied extensively.	Medium	Air pollutant emissions and noise levels (L50, L10) by link.	Low
5. Michigan Noise Model	*42b*		x	x			x					Applied in Nw. Mich.	Medium	Number of people exposed to noise levels.	Medium
6. Noise Impact of Airports	Md. DOT					x				x		Applied in Md.	High	Types of land located within 65 db contour.	Low
d. Energy															
1. Energy Consumption Methodology	AMV		o	x			x	x				Applied in Baltimore.	Medium	Gallons consumed by vehicle class and link type, British Thermal Units by land-use category.	Medium
2. Gasoline Consumption Model	*42c*		x	x			x					Applied in Mich.	Medium	Annual consumption of gasoline.	Medium
3. Highway Fuel Consumption Computer Model	*119*		x	x			x					Operational.	Medium	Vehicle population mixes by age of vehicle, fuel category, and fuel consumption rate.	Medium
4. Estimating energy consumption reductions due to transportation actions	AMV			x	o		x	x			x	Guidelines developed.	High	Regional energy reductions; indirect effects on socio-economic and environment due to proposed actions.	Low
5. Carpooling Energy Submodel	*116*			x			x					Operational.	Medium	Fuel consumption for alternative carpool/vanpool strategies.	Medium
6. Energy—UTCS-1 Network Simulation	*118*			x	o		x					Operational.	Low	Fuel consumption with and without traffic controls (including right turn on red).	High
7. PRIFRE Energy Model	AMV				x	o						Applied in Md.	Medium	Fuel consumption by time period for the various freeway segments.	Medium
8. Wisconsin Regional Energy Model—Transportation Model	*117*	o	x	o			x	x	x	x	x	Tested in Wisc.	High	Vehicle miles and associated energy use and emissions in the state.	Low
9. Fuel Consumption Curves	*121*			x			x	x	x			Operational.	High	Fuel consumption by mode for various average passenger loadings.	Low
e. Natural Environment															
1. Inventory of Critical Environmental Areas	SI		x	x								Under development.	Low	Critical environmental areas designated for use as inputs to planning assessment	High
2. Louisiana Environmental Management System (LEMS)	RI		x	x								Unknown.	Low	Baseline environmental conditions.	High
3. Procedure for using natural science information to locate urbanization	DLW			x								Applied in Louisville.	Low	Urbanized area.	High
4. Environmental Sensitivity Computer Mapping	*42d*		x	x								Tested in Michigan's Upper Peninsula.	Low	Environmental sensitivity maps on line printer.	High
5. Geo-coding	Md. DOT		o	x	x	x						Process being used.	Low	Environmental features potentially affected by alternative actions.	High
6. Composite Mapping System	*123*	x	x	x								Applied at national level.	Low	Socio-economic and physical information on maps.	Medium

[a] Abbreviations identifying the organization responsible for development and/or application of the technique include:
AMV—Alan M. Voorhees & Associates, Inc.
ANL—Argonne National Laboratory
DBT—D. B. Turner
DLW—D. L. Williams
DOT—Department of Transportation
EJC—E. J. Croke, K. G. Croke, & A. S. Kennedy
EPA—Environmental Protection Agency
ERT—Environmental Research & Technology
HSI—Hydro-Science, Inc.
JK—J. Kurtzweg
RI—Rockwell International
RIL—R. I. Larsen
SI—Smithsonian Institution
TSC—Transportation Systems Center

[b] Urban or rural areas and systems level.
[c] High—data easily available; medium—requires data manipulation; low—substantial new data collection required.
[d] Estimated Time:
Low—less than 2 months
Medium—2 to 6 months
High—over 6 months

Estimated Cost:
Less than $20,000
$20,000 to $50,000
Over $50,000

[e] x—Applicable; o—Could be applied as is or with adaptation.

TABLE 2

DESCRIPTION OF TECHNIQUES APPLICABLE TO THE SOCIAL FIELD

METHOD/TECHNIQUE	AUTHOR OR REFERENCE TO ANN. BIBLIOG.[a]	SCALE OF APPLICATION					MODE					TECHNICAL STATUS	DATA AVAIL-ABILITY[c]	OUTPUT INFORMATION	TIME AND COST OF AP-PLICATION[d]
		MULTI-STATE	STATE	SUB-STATE[b]	CORRI-DOR	PROJ-ECT	HIGH-WAY	TRAN-SIT	RAIL	AIR	GOODS MOVE-MENT				
1. Proximity Analysis	*42e*		o[e]	x[e]	o	o	x	o	o	x		Applied in Mich.	Medium	Concentration of socio-economic data and facilities around zones.	Medium
2. Community Inventory	AMV					x	x	x	x	x	x	Applied extensively.	High	Social statistics and other data about the community.	High
3. Neighborhood Social Interaction Index	B; *68*				x	x	x					Calibrated using data from Boston, Philadelphia.	High	Measure of present level of cohesion in community.	Low
4. Housing Displacement Model	VM; *68*			x	x		x					Calibrated, tested.	High	Number of households taken.	Low
5. Social Feasibility Model	MKGK; *68*				x	o	x					Applied in Md.	Medium	Indicator of level of neighborhood pedestrian dependence.	Low
6. Mobility Index	MLA; *68*				x	x	x					Not extensively field tested.	High	Number reflecting the present stability of a community.	Low
7. Social Capacity Indicators	SW; *68*				x		x					Used in Louisville, Ky.	Low	Division of area in question into homogeneous units in terms of attitudes.	Medium
8. Stability Index	HF; *68*				x		x					Used in several places in Calif.	High	Measure of present level of cohesion in a community.	Low
9. Statewide Mobility Indicators	*42f*		x	x			x		x	x		Operational.	Medium	Accessibility to various modes and socio-economic characteristics by zone.	Medium
10. Psychological Impact Model	*42f*		x	x			x					Operational.	Medium	Psychological impact index by link.	Medium

[a] Abbreviations identifying the organization responsible for development and/or application of the technique include:
AMV—Alan M. Voorhees & Associates, Inc.
B—Burkhardt
HF—Hill & Frankland
MKGK—Marshall Kaplan, Gans & Kahn
MLA—McLean & Adkin
SW—Sharpe & Williams
VM—Ventura & Mehta

[b] Urban or rural areas and systems level.

[c] High—data easily available; medium—requires data manipulation; low—substantial new data collection required.

[d] Estimated Time: Low—less than 2 months; Medium—2 to 6 months; High—over 6 months
Estimated Cost: Less than $20,000; $20,000 to $50,000; Over $50,000

[e] x—Applicable; o—Could be applied as is or with adaptation.

TABLE 3

DESCRIPTION OF TECHNIQUES APPLICABLE TO THE ECONOMIC FIELD

METHOD/TECHNIQUE	AUTHOR OR REFERENCE TO ANN. BIBLIOG.[a]	SCALE OF APPLICATION					MODE					TECHNICAL STATUS	DATA AVAIL-ABILITY[c]	OUTPUT INFORMATION	TIME AND COST OF AP-PLICATION[d]
		MULTI-STATE	STATE	SUB-STATE[b]	CORRI-DOR	PROJ-ECT	HIGH-WAY	TRAN-SIT	RAIL	AIR	GOODS MOVE-MENT				
1. Service Costs and Revenue Sources	. . .		x[e]	x								Unknown.	Medium	Projections of service costs and benefits.	Medium
2. Employment Shift-Share Analysis	LDA		x	x								Applied extensively.	High	Employment projections.	Low
3. Economic Base Analysis	*78*		x	x	x							Applied in Pittsburgh, Denver.	High	Multiplier for increase in total employment.	Low
4. Input/Output Analysis	WL; *25*			x								Extensive application.	Low	Dollar—Interindustry transactions.	High
5. Multi-Regional and Multi-Industrial Forecasting Model	Univ. of Md.; *72*	x	o[e]				x		x		x	Applied to four hypothetical alternatives.	Low	Population, employment, income, industrial output, government expenditures by OBE regions.	High
6. Economic Impact of BWI Airport on Md.	*73*		x							x	x	Applied in Md.	Medium	Direct and indirect impacts by local units.	High
7. Economic Impact of Baltimore Port on Md.	*74*		x								x	Applied in Md.	Medium	Direct and indirect impacts by cargo type and local units.	High
8. Analysis of Transit System Productivity and Equity	*140*	o	x	x				x				Applied in N.Y.	High	Cost per vehicle-mile and vehicle-hour; fare per mile vs. passenger income.	Low
9. Railroad Community Impact Analysis	*42h*		x	x					x		x	Applied in Mich.	High	Economic impacts related to taxes, employment, etc.	Medium
10. Regional Multiplier Analysis	*71*			x	x							Applied extensively.	High	Assessment of total regional impact due to capital investments.	Low

[a] Abbreviations identifying the organization responsible for development and/or application of the technique include:
LDA—L. D. Ashby
WL—W. Leontief

[b] Urban or rural areas and systems level.

[c] High—data easily available; medium—requires data manipulation; low—substantial new data collection required.

[d] Estimated Time: Low—less than 2 months; Medium—2 to 6 months; High—over 6 months
Estimated Cost: Less than $20,000; $20,000 to $50,000; Over $50,000

[e] x—Applicable; o—Could be applied as is or with adaptation.

TABLE 4

DESCRIPTION OF TECHNIQUES APPLICABLE TO THE TRAVEL FIELD

METHOD/TECHNIQUE	AUTHOR OR REFERENCE TO ANN. BIBLIOG.[a]	SCALE OF APPLICATION					MODE					TECHNICAL STATUS	DATA AVAIL-ABILITY[c]	OUTPUT INFORMATION	TIME AND COST OF AP-PLICATION[d]
		MULTI-STATE	STATE	SUB-STATE[b]	CORRI-DOR	PROJ-ECT	HIGH-WAY	TRAN-SIT	RAIL	AIR	GOODS MOVE-MENT				
1. Forecasting Product Flows	Ill. DOT		x[e]								x	Under de-velopment.	Unknown	Freight demand by substate regions.	Unknown
2. Forecasting Coal Transport Demand	*35*		x						x		x	Applied in Ill.	Medium	Demand for coal transport.	Low
3. Diversion Technique for Estimation of High-Speed Rail Ridership	*46*		x						x			Applied in N.Y.	High	Range of high-speed rail patronage.	Low
4. Potential Demand for Ports	N.Y. DOT			x							x	Under de-velopment.	Low	Port potential; sensitivity of shipments to tariff changes.	Medium
5. Sub-Area Isolation Technique	*52*		x	x			x	x				Applied extensively.	Low	Trip tables and network link volumes for sub-area.	Medium
6. General Aviation Activity Forecast	*41*	x	x							x		Applied in Md.	High	Aircraft ownership and movement by zone.	Medium
7. Air Passenger Distri-bution Model	*40*		o[e]	x						x		Applied in Md.	Low	Demand and schedule at each airport.	Medium
8. Forecasting Regional Air Passengers (Macro Approach)	*40*		o	x						x		Applied in Md.	High	Regional originations.	Low
9. Forecasting Regional Air Passengers (Micro Approach)	*40*			x						x		Applied in Md.	Medium	Zonal forecasts of passenger originations.	Medium
10. Demand Forecast From Region to Other Cities	*40*			x						x		Operational.	Medium	Zone to city air passenger demand.	High
11. Freight Transporta-tion Demand	Ky. DOT		x				x		x		x	Applied in Ky.	Low	Transportation expenditures, freight, ton miles and VMT by mode.	High
12. Highway Needs Evaluation Model	*37*		o	x			x					Applied in N.Y.	Medium	Travel cost and performance for the most desirable expressway supply.	Low
13. General Aviation Assignment Model	*41*		x							x		Applied in Md.	High	Demand by area and airport, capacity used at each airport.	Medium
14. Freight Network and Distribution Algorithm	*34*		x				x		x		x	Under de-velopment.	Low	Volumes, travel times, and distances.	High
15. Transportation De-mand Model for Manufactured Goods	*34*		x				x		x		x	Under de-velopment.	Medium	Volume produced, product destinations, modal split.	Medium
16. Transportation De-mand for Agricultural Goods	*35*		x						x		x	Applied in Ill.	Medium	Volume produced.	Medium
17. Accessibility Effects on Air Passenger Demands	N.Y. DOT			x			x		x			Under de-velopment.	High	Estimates of effect on air demand.	Low
18. Passenger Demand & Mode Split Models for Intercity Travel	AYC; *38*				x		x	x	x	x		Calibrated for N.E. Corridor.	Low	Passenger demand by mode.	High
19. Planning for Elderly & Handicapped	*50*		o	x			x	x				Test case in Md.	High	Submarket demand, priority of areas for need of services.	Low
20. Statewide Weekday Travel Model	*53*		x	o			x					Tested in Conn.	Medium	Traffic volumes on state network by link.	Medium
21. Statewide Weekend Travel Model	*54*		x	o			x					Tested in Conn.	Medium	Traffic volumes on state network by link, VMT.	Medium
22. California Statewide Model	*30*		x	x			x					Calibrated in Calif.	Low	Average daily traffic, VMT.	High

23.	Connecticut Statewide Model	Conn. DOT		x				x					Applied in Conn.	Low	Average weekday traffic, VMT.	High
24.	Corridor Location Dynamics Model	*42i*		o	o	x		x					Applied in Mich.	Medium	Optimum path based on environmental constraints.	Medium
25.	Fratar Model	TJF; *39*		x	x			x					Widely applied.	High	Growth factor.	Low
26.	Direct Demand Model	*29*		o	o	x		x	x	x	x	x	Applied in Sacramento-San Francisco Bay Area.	Low	Demand estimates by mode, assignment.	Medium
27.	National Network Model (TRANSNET)	U.S. DOT	x	o				x	x	x	x	x	Used in multiregional forecasting model.	Low	National network, travel times, assignment given O-D.	High
28.	Connecticut Weekend Travel Model	*45*		x				x					Tested in Conn.	Low	Sunday peak-period traffic volumes.	High
29.	Direct Demand Aggregate Equilibrium Model	CSI; Calif. DOT			x			x	x				Calibrated in L.A., still being tested.	Low	Trip tables by mode, assignment balanced to network capacity.	Medium
30.	Surveys			x				x	x	x	x	x	Extensively used.	Low	Information on person and freight travel including trip purpose, O-D and mode.	High
31.	Inventory Technique			x				x	x	x	x	x	Extensively used.	Low	Information on highways, transit rail, air and goods movement facilities.	High
32.	Methodology on Transit Handicapped and Elderly Decision-making	UMTA, TSC			x	x	x	x	x				Analytical approach not applied.	Medium	Costs and benefits for candidate solutions.	Medium
33.	Analysis of Factors Influencing Trip Length	AMV			x			x	x				Calibrated using Reading, Sioux City, Detroit data.	Medium	Effect of system speed, demographic variables on trip lengths.	Low
34.	Michigan Statewide Model	*42j*		x	x			x					Applied extensively in regional planning.	Low	AADT volumes on state network by link.	Medium
35.	Effective Speed Model	*42k*		x	x			x					Applied extensively in regional planning.	Low	Effective operating speeds as result of various statewide and regional plans.	Low
36.	Level of Service Model	*42l*		x	x			x					Applied extensively in regional planning.	Low	Level of service values as defined in 1965 capacity manual by link.	Low
37.	Capacity Adequacy Forecasting Model	*42m*		x	x			x					Operational but not extensively applied.	Low	Frequency of occurrence of highway deficiency on a yearly basis.	Low
38.	Passenger Demand and Modal Split Model—Intercity	*42n*		x	x			x		x	x		Calibrated for Mich.	Medium	Trips by mode.	High
39.	Statewide Commodity Flow Matrix	*42o*		x	x					x		x	Applied in Mich. analysis of R.R.	Medium	Zone to zone commodity flow.	Low
40.	State Trunkline Establishment	*42p*		x	x			x					Applied in Mich.	Medium	Analysis of travel characteristic changes by link before and after.	Medium

[a] Abbreviations identifying the organization responsible for development and/or application of the technique include:
AMV—Alan M. Voorhees & Associates, Inc.
AYC—Arthur Young & Co.
CSI—Cambridge Systematics, Inc.
DOT—Department of Transportation
TSC—Transportation Systems Center
UMTA—Urban Mass Transportation Administration

[b] Urban or rural areas and systems level.

[c] High—data easily available; medium—requires data manipulation; low—substantial new data collection required.

[d] Estimated Time:
Low—less than 2 months
Medium—2 to 6 months
High—over 6 months

Estimated Cost:
Less than $20,000
$20,000 to $50,000
Over $50,000

[e] x—Applicable; o—Could be applied as is or with adaptation.

TABLE 5

DESCRIPTION OF TECHNIQUES APPLICABLE TO THE DEVELOPMENT FIELD

METHOD/TECHNIQUE	AUTHOR OR REFERENCE TO ANN. BIBLIOG.[a]	SCALE OF APPLICATION					MODE					TECHNICAL STATUS	DATA AVAIL-ABILITY[c]	OUTPUT INFORMATION	TIME AND COST OF AP-PLICATION[d]
		MULTI-STATE	STATE	SUB-STATE[b]	CORRI-DOR	PROJ-ECT	HIGH-WAY	TRAN-SIT	RAIL	AIR	GOODS MOVE-MENT				
1. Trend Procedure	*55*		x[e]	x								Applied in Ill., Mo.	High	Population and employment by zones.	Low
2. Place Classification	Wis. DOT		x				x			x		Applied in Wis.	High	Ranking of activity centers.	Low
3. Statewide Activity Allocation Model	*64*	o[e]	x				x	x				Tested in Conn.	Medium	Population and employment by zone.	Medium
4. Demographic & Economic Modeling System (DEMOS)	*25*		x									Applied in Ky.	High	Population, employment, and vehicles by zone.	Low
5. Bay Area Simulation Study Model (BASS)	*65*			x			x	x				Validated in Bay Area.	Low	Population, employment, housing, and land development by zones.	Medium
6. EMPIRIC	*59*			x	x		x	x				Extensive application.	Low	Demographic, economic, and land-use profile.	Medium
7. Urban Systems Model (USM)	*63*			x	x		x	x				Extensive application.	Medium	Population, employment, air, noise, water levels.	Medium
8. Projective Land Use Model (PLUM)	*56*			x	x		x	x				Extensive application.	Medium	Demographic, economic, and land-use profile.	Medium
9. Development Pressure Index	*60*				x	x	x	x				Operational.	High	Indicator on a zonal basis for either new development or redevelopment pressure.	Low

[a] Abbreviations identifying the organization responsible for development and/or application of the technique include:
Wis. DOT—Wisconsin Department of Transportation
[b] Urban or rural areas and systems level.
[c] High—data easily available; medium—requires data manipulation; low—substantial new data collection required.
[d] Estimated Time:
Low—less than 2 months
Medium—2 to 6 months
High—over 6 months

Estimated Cost:
Less than $20,000
$20,000 to $50,000
Over $50,000

[e] x—Applicable; o—Could be applied as is or with adaptation.

TABLE 6

DESCRIPTION OF TECHNIQUES APPLICABLE TO THE LEGAL/ADMINISTRATIVE/INSTITUTIONAL/FINANCIAL FIELD

METHOD/TECHNIQUE	AUTHOR OR REFERENCE TO ANN. BIBLIOG.[a]	SCALE OF APPLICATION					MODE					TECHNICAL STATUS	DATA AVAILABILITY[c]	OUTPUT INFORMATION	TIME AND COST OF APPLICATION[d]
		MULTI-STATE	STATE	SUB-STATE[b]	CORRIDOR	PROJECT	HIGHWAY	TRANSIT	RAIL	AIR	GOODS MOVEMENT				
1. Rail Abandonment & Subsidy Requirements	*35*		x[e]	o[e]	o				x			Applied in Ill.	Medium	Increased transportation and relocation costs, subsidy total and by carload.	Medium
2. Revenue Cost Analysis of High-Speed Rail Service	*46*		x		x				x			Applied in N.Y.	High	Revenue-operating and revenue-total cost ratios.	Low
3. Benefit Cost Analysis of High-Speed Rail Service	*46*		x		x				x			Applied in N.Y.	High	Annual user benefits by corridor.	Low
4. Short-Range Capital Resource Availability Model (SCRAM)	*138*		x									Applied in Md.	High	Value of bond issues, capital operating expenditure and revenues by year.	Medium
5. Technique for Projecting Transit Deficits	N.Y. DOT; *17*		x	o	o			x				Applied in N.Y.	High	Operating cost, ridership, revenue, deficit.	Low
6. Airport Financial Model	Calif. DOT, DMJM		x	x		x				x		Applied in Calif.	High	Capital and operational aviation costs, cash flow.	Unknown
7. Comparison of Transportation Payments & Expenditures	KBS		x	o				x				Theory not applied.	High	Regional surplus/deficit.	Low
8. Analysis of State Capability to Meet Highway Construction Needs	ITC		x	o			x					Applied in Ill.	High	Percent of needs satisfied by year.	Low
9. Participation Process with Local Officials, Citizens	USTC		x	x	x	x	x					In use in Utah.	High	Suggestions for programs and individual projects.	Low
10. Legislative Process for Actions	ULA		x				x					In use in Utah.	High	Road construction schedule, agreement by company on prepayment of taxes.	Low
11. Benefit Cost Analysis	*136*		x		x	x			x			Applied in Conn.	Medium	Benefit-cost ratio with and without rehabilitation.	Medium
12. Project Management System	Utah DOT		x			x	x					Operational.	High	Status of projects, funds obligated.	Medium
13. Intercity Route Cost Effectiveness Technique	Oreg. DOT		x		x		x		x			Under development.	Medium	Comparative cost effectiveness measures for route improvements.	Medium
14. Technique for Assessing Systemwide Tradeoffs Between Design Standards & Costs	*61*		o	x								Applied in N.Y.	Medium	Sensitivity of costs to changes in design standards.	Medium
15. Highway User Revenue Model	*62*	o	x	x								Applied in Md.	High	Forecasts of revenues from gas tax collection, registration fees, and excise taxes.	Low
16. Systems Planning Report	*129*					x	x					Applied in Md.	Medium	Preliminary information on need for project, cost and project impacts, especially environmental.	Low
17. Problem Definition & Project Proposal Report	*131*					x	x					Applied in N.Y.	Medium	Preliminary information on need for project, cost and project impacts; suggested project scope.	Low
18. Railroad Financial Impact Analysis	*42q*		x	x					x		x	Applied in Mich.	Medium	Financial viability for each state railroad segment.	Medium

[a] Abbreviations identifying the organization responsible for development and/or application of the technique include:
DMJM—Daniel, Mann, Johnson & Mendenhall
DOT—Department of Transportation
ITC—Illinois Transportation Commission
KBS—Kurnow, Briel, Silberman
USTC—Utah State Transportation Commission
ULA—Utah Legislative Assembly

[b] Urban or rural areas and systems level.

[c] High—data easily available; medium—requires data manipulation; low—substantial new data collection required.

[d] Estimated Time:
Low—less than 2 months
Medium—2 to 6 months
High—over 6 months

Estimated Cost:
Less than $20,000
$20,000 to $50,000
Over $50,000

[e] x—Applicable; o—Could be applied as is or with adaptation.

TABLE 7

DESCRIPTION OF TECHNIQUES APPLICABLE TO THE PLAN AND PROGRAM EVALUTION FIELD

METHOD/TECHNIQUE	AUTHOR OR REFERENCE TO ANN. BIBLIOG.[a]	SCALE OF APPLICATION					MODE					TECHNICAL STATUS	DATA AVAIL-ABILITY[b]	OUTPUT INFORMATION	TIME AND COST OF AP-PLICATION[d]
		MULTI-STATE	STATE	SUB-STATE[b]	CORRI-DOR	PROJ-ECT	HIGH-WAY	TRAN-SIT	RAIL	AIR	GOODS MOVE-MENT				
1. Priority Ranking of Branch Lines	*152*		x[c]						x			Applied in Md.	Medium	Branchline ranking based on profitability.	Medium
2. Time Staging Analysis	*154*		x	x	x	o[e]	x					Applied in Santa Barbara.	High	Net present value of each near-term decision.	Unknown
3. Transportation Re-source Allocation Model (TRANS)	*145*		x				x					Applied in N.C.	Medium	A set of projects with maxi-mum effectiveness.	Low
3a. Developing Effective Measures	*145*					x	x					Applied in N.C.	Medium	Scores of each project, weighted totals.	Low
4. Zero Base Budgeting	St. of Ill.		x	x								Applied in Ill.	High	Decision packages showing performance at various funding levels.	Low
5. California Transpor-tation System Evaluation	TRW, WSA		x	x			x	x	x	x		Developed for Calif.	Varies	Based on evaluation factor.	Varies
6. Cost Benefit Analysis	*42r*		x	o			x					Tested in Mich.	Low	Net present worth, benefit-cost ratios.	Medium
7. Priority Programming Improvement Methodology	*AMV; 153*		o	x			x	x				Applied in an Ontario subarea.	Low	Project set maximizing present worth of benefits.	Medium
8. Priority Analysis for Ranking Transporta-tion Projects	Ga. DOT; *142*		x	o			x					Calibrated in Ga.	Medium	Ranking of projects in each category based on critical needs.	Low
9. Sufficiency Rating	*155*		x	o			x					Applied in Oreg.	High	Ranking of projects based on critical needs.	Low
10. Reduced Sufficiency Rating	Oreg. DOT		x	o			x					Operational by Sept. '76	High	Ranking of projects based on critical needs.	Low
11. Heuristic Technique for Generating Multiple-Period Investment Programs	JP		x	x			x					Developed but not applied.	Medium	Multiple period investment program maximizing benefits.	Low
12. Utah Priority Index	*161*		x				x					Applied in Utah.	High	Priority ranking of projects based on critical needs.	Low
13. Cost-Effectiveness Ranking for Airports	*47*	o[e]	x							x		Applied in Oreg.	High	Ranking of improvement projects; rank of airports.	Low
14. Sketch-Planning Approach to State-wide Transportation Planning	*141*		x				x	x	x	x	x	Applied in N.C.	High	Transportation requirements for each future and corre-sponding development pattern.	High
15. Evaluation Matrix	Calif. DOT; *143*	o	x	x	x	x	x	x	x	x	x	Applied in Calif.	Medium	Display of input information.	High

16.	Procedures for Rail Planning	*165*		x		x				x		Applied in Wis., Mich.	Varies	State railroad plan.	Varies
17.	Highway Needs Evaluation Model	*162*		x	o	o	o	x				To be tested.	Medium	Changes made by improvement, final conditions at end of study period, and capital and annual costs for each highway section.	Medium
18.	Highway Investment Analysis Package (HIAP)	ECI; *147*	o	x	x			x				To be tested.	Medium	User and non-user highway impacts, net present value and benefit-cost ratios for each investment strategy.	Medium
19.	Dial-A-Ride City Selection	*42s*		x	x				x			Operational.	Low	Index and ranking of cities related to potential success.	Medium
20.	Objective Priority Programming Procedure	GA; *163*		x	x			x				Tested in Ala.	Medium	Project cost-effectiveness rankings based on cost, sufficiency rating and social, economic, and environmental impact.	Medium

[a] Abbreviations identifying the organization responsible for development and/or application of the technique include:
AMV—Alan M. Voorhees & Associates, Inc.
DOT—Department of Transportation
ECI—ECI Systems, Inc.
GA—General Analytics, Inc.
JP—Juster & Pecknold
TRW—TRW, Inc.
WSA—Wilbur Smith and Associates

[b] Urban or rural areas and systems level.
[c] High—data easily available; medium—requires data manipulation; low—substantial new data collection required.
[d] Estimated Time:
Low—less than 2 months
Medium—2 to 6 months
High—over 6 months

Estimated Cost:
Less than $20,000
$20,000 to $50,000
Over $50,000

[e] x—Applicable; o—Could be applied as is or with adaptation.

TABLE 8

SUMMARY OF DATA SOURCES AND AVAILABILITY BY LEVEL OF DETAIL

DATA ITEM	SOURCE [a]	MULTI-STATE	STATE	SUB-STATE	COUNTY	CITY	TRACT	PROJECT
Environmental								
Air quality standards	Federal Register	x						
State air quality standards	BAQC		x					
Background air quality	Monitoring stations				x	x		
Emission rates (vehicles and other sources)	EPA publications; e.g., AP.42	x						
Emissions data (inventory)	NEDS		x		x	x		
Air movement, humidity, precipitation, temperature	U.S. Weather Bureau		x		x	x		
Water quality, flow characteristics, storm flow characteristics	USGS, USDA, US Army Corps of Engineers			x				x
Noise standards	EPA publications	x						
Noise levels	Monitoring							x
Unit energy consumption	Publications	x						
Soil, geology, mineral resources, topography, small area acreage	USGS, USDA, survey		x		x			
Social								
Population characteristics (age, sex, density)	Population census reports	x	x	x	x	x	x	x
Social and economic characteristics (residence 5 yrs. ago; year moved into present house; place of work; means of transportation to work; income; birth, death, migration rates)	Population census reports	x	x	x	x	x	x	x
Population projection by age group	U.S. Bureau of Census, Bureau of Economic Analysis	x	x	x				
Dwelling units in structure	Housing census reports		x		x	x	x	
Economic								
Employment by type, labor force, retail sales, payrolls by industry type, earnings by industry type, employment, income	Censuses of business, manufacturing, transportation and agriculture; BLS, BEA		x	x	x	x		
Operating costs of transportation modes, capital costs, maintenance costs, relocation costs	Publications, operating agencies			x				x
Auto ownership	Housing census reports		x		x	x	x	
Aircraft ownership	FAA	x						
Regional exports	Census of Transportation		x	x				
Income projections	BEA			x [b]				
Employment projections	BEA, NPA			x [b]				
Inflation rate, unemployment rate	BLS	x	x					
User benefits	Publications		x	x	x	x		x
Travel								
Inventory of transportation facilities	US DOT, state, county, and local agencies, operating agencies, public utilities/services commission		x	x	x	x		x
Vehicle classification	Dept. of Motor Vehicles	x	x					
Travel patterns	O-D surveys, NPTS, NTS, various transportation studies	x	x	x				x
Rail tonnage, railroad density charts	FRA, publications, shipper survey		x					x

DATA ITEM	SOURCE [a]	MULTI-STATE	STATE	SUB-STATE	COUNTY	CITY	TRACT	PROJECT
Development								
Land use information including population ceiling for small areas	Regional, county and local agencies, USGS, USDA, ERTS/LANDSAT		x	x	x	x		
Legal/Administrative/Institutional/Financial								
Revenues (fuel tax, fares, tolls, etc.)	State, regional, county and city agencies		x	x	x	x		
Budgets, federal aid	Federal and state agencies	x	x					
Public opinions	Public		x	x	x	x		x
Interest rates	Banks	x	x					
Plan and Program Evaluation								
Effectiveness measures for projects	State, regional and local agencies		x	x				x
Transportation plans (state, urban, regional)	Office of Planning, regional agencies		x	x				

[a] Sources:
BAQC—Bureau of Air Quality Control
BEA—Bureau of Economic Analysis
BLS—Bureau of Labor Statistics
FAA—Federal Aviation Administration
FRA—Federal Railroad Administration
NEDS—National Emission Data Survey
NPA—National Planning Association
NPTS—Nationwide Personal Transportation Study
NTS—National Travel Survey
USDA—U.S. Department of Agriculture
US DOT—U.S. Department of Transportation
US EPA—U.S. Environmental Protection Agency
USGS—U.S. Geological Survey
[b] Economic areas.
[c] x denotes the level of detail at which data are generally available.

housing, business, manufacturing, transportation, and agriculture). The Bureau of Labor Statistics (BLS) is a useful source of economic data. The smallest unit at which information is available from the Census of Manufacture and Transportation and the BLS is the county level. The Census of Business provides information at the city level also.

BEA develops projections of income and employment for economic areas (areas that are combinations of counties grouped around important cities without regard to state boundaries). BEA also provides projections of earnings by industry type. Employment projections for metropolitan areas are prepared by the National Planning Association.

Travel Field

The data items in this field include an inventory of transportation facilities as well as travel patterns of people and goods. Information on transportation facilities includes the distance, speed, and volumes on major roads and highways, transit, rail, and air routes, and passenger volumes; terminal facilities, transfer facilities, time, costs, and utilization for transit, rail, air, truck, and ports.

Travel patterns of people and goods are obtained through origin-destination (O-D) surveys. These surveys provide information on trip purpose, mode, origin and destination, trip length, vehicle and passenger miles of travel, and ton-miles of freight.

Data on major roads and highways are available from state, county, and local agencies. Data on transit facilities, rail, airports, ports, and truck facilities are generally available from operating agencies or public utilities/service commissions. Because data on travel patterns are obtained through O-D surveys, their availability varies from place to place. This information is made widely available for urban areas, but few states have conducted a statewide O-D survey. In most areas, O-D surveys have been conducted for one time period, possibly two. Relatively few have been conducted since the mid-1960's.

On the national level, a personal transportation survey was conducted in 1969-70 to obtain information on national patterns of travel. Another survey, the National Travel Survey, provides annual travel pattern information for long-distance travel (greater than 100 miles). NCHRP Project 8-17, currently underway, is identifying in detail the freight data availability for statewide transportation system planning.

Development Field

To obtain development patterns for a region or state, information is required on land use including densities, socioeconomics, and transportation facilities. Land-use data are generally available through local, county, and regional planning agencies. In addition, USGS and USDA are sources of aerial photos and other mapped coverage of land use.

Legal/Administrative/Institutional/Finance Field

The data needs of the finance subgroup overlap those of the economic field. The data items relate to revenues and costs, including interest rates for estimating present worth of benefits. Revenues may be generated from transportation structure or from public structure, such as fuel tax revenues, fares or tolls from users. The state, regional, county, and city planning agencies are the principal sources for this information. Federal policies may affect revenues and this effect has to be assessed. Costs include operating costs, maintenance costs, capital costs, and the like, which can be obtained as described in the economic section.

Plan and Program Evaluation Field

This category requires information on planning goals and priorities as well as standards and criteria for each program. This information is available from policies and plans or the people who will be affected by the proposal. Other data needs in this field are the measures of effectiveness for assessing candidate projects and estimating system benefits. These include the social factors (community cohesion, service sufficiency, transit mobility), statewide/regional development benefits (employment opportunities, change in housing costs), user benefits (travel time and costs, transit user cost and comfort, accidents), operator benefits (maintenance costs, transit operating costs), and environmental factors (noise, air, water, natural land areas). The availability of this information has been described previously.

LINKING AVAILABLE TECHNIQUES TO STATE-LEVEL INFORMATION NEEDS

The preceding three sections presented the major findings of Project 8-18 research on (a) state-level issues and information needs, (b) available methods and techniques, and (c) state-level data availability. As previously noted, Figure 2 summarizes major information needs, which were identified in each of the thirteen states where interviews were conducted, under eleven issue areas.

Tables 1 through 7 give a listing of available techniques classified into groupings by the field of impact or area of concern that they may be used to address.

As can be seen from scanning down any column of Figure 2, information from a number of fields is needed to guide decisions in each of the issue areas. For example, states need information on the consequences of the various actions that may be undertaken as a result of "Revenue Shortfall" (Fig. 2, first column). This includes the social, economic, and environmental effects of reducing or postponing new highway construction and deferring maintenance. Also, states in which motor vehicle use taxes are earmarked for transportation purposes need better techniques for predicting revenues, particularly as they may be affected by energy conservation policies. Thus, in general, there is no simple one-to-one correspondence between issue areas and fields (i.e., fields of impacts or areas of concern).

Figure 3 has been prepared so that information needs identified for each issue area can be more precisely related to technique requirements. This figure summarizes, for each field of impact or area of concern, what information typically is needed to help inform decision-makers in each issue area.

Development of Figure 3 was based on a review of each of the issue areas applying issue forms, which provided a structured framework to ensure that interviewers identified specific information used or needed and the context for each of the major issues in the state. In preparing entries for Figure 3, emphasis was placed on those information needs common to several states. Empty cells in Figure 3 do not imply that actions taken in response to a particular type of issue do not have an impact in that area. Rather, empty cells imply that interviewees judged information needs in other areas to be of higher priority, or that information is being adequately provided at present. Because each box in Figure 3 linked major issues (column heads such as "Revenue Shortfall") with specific impact fields (row headings such as "Environmental" or "Social"), the catalogue of methods and techniques in Tables 1 through 7 were searched to find applicable techniques to satisfy an identified information need. The results of this process are documented in Tables 9 through 19. These tables give information needs and the techniques to satisfy them by impact field.

Several points should be emphasized about these tables. First, for many of the information needs described in Figure 3, there were no techniques identified to satisfy them. This lack of available techniques was particularly noticeable in the process-related issue areas of "Organization and Management" and "Coordination with Other State and Regional Programs." For information needs for which there are no identified techniques, no reference is made in Tables 9 through 19.

Second, the information needs described in several of the boxes within the issue column of Figure 3 are the same or are very similar, and the techniques to address the information needs are the same. Where the information needs and available techniques are the same for several fields of impact, they are presented only once in the tables. An example of this situation can be found in the "Travel," "Financial," and "Plan and Program Evaluation" rows of the Figure 3 column "Cost Effectiveness in Highway Standards and Maintenance." The information needs for these impact fields are very similar, hence only "Travel" impacts are listed in Table 16.

Tables 9 through 19 give the comprehensive linking together of identified information needs in statewide transportation planning and programming with the techniques which the research team has found to satisfy them. The numerical identification following each technique given in Tables 9 through 19 refers to the table number and item of Tables 1 through 7 where more detailed technique descriptions are to be found.

EVALUATION OF PHASE II PROJECTS

After having linked information needs with available techniques, the next step was to define and evaluate potential projects that might be undertaken in the Phase II effort. Potential projects would involve the application of a technique or set of techniques that provides information to assist in resolving state-level plan and program evaluation issues.

TABLE 9

LINKING OF INFORMATION NEEDS AND TECHNIQUES WITHIN THE ISSUE OF REVENUE SHORTFALL

INFORMATION NEED	TECHNIQUE
Social Effects of a significant decrease in mobility on the transit-dependent, the general public, and businesses.	• Highway Needs Evaluation Model (Table 4-12 [a]) • Planning for Elderly and Handicapped (Table 4-19) • Technique for Projecting Transit Deficits (Table 6-5)
Economic Costs to major industries and the effects on operations, markets, and jobs if transportation systems are allowed to deteriorate.	• Employment Shift-Share Analysis (Table 3-2) • Input/Output Analysis (Table 3-4) • Multi-Regional and Multi-Industrial Forecasting Model (Table 3-5) • Economic Impact of BWI Airport on Md. (Table 3-6) • Economic Impact of Baltimore Port on Md. (Table 3-7) • Freight Transportation Demand (Table 4-11) • Highway Needs Evaluation Model (Table 4-12)
Travel Effects of reduced level of service that will result from cutbacks and the effects this will have on travel and goods movement.	• Passenger Demand and Mode Split Models for Intercity Travel (Table 4-18) • Direct Demand Model and Equilibrium Model (Tables 4-26 and 4-29) • Level of Service Model (Table 4-36) • Highway Needs Evaluation Model (Table 4-12) • Technique for Projecting Transit Deficits (Table 6-5) • Input/Output Analysis (Table 3-4) • Multi-Regional and Multi-Industrial Forecasting Model (Table 3-5) • Employment Shift-Share Analysis (Table 3-2) • Economic Impact of BWI Airport on Md. (Table 3-6) • Economic Impact of Baltimore Port on Md. (Table 3-7) • Freight Transportation Demand (Table 4-11) • Analysis of Factors Influencing Trip Lengths (Table 4-33) • Planning for Elderly and Handicapped (Table 4-19)
Legal/Administrative/Institutional Impact information useful in the legislative and executive budgeting process because an increasing number of state transportation agencies are forced to compete with other state agencies for general revenues.	• Evaluation Matrix (Table 7-15)
Financial Forecasts of revenues from highway user taxes. In particular, states need the capability to predict the effects of national energy policies and trends on state highway user tax revenue.	• Energy Consumption Methodology (Table 1d-1) • Gasoline Consumption Model (Table 1d-2) • Highway Fuel Consumption Computer Model (Table 1d-3) • Highway Needs Evaluation Model (Table 4-12) • Estimating Energy Consumption Reductions Due to Transportation Actions (Table 1d-4) • Carpooling Energy Submodel (Table 1d-5) • Energy-UTCS-1 Network Simulation Model (Table 1d-6) • PRIFRE Energy Model (Table 1d-7) • Wisconsin Regional Energy Model-Transportation Model (Table 1d-8) • Fuel Consumption Curves (Table 1d-9)
Plan and Program Evaluation Estimates on a regional and statewide basis of the consequences of various levels of expenditures for transportation.	• Priority Programming Improvement Methodology (Table 7-7) • Intercity Route Cost-Effectiveness Evaluation Technique (Table 6-13) • Highway Investment Analysis Package (Table 7-18) • Objective Priority Programming Procedures (Table 7-20)

[a] Second number refers to item in table specified (i.e., Table 4, item 12).

FIGURE 3

TYPICAL INFORMATION NEEDS IN ADDRESSING MAJOR ISSUES BY TYPE OF IMPACT OR AREA OF CONCERN

	MULTIMODAL ISSUES				
TYPE OF IMPACT ON AREA OF CONCERN	REVENUE SHORTFALL	DEVELOPMENT OF MULTIMODAL TRANSPORTATION POLICIES, PLANS AND PROGRAMS	ORGANIZATION AND MANAGEMENT	COORDINATION WITH OTHER STATE AND REGIONAL PROGRAMS	DEVELOPMENT OF ENERGY POLICY, PLANS, AND PROGRAMS
Environmental • General • Air • Water • Noise • Energy • Natural	Effects of national energy policy and trends on revenues (where earmarked funds are used).	Need to assess all environmental impacts of alternative plans and programs at the system level with more simple methods. Need planning data on energy resource development projects.	Federal environmental requirements are biggest problem in expediting projects. Need management level information on status and reason for delays as they occur. Need consistency in definitions of environmental impact measures across modes.	Problems exist in some states in agreement on air quality plans, alternatives to be analyzed and credibility of impact assessments. Need better data on environmental constraints and resources from other agencies.	Energy efficiency of modes; effects of various actions. Need contingency plans both for crises and for long-term changes.
Social	Effects of significant decrease in mobility to transit-dependent, to general public, and to business.		Need to identify social and environmental impact issues early in project development and take appropriate action.	Some states are beginning to work with other state and local agencies on transportation aspects of health care, tourism, education, etc.	
Economic	Costs to major industries and effects on operations, markets, jobs if transportation system is allowed to deteriorate.	Effects of subsidies for mode on intermodal competition. Comparable economic benefit measures across modes. Need contingency plans.	More emphasis on need for broad economic impact information as a result of reorganization.		Distributional effects of gas tax increases are of concern.
Travel	Reduction in level of service that will result and its effects on travel and goods movement.	Assessment of intermodal tradeoffs for freight movement. Statewide O-D data lacking.	Efforts to reorganize state transportation functions; make agencies more aware of need to exchange and compare data, especially on travel.		Demand relationships sensitive to energy policy options. Carpooling and vanpooling data based on measurement needed.
Development		Need more detailed information on state plans and development trends for long-range forecasts.	Integration of modal planning often highlights transportation/land use relationships at terminals and transfer points.	State planning data lacking; regional data not consistent. Need to assist others in transportation aspects of development planning.	Identify development needs related to energy resources: location costs, facility needs, access needs.
Legal/ Administrative/ Institutional	As states must seek general revenues more, they need to direct information more to needs of budget process of executive and legislative branches.	Simplify communications of policies, plans, and programs among actors.	Better definition of rules and better communication among various units involved in planning and programming.	New TIP and some new state requirements are resulting in need for basic changes in state/ regional procedures and communications.	Forthcoming FEA guidelines for recent Energy Act are awaited.

		MODE-SPECIFIC ISSUES			
RELATIONSHIP BETWEEN TRANSPORTATION IMPROVEMENTS AND DEVELOPMENT	MAJOR CORRIDOR IMPROVEMENTS	COST EFFECTIVENESS IN HIGHWAY STANDARDS AND MAINTENANCE	IMPROVEMENT/ ABANDONMENT OF RAIL SERVICE	FUNDING OF TRANSIT SERVICES AND IMPROVEMENTS	AIRPORT CAPITAL IMPROVEMENTS
	Need better preliminary environmental assessment data sources and methods at reasonable costs.	Lack of a general way of taking into account environmental factors in determining most cost-effective standards to use system-wide.			Air quality impacts around airports. Noise forecasts, land-use controls, abatement actions.
Need for jobs, local attitudes regarding intensiveness of development.	Homes and jobs displaced, disruption of of communities.		Effects on jobs and labor agreements.	Need to establish standards for service that reflect needs of transit-dependent as well as other general modes.	
Dependency of industry on rail access, highway costs or port access. Role of transportation as catalyst for development changes.	Capital and operating costs and deficits. Effects on commodity prices and markets.	One state (PA) ranks improvements on user cost savings due to reconstruction or resurfacing. Another (NY) does benefit/cost analysis for all projects.	Benefit/cost ratio for branch line subsidy in State Rail Plans.	Comparative productivity and operating cost data. Line-by-line operating cost data poor almost everywhere.	
Potential for serving planned development by transit: as land-use control criteria.	Travel times and costs for subareas. Measures comparable across modes for multimode corridor studies.	Pavement condition, accidents, traffic, geometrics used in sufficiency ratings, but often with reference to standards that may not be cost effective.	Commuter costs and travel time for goods or passengers by rail and highway. Assessment of possible demand shift. Need methods for goods movement forecasting.	Need to estimate latent demand in rural areas and small towns without service now.	Forecasts of flows on access systems and airports.
Impact of alternatives on development. Control of development at transportation facilities.	Effects on industry, markets, jobs in areas served; role of transportation itself and in combination with other specific actions.	Need to determine under what conditions access control is desirable on cost effectiveness basis to protect capacity and function of highways.	Effects of abandonments on firms served; jobs, markets lost; other community impacts.		Effect of improved service as major factor in attracting industry.
Potential for combining transportation improvements with development control.		Management should monitor design process to assure that project concept and general design guidelines as defined in program are adhered to.	Need standards and methods for cost analysis from federal government in addition to what is now available. Changes in law needed to expand options, etc.	Management assistance needs of small operators. Need legal basis for obtaining good cost and operating data from transit operators.	Need to define state versus local role and responsibility.

FIGURE 3

TYPICAL INFORMATION NEEDS IN ADDRESSING MAJOR ISSUES BY TYPE OF IMPACT OR AREA OF CONCERN (continued)

	MULTIMODAL ISSUES				
TYPE OF IMPACT ON AREA OF CONCERN	REVENUE SHORTFALL	DEVELOPMENT OF MULTIMODAL TRANSPORTATION POLICIES, PLANS AND PROGRAMS	ORGANIZATION AND MANAGEMENT	COORDINATION WITH OTHER STATE AND REGIONAL PROGRAMS	DEVELOPMENT OF ENERGY POLICY, PLANS, AND PROGRAMS
Financial	Forecast revenue in states with earmarking. Uncertainty about federal policies affecting revenue.	Need to compare plans and programs based on alternative financial assumptions.	Up-to-date cash flow data by project and source are needed.		Need to assess effects of energy policy options on revenues.
Plan and Program Evaluation	Estimate system benefits rather than project-level data.	Need measures of effectiveness to assess candidate projects and programs in relation to policies. Need standards and criteria for each program.	Efforts to integrate planning and program functions put more stress on need for common approaches to program evaluation across modes.	Trend toward use of general revenue results in new program evaluation requirements from budget agencies.	Energy impacts of alternative plans and programs needed.

Twenty-one potential projects, described in Appendix D, were identified for Phase II testing. These projects were selected because they all have potential significance for demonstrating the use of techniques that will serve important information needs in the state transportation planning and programming process.

These potential projects were identified from among all the techniques listed in Tables 1 through 7 based primarily on information needs, with some general consideration being given to other criteria that were later more formally applied in evaluating projects for Phase II.

The process of identifying potential projects involved line-by-line comparison of the identified information needs (from all states) with the identified available techniques (from all states) in the corresponding category (identified by a particular issue area and field of impact). Consideration was given to different types of needs in this analysis, ranging from information needs in some states that could be immediately assisted by the application of techniques in use in other states to needs that would necessitate significant modification of existing techniques.

In some instances, information needs were identified which will require the development of new techniques. In other instances, the information needs do not lend themselves to the use of existing techniques, but instead call for new procedures or communications processes. To the extent that these information requirements depend on "process" and cannot be significantly assisted by the use of systematic analytical techniques, the need lies outside the bounds of this project and was dropped from consideration.

The projects would all involve use of techniques, as distinct from procedures, although some of them are very simple techniques such as single-equation models, and some fall on the borderline between analytical methods and study procedures or communications processes. Two borderline cases might be cited as examples of projects that were included and given serious consideration even though they might be judged to be somewhat more procedural than technique oriented. Both are included because of their potential importance in several state planning programs:

1. Project No. 9: Methodology for Predicting Statewide Economic Impacts of Varying Funding Levels—No existing methods are available. The project would involve development of some new techniques and require some research. However, it must be judged as a high-priority need based on the importance given this by several states.
2. Project No. 16: Evaluation Reporting Methods in the Plan Development Process—Although this project would be a technique only in the sense of providing a systematic format for organizing complex information, it is included because it is the core of the information needed for decision making. It has too often been given so little attention by planners that the quality of decisions suffers significantly as a result.

Because sufficient funds are not available to conduct all of the twenty-one projects identified for Phase II consideration, it was necessary to develop criteria for evaluating these projects so that the highest ranking ones could be tested in Phase II. The evaluation criteria and evaluation process that were developed are described in Appendix E.

Four basic criteria for evaluation of projects were selected. Based on these criteria, an ideal project would be the one that needs research, has a high probability of suc-

		MODE-SPECIFIC ISSUES			
RELATIONSHIP BETWEEN TRANSPORTATION IMPROVEMENTS AND DEVELOPMENT	MAJOR CORRIDOR IMPROVEMENTS	COST EFFECTIVENESS IN HIGHWAY STANDARDS AND MAINTENANCE	IMPROVEMENT/ ABANDONMENT OF RAIL SERVICE	FUNDING OF TRANSIT SERVICES AND IMPROVEMENTS	AIRPORT CAPITAL IMPROVEMENTS
	Cost of alternative corridor improvements and availability of funding.	Financial constraints force more attention to cost effectiveness and a shorter range for design.	Rail plans are constrained by eligibility limits in law; show economic need for railbanking and other needs not now eligible.	NY has method for forecasting deficits. Need some funding guidelines from UMTA at state level.	Revenue forecasts are more difficult—uncertainty over demand, fuel costs, etc.
Plans can be used as means to attract development. Show cost effectiveness of access control.	Determine most cost-effective standards for highways and use these to guide programming.	Several states are developing revised standards to use in programs based on system-wide cost effectiveness criteria.	Need to define more accurately the state role versus industry's benefits/ responsibility.	General cost-effective standards for maintenance of old facilities needed.	Oregon has cost-effectiveness index for setting priorities.

cess leading to results of great utility, and could be accomplished at low cost. All candidate projects were evaluated by assigning a value between 0 and 1 for each of the following criteria:

1. Need—
   a. Likelihood of duplication of effort.
   b. Amount of gap in current state of the art.
   c. Contribution to improvement of field.
2. Utility—
   a. Usefulness in sketch planning.
   b. Likelihood of providing critical information.
   c. Quickness of application.
3. Probability of Success—
   The product of the first three variables gave a measure of the over-all need and the product of the second three gave a measure of the over-all utility of each candidate project. A measure of the potential effectiveness of each candidate project was then obtained by multiplying the values for need, utility, and probability of success.
4. Costs—
   Two cost factors were estimated—person-months of effort required from both the research team and the state agency in order to complete a Phase II project.

The results of the evaluation are presented in Table 20. The table shows the evaluations prepared for each of the twenty-one candidate projects for each of the nine listed criteria. Also included in this table are the calculated values (derived from the detailed criteria) for:

1. Over-all need.
2. Over-all usefulness.
3. Effectiveness.
4. Over-all cost.
5. Cost-effectiveness ratio.

The projects were ranked in order of decreasing value of the cost-effectiveness ratio. With the budgetary limitations on Phase II, only a small number of projects can be implemented. The projects selected for Phase II testing are presented in Chapter Four.

TABLE 10

LINKING OF INFORMATION NEEDS AND TECHNIQUES WITHIN THE ISSUE OF DEVELOPMENT OF MULTIMODAL TRANSPORTATION POLICIES, PLANS, AND PROGRAMS

INFORMATION NEED	TECHNIQUE
Environmental	
Information at the system planning stage on the environmental impacts of alternative plans and programs.	• Emission Forecasting (Table 1-a.1 [a]) • Proportional Model (Table 1-a.3) • Larsen's Model (Table 1-a.5) • Emissions Projection Methodology (Table 1-a.8) • Michigan Air Pollution Model (Table 1-a.10) • Environmental Impact of Policies (Table 1-a.13) • Water Quality Model (Table 1-b.1) • Highway Noise Prediction Model (Table 1-c.3) • SAPOLLUT (Table 1-c.4) • Michigan Noise Model (Table 1-c.5) • Energy Consumption Methodology (Table 1-d.1) • Highway Fuel Consumption Computer Model (Table 1-d.3)
Economic	
Comparable measures of the economic benefits from investments in the various modes, as well as information on the effects of subsidizing one mode in intermodal competition.	• Freight Network and Distribution Algorithm (Table 4-14) • Transportation Demand Model for Manufactured Goods (Table 4-15) • Transportation Demand for Agricultural Goods (Table 4-16) • Potential Demand for Ports (Table 4-4) • Priority Programming Improvement Methodology (Table 7-7)
Travel	
Assessment of intermodal trade-offs for freight movement. Lack of statewide O-D data.	• Potential Demand for Ports (Table 4-4) • Freight Network and Distribution Algorithm (Table 4-14) • Transportation Demand Model for Manufactured Goods (Table 4-15) • Transportation Demand for Agricultural Goods (Table 4-16) • Priority Programming Improvement Methodology (Table 7-7)
Legal/Administrative/ Institutional	
Simplifying communications of policies, plans, and programs among actors.	• Participation Process with Local Officials, Citizens (Table 6-9)
Financial	
Comparison of plans and programs based on alternative assumptions about future levels of funding.	• Airport Financial Model (Table 6-6) • Analysis of State Capability to Meet Highway Construction Needs (Table 6-8) • Technique for Projecting Transit Deficits (Table 6-5)
Plan and Program Evaluation	
Measures of effectiveness (i.e., standards and criteria) to assess each candidate project and program relative to policies.	• Transportation Resource Allocation Model (TRANS) (Table 7-3) • Cost Benefit Analysis (Table 7-6) • Priority Programming Improvement Methodology (Table 7-7) • Priority Analysis for Ranking Transportation Projects (Table 7-8) • Sufficiency Rating (Table 7-9) • Developing Effective Measures (Table 7-3a) • Zero Base Budgeting (Table 7-4) • Reduced Sufficiency Rating (Table 7-10) • Heuristic Technique for Generating Multiple-Period Investment Programs (Table 7-11) • Utah Priority Index (Table 7-12) • Cost Effectiveness Ranking for Airports (Table 7-13) • Highway Investment Analysis Package (Table 7-18) • Highway Needs Evaluation Model (Table 7-17) • Dial-A-Ride City Selection (Table 7-19) • Objective Priority Programming Procedures (Table 7-20)

[a] Second number refers to item in table specified (i.e., Table 1, item a.1).

TABLE 11

LINKING OF INFORMATION NEEDS AND TECHNIQUES WITHIN THE ISSUE OF ORGANIZATION AND MANAGEMENT

INFORMATION NEED	TECHNIQUE	INFORMATION NEED	TECHNIQUE
Environmental		**Social**	
Management-level information on federal environmental requirements, the biggest problem in expediting projects; their status, and reasons for delays as they occur.	• Project Management System (Table 6-12[a])	Identification of social and environmental impact issues early in project development and initiation of appropriate action.	• Community Inventory (Table 2-2)
		Financial	
		Up-to-date cash flow data by project and source.	• Project Management System (Table 6-12)

[a] Second number refers to item in table specified (i.e., Table 6, item 12).

TABLE 12

LINKING OF INFORMATION NEEDS AND TECHNIQUES WITHIN THE ISSUE OF COORDINATION WITH OTHER STATE AND REGIONAL PROGRAMS

INFORMATION NEED	TECHNIQUE	INFORMATION NEED	TECHNIQUE
Environmental		**Social**	
Agreement among states on air quality plans, alternatives to be analyzed, and credibility of impact assessments.	• Emissions Forecasting (Table 1-a.1[a]) • Proportional Model (Table 1-a.3) • Emissions Projection Methodology (Table 1-a.8) • Environmental Impact of Policies (Table 1-a.13) • Larsen's Model (Table 1-a.5) • Air Pollution Simulation (Table 1-a.6) • Air Quality for Urban and Industrial Planning (AQUIP) (Table 1-a.9) • Michigan Air Pollution Model (Table 1-a.10) • Air Transportation Impact Model (ATIM) (Table 1-a.11) • Land Use Based Air Quality Projection System (Table 1-a.12)	Transportation aspects of services provided by other state and local agencies, such as those responsible for health care, tourism, and education.	• Proximity Analysis (Table 2-1)
		Development	
		Compilation of state planning data and more consistent regional data.	• Bay Area Simulation Study (BASS) (Table 5-5) • Statewide Activity Allocation Model (Table 5-3)
		Legal/Administrative/ Institutional	
		New TIP and some new state requirements resulting in a need for basic changes in state/regional procedures and communications.	• Participation Process with Local Officials and Citizens (Table 6-9) • Systems Planning Report (Table 6-16) • Problem Definition and Project Proposal Report (Table 6-17) • Evaluation Matrix (Table 7-15)

[a] Second number refers to item in table specified (i.e., Table 1, item a.1).

TABLE 13

LINKING OF INFORMATION NEEDS AND TECHNIQUES WITHIN THE ISSUE OF DEVELOPMENT OF ENERGY POLICY, PLAN, AND PROGRAM

INFORMATION NEED	TECHNIQUE
Environmental	
Energy efficiency of the different modes of travel and the effects of various transportation actions on energy consumption.	• Highway Fuel Consumption Computer Model (Table 1-d.3 [a]) • Estimating Energy Consumption Reductions Due to Transportation Actions (Table 1-d.4)
Economic	
Distributional effects of gas tax increases.	• Energy Consumption Methodology (Table 1-d.1) • Gasoline Consumption Model (Table 1-d.2) • Highway Fuel Consumption Computer Model (Table 1-d.3) • Estimating Energy Consumption Reductions Due to Transportation Actions (Table 1-d.4) • Highway User Revenue Model (Table 6-15)
Travel	
Effects on gasoline consumption of specific actions states can take such as carpooling and vanpooling programs, and right turn on red.	• Energy Consumption Methodology (Table 1-d.1) • Gasoline Consumption Model (Table 1-d.2) • Highway Fuel Consumption Computer Model (Table 1-d.3) • Estimating Energy Consumption Reductions Due to Transportation Actions (Table 1-d.4) • Highway User Revenue Model (Table 6-15)
Development	
Identification of access needs of energy resource development sites.	• Forecasting Coal Transport Demand (Table 4-2)
Financial	
Assessment of effects of energy policy options on revenues.	• Energy Consumption Methodology (Table 1-d.1) • Gasoline Consumption Model (Table 1-d.2) • Highway Fuel Consumption Computer Model (Table 1-d.3) • Estimating Energy Consumption Reductions Due to Transportation Actions (Table 1-d.4) • Highway User Revenue Model (Table 6-15)
Plan and Program Evaluation	
Capability to forecast the energy impacts of alternative plans and programs.	• Energy Consumption Methodology (Table 1-d.1) • Gasoline Consumption Model (Table 1-d.2) • Highway Fuel Consumption Computer Model (Table 1-d.3) • Estimating Energy Consumption Reductions Due to Transportation Actions (Table 1-d.4) • Carpooling Energy Submodel (Table 1-d.5) • Energy-UTCS-1 Network Simulation Model (Table 1-d.6) • PRIFRE Energy Model (Table 1-d.7) • Highway User Revenue Model (Table 6-15)

[a] Second number refers to item in table specified (i.e., Table 1, item d.3).

TABLE 14

LINKING OF INFORMATION NEEDS AND TECHNIQUES WITHIN THE ISSUE OF RELATIONSHIP BETWEEN TRANSPORTATION IMPROVEMENTS AND DEVELOPMENT

INFORMATION NEED	TECHNIQUE
Economic	
Better information on the goods movement demand for transportation services generated by industrial and other large economic development sites.	• Forecasting Product Flows (Table 4-1 [a]) • Freight Transportation Demand (Table 4-11) • Freight Network and Distribution Algorithm (Table 4-14) • Transportation Demand Model for Manufactured Goods (Table 4-15) • Transportation Demand for Agricultural Goods (Table 4-16) • Statewide Commodity Flow Matrix (Table 4-39)
Travel	
The potential to serve planned developments with transit, using transit as a control on nearby land use.	• Direct Demand Model (Table 4-26)
Development	
Impacts of transportation project alternatives on development patterns.	• Bay Area Simulation Study Model (BASS) (Table 5-5) • EMPIRIC (Table 5-6) • Urban Systems Model (USM) (Table 5-7) • Projective Land Use Model (PLUM) (Table 5-8)

[a] Second number refers to item in table specified (i.e., Table 4, item 1).

TABLE 15

LINKING OF INFORMATION NEEDS AND TECHNIQUES WITHIN THE ISSUE OF MAJOR CORRIDOR IMPROVEMENTS

INFORMATION NEED	TECHNIQUE
Environmental	
Better data sources and low-cost techniques with which to make preliminary environmental assessments.	• Environmental Sensitivity Computer Mapping (Table 1-e.4[a]) • Geo-coding (Table 1-e.5) • Composite Mapping System (Table 1-e.6)
Social	
Better information on the number of homes and jobs displaced by an improvement and an assessment of the degree of community disruption.	• Community Inventory (Table 2-2) • Neighborhood Social Interaction Index (Table 2-3) • Housing Displacement Model (Table 2-4) • Social Feasibility Model (Table 2-5) • Mobility Index (Table 2-6) • Social Capacity Indicators (Table 2-7) • Stability Index (Table 2-8) • Statewide Mobility Indicators (Table 2-9)
Travel	
Travel time and cost measures by corridor subarea, which are comparable across modes for multimodal corridor studies.	• Passenger Demand and Mode Split Models for Intercity Travel (Table 4-18) • Corridor Location Dynamics Model (Table 4-24) • Direct Demand Model (Table 4-26) • Passenger Demand and Modal Split Model—Intercity (Table 4-38)
Development	
Effects on industry, markets, and jobs in the corridor area due to a major improvement, and the role of transportation alone and in combination with other specific actions in developing these areas.	• Employment Shift-Share Analysis (Table 3-2) • Economic Base Analysis (Table 3-3) • Projective Land Use Model (Table 5-8)
Financial	
Capital and operating costs and deficits of alternative corridor improvements and availability of funding.	• Short-Range Capital Resource Availability Model (Table 6-4) • Service Costs and Revenue Sources (Table 3-1) • Revenue Cost Analysis of High Speed Rail Service (Table 6-2) • Technique for Projecting Transit Deficits (Table 6-5) • Passenger Demand and Mode Split Models for Intercity Travel (Table 4-8) • Direct Demand Model (Table 4-26) • Analysis of Transit System Productivity and Equity (Table 3-8)
Plan and Program Evaluation	
Determination of the most cost-effective standards for highways in order to guide programming.	• Intercity Route Cost Effectiveness Technique (Table 6-13)

[a] Second number refers to item in table specified (i.e., Table 1, item e.4).

TABLE 16

LINKING OF INFORMATION NEEDS AND TECHNIQUES WITHIN THE ISSUE OF COST EFFECTIVENESS IN HIGHWAY STANDARDS AND MAINTENANCE

INFORMATION NEED	TECHNIQUE
Travel	
Determination and use of more cost-effective standards in sufficiency ratings. Similarly, there is a need to be more cost effective through the use of a smaller range in design standards.	• Technique for Assessing Systemwide Tradeoffs Between Design Standards and Costs (Table 6-14[a])
Legal/Administrative/Institutional	
Management system to monitor the design process to assure adherence to a project's concept and general design guidelines as defined in the program.	• Project Management System (Table 6-12)

[a] Second number refers to item in table specified (i.e., Table 6, item 14).

TABLE 17

LINKING OF INFORMATION NEEDS AND TECHNIQUES WITHIN THE ISSUE OF IMPROVEMENT OR ABANDONMENT OF RAIL SERVICE

INFORMATION NEED	TECHNIQUE
Social	
Sound basis for determining the effects of abandonment on jobs and labor agreements.	• Rail Abandonment and Subsidy Requirements (Table 6-1 [a])
Economic	
Development of a benefit-cost ratio for branch line subsidies for use in state rail planning is needed.	• Rail Abandonment and Subsidy Requirements (Table 6-1) • Benefit-Cost Analysis (Table 6-11) • Railroad Financial Impact Analysis (Table 6-18)
Travel	
Development of comparable costs and travel times for freight and passengers by rail and highway, and an estimate of possible demand shift resulting from abandonment or improvement of a line is needed.	• Forecasting Product Flows (Table 4-1) • Forecasting Coal Transport Demand (Table 4-2) • Freight Transportation Demand (Table 4-11) • Transportation Demand Model for Manufactured Goods (Table 4-15) • Transportation Demand for Agricultural Goods (Table 4-16) • Revenue Cost Analysis of High-Speed Rail Service (Table 6-2)
Plan and Program Evaluation	
More accurate definition of the state's role versus industry's benefits/responsibilities in the provision of rail service.	• Priority Ranking of Branch Lines (Table 7-1) • Procedures for Rail Planning (Table 7-16)

[a] Second number refers to item in table specified (i.e., Table 6, item 1).

TABLE 18

LINKING OF INFORMATION NEEDS AND TECHNIQUES WITHIN THE ISSUE OF FUNDING OF TRANSIT SERVICES AND IMPROVEMENTS

INFORMATION NEED	TECHNIQUE
Social	
Establishment of service standards that reflect the mobility requirements of the transit-dependent.	• Planning for the Elderly and Handicapped (Table 4-19 [a]) • Dial-a-Ride City Selection (Table 7-19)
Economic	
Comparative productivity and operating cost data, especially on a line-by-line basis.	• Analysis of Transit System Productivity and Equity (Table 3-8)
Financial	
Method for forecasting transit deficits.	• Technique for Projecting Transit Deficits (Table 6-5)

[a] Second number refers to item in table specified (i.e., Table 4, item 19).

TABLE 19

LINKING OF INFORMATION NEEDS AND TECHNIQUES WITHIN THE ISSUE OF AIRPORT CAPITAL IMPROVEMENTS

INFORMATION NEED	TECHNIQUE
Environmental	
Methods to forecast air quality, noise, and land-use impacts around airports, as well as impact abatement measures.	• Air Transportation Impact Model (Table 1-a.11) • Airport Impact Methodology (Table 1-a.7) • Noise Impact of Airports (Table 1-c.6)
Travel	
Forecasts of traffic flows on airport access systems and of air traffic at airports.	• General Aviation Activity Forecast (Table 4-6) • Air Passenger Distribution Model (Table 4-7) • Forecasting Regional Air Passengers (Macro Approach) (Table 4-8) • Forecasting Regional Air Passengers (Micro Approach) (Table 4-9) • General Aviation Assignment Model (Table 4-13)
Plan and Program Evaluation	
Development of a cost-effectiveness index for setting priorities.	• Cost Effectiveness Ranking for Airports (Table 7-13)

[a] Second number refers to item in table specified (i.e., Table 1, item a.11).

CHAPTER THREE

APPLICATIONS OF RESEARCH FINDINGS

The Phase I findings have four general areas of application:

1. To help states describe emerging issues and the information needs associated with the issues.
2. To help field practitioners responsible for developing information on the impacts of specific state-level plan and program options.
3. To provide study designs for testing and refining high-priority methodologies to improve state planning and programming in Phase II of the study.
4. To provide for future research by describing methods that are potentially very useful in addressing important issues.

In addition, a brief statement of how these methods might be tested and refined is also provided.

The material presented in Chapter Two indicates major issues and the scope of information needed to address these issues. Some of these issues, such as revenue shortfall, have arisen in almost all states. Others, such as state-level planning for energy conservation and railroad reorganization, are emerging issues which are currently being addressed in only a limited number of states. States where these issues will arise in the future can profit by drawing upon past experience to anticipate needs for information and to start developing the capabilities required to satisfy these needs.

The Phase I findings can also be applied directly by states in analyzing their plans and programs. Figure 3 shows needs for information by field of impact in analyzing plan and program options in each of eleven issue areas. Field practitioners can use the summary information contained in the figure to identify important aspects of the consequences of plan and program options which otherwise might be overlooked. While the material in Figure 3 cannot be regarded as a comprehensive checklist of information needs, it does highlight those needs which have proved to be most critical in state-level transportation decision making.

Tables 9 through 19 list techniques that are applicable in satisfying the information needs identified in Figure 3. Thus, once field practitioners have specified the information they wish to develop or collect in analyzing plan and program options, the tables can be used to identify applicable techniques.

Tables 1 through 7 describe the output of each technique and an estimate of its time and cost of application. These estimated times and costs can be used to screen out techniques that cannot be implemented within the time and cost constraints faced by field practitioners.

The Phase I findings on information needs and available

TABLE 20

SUMMARY EVALUATION OF CANDIDATE PROJECTS FOR PHASE II OF NCHRP 8-18

	(N) NEED FOR RESEARCH				(U) UTILITY OF RESULTS				(P)	(E)	(C) COSTS			(E/C)
CANDIDATE PROJECTS	LIKELIHOOD OF DUPLICATION OF EFFORT (D)	AMOUNT OF GAP IN CURRENT STATE OF ART (G)	CONTRIBUTION TO IMPROVEMENT OF FIELD (S)	OVER-ALL NEED RATING: N = D · G · S (N)	USEFULNESS IN SKETCH PLANNING (SP)	LIKELIHOOD OF PROVIDING CRITICAL INFORMATION (CI)	QUCKNESS OF APPLICATION (Q)	OVER-ALL USEFULNESS RATING: U = SP · CI · Q (U)	PROBABILITY OF SUCCESS (P)	EFFECTIVENESS: E = N · U · P (E)	PERSON-YEARS FOR STATE (CS)	PERSON-YEARS FOR CONSULTANT (CC)	OVER-ALL COST: C = CS + CC (C)	COST-EFFECTIVENESS RATIO (E/C)
1. Simple Transit Ridership, Revenue and Cost Forecasting Techniques	0.8	0.8	0.8	0.51	0.8	0.9	0.9	0.65	0.8	0.27	0.5	0.5	1.0	0.27
2. Methodology to Link Highway System Planning and Project Planning	0.9	0.9	0.9	0.73	0.9	0.8	0.9	0.65	0.6	0.28	0.5	0.5	1.0	0.28
3. Priority Programming Methodology	0.9	1.0	1.0	0.9	0.7	0.9	1.0	0.63	0.9	0.51	1.0	0.5	1.5	0.34
4. Multimodal Program Evaluation Methodology	0.9	0.8	0.9	0.65	0.6	0.6	0.8	0.29	0.5	0.09	0.5	0.5	1.0	0.09
5. Technique for Assessing Systemwide Tradeoffs Between Design Standards and Costs	0.9	0.9	0.9	0.73	0.8	0.9	0.7	0.50	0.9	0.33	1.5	0.25	1.75	0.19
6. Composite Mapping System	0.7	0.6	0.6	0.25	0.9	0.9	0.9	0.73	0.9	0.16	1.0	0.5	1.5	0.11
7. Statewide Energy Conservation Forecasting Techniques	1.0	0.9	0.9	0.81	0.9	0.9	0.9	0.73	0.8	0.47	1.0	0.5	1.5	0.31
8. Highway User Revenue Forecasting and Analysis Techniques	0.9	0.9	0.9	0.73	0.9	0.9	0.8	0.65	0.9	0.43	0.5	0.5	1.0	0.43
9. Methodology for Predicting Statewide Economic Impacts of Varying Funding Levels	0.9	0.9	0.9	0.73	0.9	0.9	0.8	0.65	0.9	0.43	1.0	0.5	1.5	0.29
10. Rail System Planning Methods	0.4	0.4	0.5	0.08	0.6	0.5	0.7	0.21	0.7	0.01	0	0.5	0.5	0.02
11. Planning for Elderly and Handicapped	0.7	0.8	0.8	0.45	0.9	0.8	0.9	0.65	0.8	0.23	1.0	0.5	1.5	0.16
12. Statewide Activity Allocation Model	0.9	0.9	0.9	0.73	0.8	0.8	0.7	0.45	0.9	0.29	1.5	1.0	2.5	0.12
13. Emission and Air Quality Projection Methodologies	0.8	0.9	0.7	0.5	0.9	0.9	0.7	0.57	0.8	0.23	2.0	1.0	3.0	0.08
14. Air Carrier Demand Distribution	0.8	0.5	0.7	0.28	0.1	0.2	0.3	0.01	1.0	0	3.0	1.0	4.0	0
15. Aviation System Cost-Effectiveness Analysis	0.4	0.5	0.5	0.1	0.1	0.2	0.3	0.01	1.0	0	1.0	0.25	1.25	0
16. Evaluation Reporting Methods in the Plan Development Process	0.7	0.7	0.7	0.35	0.7	0.8	0.7	0.39	0.5	0.07	0.5	0.5	1.0	0.07
17. TSM—Packaging and Evaluating Alternatives	0.9	1.0	0.9	0.81	0.9	0.9	0.9	0.73	0.7	0.41	1.5	1.0	2.5	0.17
18. Freight Transportation Demand Analysis	0.9	0.8	0.9	0.65	0.7	0.9	0.7	0.44	0.7	0.2	2.0	1.5	3.5	0.06
19. Port Commodity Flow Analysis	0.7	0.5	0.6	0.21	0.1	0.3	0.3	0.01	1.0	0	3.0	1.0	4.0	0
20. Combine Performance Effectiveness Analysis with Proj. and Prog. Monitoring System	0.9	0.8	0.4	0.29	0.4	0.1	0.3	0.01	0.3	0	2.0	1.0	3.0	0
21. Project Management System	1.0	0.5	0.5	0.25	0.6	0.4	0.4	0.10	0.4	0.01	2.0	0.5	2.5	0.004

techniques were used by the research team in identifying projects for Phase II testing.

Particularly troublesome in the process of putting together potential Phase II projects was the lack of identified operational, inexpensive techniques with which to satisfy many of the states' most pressing information needs. Because of the lack of good techniques and the research team's concern with being responsive to the articulated needs of the states, several of the Phase II candidate projects were more process-oriented or involved more development of new methodology than was originally envisioned in the scope of the project. Several highly desirable research projects were given low scores in the research team's Phase II evaluation/selection process as a result of one or the other of these factors. The low-scoring projects are very promising for future development despite the fact that they were not recommended for Phase II testing.

There are three particular issue areas that inspired highly desirable but low-scoring Phase II candidates. Revenue shortfall, which has forced most states to cut back programs particularly with respect to highways, was the issue to which the research team was responding with the proposed project "Methodology for Predicting Statewide Economic Impacts of Varying Funding Levels." Revenue shortfall and the increasing responsibility of many states for development of financially attainable multimodal programs led to the project entitled "Multimodal Program Evaluation Methodology." The expanding role of state governments in the funding of transit services and improvements reinforced the project team's own perceptions of the need for the type of information provided through the "Simple Transit Ridership, Revenue and Cost Forecasting Techniques" project. The importance of each of these three projects is briefly discussed.

As more states seek to use general revenues or increase earmarked taxes, the need for information on economic benefits of transportation programs grows. To a large extent this need is based on experience in interacting with state budget offices, legislators, governor's offices, and the public in trying either to:

1. Demonstrate the need for additional funds to sustain the transportation improvement program in the face of a severe financial squeeze.
2. Demonstrate that cutbacks in funding will have serious consequences on the state's economic health.

Efforts to integrate the programming process for different modal programs also contribute to the need for economic impact information as a common evaluation yardstick. Recognizing that developing a comprehensive economic evaluation framework was beyond the scope of Phase II, the research team proposed the project "Methodology for Predicting Statewide Economic Impacts of Varying Funding Levels" as a modest first step to produce needed economic information.

The states badly need common evaluation measures that enable state transportation agencies to make comparisons across different modal programs and identify the tradeoffs between investing uncommitted funds in one mode rather than another. Such measures must be capable of communicating important information to all participants in key programming decisions including a state budget office, governor's office, and legislature in addition to the state's top-level transportation administrators. Development of a multimodal program evaluation methodology specifying methods for collecting and analyzing all needed data and providing evaluation measures for all candidate program elements was assessed to be too time-consuming and open-ended for Phase II selection.

More than half of the states visited identified issues related to the funding of transit services and improvements. For the most part, states are uncertain about what levels of service to provide in areas not previously served by transit (or in the case of new programs for those who are transit-dependent); trying to develop guidelines for providing operating subsidies; and trying to decide the appropriate state level of capital assistance for their major urban areas. A useful tool for answering questions related to the funding of transit services would be a set of simple analytic techniques that forecast ridership, revenues, and costs for local transit systems. Preliminary work in this area has been done by three of the states visited. Also, NCHRP Project 8-16 is developing guidelines for public transportation levels of service and evaluation. Hence, the research project "Simple Transit Ridership, Revenue and Cost Forecasting Techniques" was not rated as highly for Phase II application as other projects.

One final problem that should be mentioned is the difficulty states have had in putting evaluation information into a format that clearly communicates issues and choices. Formats and techniques for communicating information about policies, issues, and plan alternatives are severely lacking in many states. The research project developed to address this issue was deemed to be too process-oriented for Phase II testing.

CHAPTER FOUR

CONCLUSIONS AND SUGGESTED RESEARCH

CONCLUSIONS

The results of the Phase I effort have provided techniques for evaluating state-level transportation planning and programming options. The recommendations for further research, specifically in Phase II of this project, made in the following section are based upon the findings summarized.

Seventy-five major state-level issues were identified based on the literature review and the interviews with selected state and federal agency personnel. In most states, important information needs were found in each of the following issue areas:

1. Revenue shortfall.
2. Development of multimodal transportation policies, plans, and programs.
3. Organization and management.
4. Coordination with other state and regional programs.
5. Development of energy policy, plans, and programs.
6. Relationship between transportation improvements and development.
7. Major corridor improvements.
8. Cost effectiveness in highway standards and maintenance.
9. Improvement/abandonment of rail service.
10. Funding of transit services and improvements.
11. Airport capital improvements.

A large proportion of the information needs can be attributed to very few events or actions:

1. A financial squeeze which has resulted from the fact that costs have been increasing at a much higher rate than revenues.
2. New federal requirements for the development of metropolitan area transportation improvement programs.
3. Delays in expediting the individual projects due to environmental impact procedures.
4. Increased concern for needs of the transit-dependent.
5. Federal requirements for state aviation system planning as a precondition for airport improvement grants.
6. The Regional Rail Reorganization Act of 1973 which required state rail plans as a precondition for federal operating subsidies.
7. The Energy Policy and Conservation Act which requires state energy conservation plans as a precondition for FEA grants to aid in implementing energy conservation actions.

Techniques are needed to provide the information to assist in evaluation prior to resolution of the issues. The literature review and interviews led to the identification of 144 techniques. These techniques ranged from surveys or monitoring to computerized simulation models. These were categorized into seven groups by field of impact:

1. Environmental.
2. Social.
3. Economic.
4. Travel.
5. Development.
6. Legal/administrative/institutional/financial.
7. Plan and program evaluation.

Most of these techniques have been applied in many states. Some techniques were identified that are currently under development and have never been applied. Between these two extremes, there are many techniques which have been applied in a state and may represent a significant improvement over current practice in other states.

The information needs in the issue areas were linked to the techniques to provide this information. For many, there were no available techniques to satisfy the information needs. Also experienced was a lack of identified operational, inexpensive techniques with which to satisfy the states' most pressing information needs. In other cases, the information need identified for some issue areas was the same or similar so that the techniques to address the information need are the same.

After linking information needs to available techniques, potential projects that might be undertaken in Phase II were defined. These projects would involve the application of one or more techniques in a state. Twenty-one projects were selected, all of which have potential significance for demonstrating the use of techniques that will serve important information needs in the state transportation planning and programming process. The projects selected for further research in Phase II are presented.

FURTHER RESEARCH

The Request for Proposal and the research team's proposal had discussed, very broadly, the research to be conducted in Phase II. The broad discussion and the Phase I efforts have resulted in specific recommendations for research in Phase II of this study.

Because sufficient funds are available to conduct only a small proportion of twenty-one projects identified for Phase II consideration, criteria for evaluating these projects were developed, as described in Chapter Two. These projects were ranked, based on the evaluation. Given the budgetary limitations in Phase II, the research team selected the highest ranking projects that could be completed with a combination of state staff and research team staff effort. The resulting projects and demonstration states are:

1. Highway User Revenue Forecasting and Analysis Techniques—Kentucky.

2. Priority Programming Methodology—Maryland.
3. Statewide Energy Conservation Forecasting Techniques—Georgia.

Demonstration states for the three projects were identified, based on the following criteria:

1. Major transportation issues identified by the state during the interview process.
2. Methodology recommended for testing in Phase II.
3. Range of available data to test the recommended methodology.
4. Work program of the state.
5. The geographic location of the state.

The description of the three selected projects is presented in Appendix D.

The eighteen projects that were evaluated and rejected for testing in Phase II are good candidates for further research. These projects are also described in Appendix D. Some of these projects could be taken intact and applied by interested states. Others might serve as a preliminary description of future NCHRP projects, and some might be prototypes for development by Federal Highway Administration, Urban Mass Transportation Administration, or a university research center.

APPENDIX A

PROCESS FOR IDENTIFICATION OF ISSUES AND TECHNIQUES

A two-pronged approach was taken to identify major state-level transportation issues and the techniques (existing and under development) for resolving these issues. An extensive body of literature was reviewed. The knowledge gained from this static source was then supplemented by field interviews of those persons currently actively involved in statewide transportation planning. The process for carrying out the literature review and interviews is discussed below.

LITERATURE REVIEW

Prior to initiation of the literature review, standard forms were developed to document the sources and describe the methods/techniques. Figure A-1 shows the general survey form which was developed. The framework developed in Tables A-1 and A-2 was used when a general overview of the source revealed a specific issue area or technique, respectively. These outlines provided the framework in which the literature review was conducted.

The literature review took place in a two-phase process: (a) a preliminary survey followed by (b) an in-depth review of specific documents as illustrated in Figure A-2. To begin the literature review, the following sources of information were used:

1. Highway Research Information Service (HRIS)—summaries of projects in progress and abstracts of published works.
2. Literature obtained from state agencies.
3. U.S. Department of Transportation library.
4. Alan M. Voorhees & Associates, Inc., and System Design Concepts, Inc., libraries.
5. General references known to the team participants.

TABLE A-1

INFORMATION ON RESOLVING STATE-LEVEL TRANSPORTATION ISSUES

Decision Context	
Type of Action Considered	
Range of Alternatives Analyzed	
Time, Dollars and Manpower Available	
Major Participants	
Relationship to Ongoing Planning/Programming Process	
Information Developed/Collected to Guide Decision-Making	
Types of Impact Information	
Methods used to Develop Information	
Usefulness of Methods	
Desired Information Not Available	
Types of Impact Information	
Most Useful Format for Presenting Information	
Efforts Undertaken to Obtain Information	

FIGURE A-1

LITERATURE SURVEY FORM

Reviewer: _____

Date of Review: _____

Title: _____

_____

Author(s): _____

_____

Date of Publication: _____

Place: _____

Form: ☐ Final

☐ Draft

FOCUS AREAS

Study Type	Geographic	Field
_Research	_National	_Environmental
_Methodology	_State	_Social
_Technique	_Regional	_Economic
_Development	_Urban	_Travel
_Application	_Rural	_Development
_Issue Identification		_Legal
_Policy Evaluation	Mode	_Administrative, Institutional
_Program Evaluation	_Highway	_Finance
_(Other) _____	_Transit	
	_Rail	
	_Air	
	_Pipeline	
	_Goods Movement	

Summary/Abstract:

Does this report relate to objectives of NCHRP 8-18? _____
If yes, what parts (attach, if necessary, xerox of relevant sections) of report are relevant?

Provide additional comments on reverse side or attach sheets, as necessary.

The HRIS search provided abstracts of over 500 sources. A judgment was made on the basis of the abstract as to whether the source related to the needs and objectives of NCHRP Project 8-18. For the 150 sources that were relevant, the original articles, books, and reports were obtained and reviewed by members of the team using the framework described above. The review work was divided by subject area and assigned to personnel with backgrounds in those functional areas.

The U.S. Department of Transportation (U.S. DOT); Alan M. Voorhees & Associates, Inc. (AMV); and System Design Concepts, Inc. (SyDec) libraries were utilized and those relevant sources were reviewed by completion of the forms. The HRIS, U.S. DOT, and AMV/SyDec library sources were supplemented by personal references available to members of the study team. In addition, documents relevant to state transportation planning and programming, such as state transportation plans, state land-use plans, air quality implementation plans, and metropolitan area plans were obtained from the states and reviewed.

If, during the course of review of materials from the four major sources listed above, additional references appeared useful and relevant, they were also reviewed. The manner in which the literature review was carried out (preview of materials from many sources, in-depth review and evaluation, and review of materials noted in the original references) assures that it was covered in both breadth and depth.

FIELD INTERVIEWS

Key persons currently working in the field experienced with statewide transportation planning were personally interviewed by members of the study team. Over a period of three months, over 100 persons in several states and federal agencies were interviewed. These interviews were structured to obtain the following information:

1. Identification of major issues and of current problems being experienced in statewide transportation planning and programming.
2. Identification of techniques that are currently being used at the statewide level but have not yet received attention in the literature.
3. Identification of additional sources of information on techniques that may not yet be widely distributed.
4. Identification of types of needs which are perceived by those in the field.

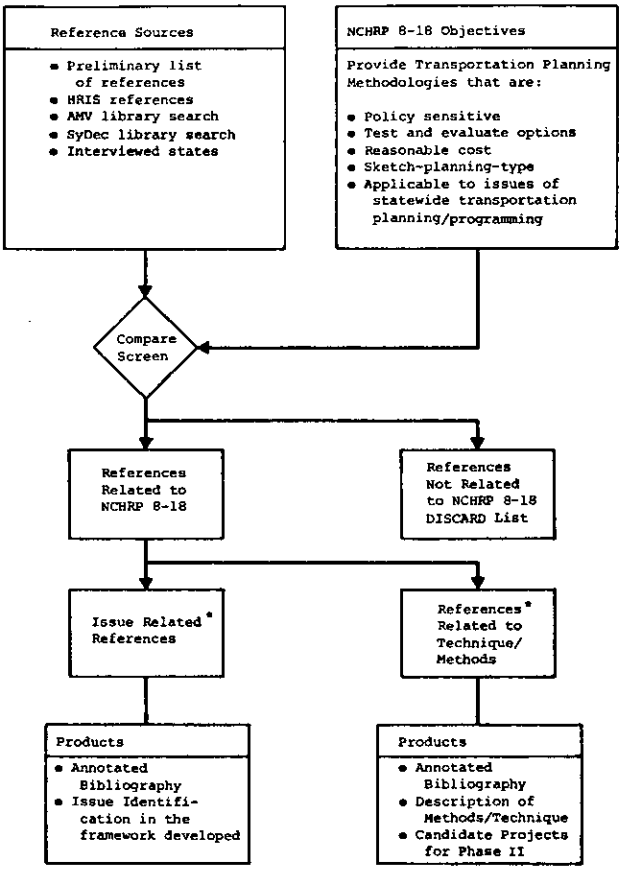
TABLE A-2

FRAMEWORK FOR DESCRIBING METHODS/TECHNIQUES FOR EVALUATING STATEWIDE PLANNING/PROGRAMMING OPTIONS

Method / Technique	Principal Components	Critical Concerns	Level of Analysis	Status	Unit of Measure	Input Data	Output Information	Resource Requirements				Special Expertise Requirements	Level of Uncertainty In Output Data	Limitations	Standards/ Criteria or Guidelines for Measuring Effectiveness
								Development		Application					
								Time	Cost	Time	Cost				

FIGURE A-2

GENERAL PROCESS FOR LITERATURE SURVEY



* Some references may fall in both groups.

5. Solicitation of possible solutions to problems and needs.

6. Solicitation of interest in participating in Phase II of the NCHRP Project 8-18.

Thirteen states visited for this purpose were: California, Connecticut, Georgia, Illinois, Kentucky, Maryland, Massachusetts, Michigan, New York, Oregon, Pennsylvania, Utah, and West Virginia.

By means of personal contact in each state, key actors in that state's transportation decision making process were identified. These included policy-makers and key technical people. Documents relevant to state transportation planning and programming, such as state transportation plans, state land-use plans, air quality implementation plans, and metropolitan area plans were obtained and reviewed prior to conducting interviews.

As a mechanism for structuring the interview so as to maximize its usefulness, preparation for the interview focused on identifying the transportation decisions the state agency makes and then identifying those decisions in which the person being interviewed participates. A careful distinction was made between those decisions made on a regular basis and those that are unique. An example of the former is the annual allocation of funds to each mode within the state transportation agency. An example of the latter is a decision to contribute to the capital costs of a fixed rail transit system in the state's largest city.

For each of the agencies visited: (a) detailed minutes of interviews were taken, (b) a description of the transportation decision making process was prepared, (c) key transportation issues were identified, and (d) prepared forms were filled out summarizing:

1. *Issue description*—(a) In the decision context, what were the types of actions considered; range of alternatives analyzed; time, dollars, and manpower available; major participants; and relationships to the ongoing planning/programming process? (b) What information was developed/collected to guide decision making—what types of impact information; what was the usefulness of methods? (c) What desired information was not available—what type of impact information; what was the most useful format for presenting information; and what efforts were undertaken to obtain information?

2. *Technique description*—What were the input and output data requirements, mode and scale of application, and time and cost of application?

APPENDIX B

ANNOTATED BIBLIOGRAPHY

The literature search performed during the study is the basis for this annotated bibliography. The initial collection of about 500 references was subject to a preliminary screening process, resulting in the selection of approximately 165 references for further screening and review. Annotations were prepared for those considered significant to the project, as previously shown in Figure A-2.

The bibliography is separated into two major categories—those references related to major issues facing decision-makers at the state level (Part I) and those related to techniques available to provide information to resolve these issues (Part II). The entries in the major categories are further classified according to field of impact.

PART I—ISSUE RELATED

TRAVEL

1. HAZEN, PHILIP. "A Comparative Analysis of Statewide Transportation Studies," *Hwy. Res. Record No. 401* (1972) pp. 39-54.

The article reviews in some detail five statewide transportation studies. These plans are important as they provide the means for coordinating capital improvements with the activities of other state agencies and provide a means for the balanced allocations of projects in the many regions and urban areas of a state. The author has selected studies in Iowa, Wisconsin, Rhode Island, Connecticut, and California in order to get a better understanding of what constitutes a good statewide transportation planning study. From the information gained about the different types of transportation studies, a classification system was developed which describes the study type in terms of the magnitude of required resources, the study objective, and the necessary procedures. It is hoped that this information will aid new studies in achieving a balance among data collection, modal development, and final plan development.

From this analysis of a wide range of transportation studies, the author drew a series of conclusions applicable to future studies. These include: the importance of the study design, the availability or establishment of goals for all state activities, and a subset of goals established for the transportation system. The goals and study objectives should be further developed into a set of evaluation criteria or performance standards for alternative testing and plan development. Further conclusions were: the importance of the data collection design; the alternatives should indicate the range of investment levels as well as different physical configurations; and the planning effort is wasted unless it leads to implemented improvements.

2. HOEL, LESTER A. "Workshop 3B: Systems Planning and Programming Methodology—Freight Movement," *TRB Spec. Rep. 146* (1974) pp. 149-151.

This is a brief summary of the workshop discussion of the state's role in freight transportation. The need for state involvement because of its broad powers, financial resources, multimodal viewpoint, and the need for land-use related planning is cited. The discussion of methodology suggests that specific analysis tools be developed for specific problems, yet be flexible enough to apply elsewhere. Models should be simple and quick to respond to critical problems. The major deficiency in this area is the dearth of available freight data. The first step is to determine exactly what the data needs are, to identify and classify existing data, to develop flow maps for freight, and to provide for exchange of data with private industry. High priority research problem areas are identified:

1. Freight data required for statewide system planning.
2. Carrier facility curtailments and abandonments.
3. Simple freight demand models.

3. HUMPHREY, THOMAS F. "Workshop 3A: Systems Planning and Programming Methodology—Passenger Travel," *TRB Spec. Rep. 146* (1974) pp. 91-101.
4. "Report of the Director of the Department of Transportation to the Transportation Commission." Oregon DOT, Office of the Director. (undated).

The report is a broad summary of transportation in Oregon, including transportation facilities; coordination between Oregon DOT and other agencies; transportation policy issues such as energy, mobility, land use, environment, public participation; transportation systems planning techniques and activities; and transportation financing and finance issues.

ENVIRONMENTAL

5. *Air Quality—Land Use Considerations in On-Going State Planning Process.* California Air Resources Board, Sacramento (1974).

This report is intended as a reconnaissance of the present state of air quality/land use planning at the state level in California. It attempts to identify and describe state programs with a direct or indirect relationship to air quality/land use planning and identify program areas with potential for coordination with air quality goals. It suggests the need to expand the ARB's liaison with these and other state agencies in order to fully integrate the state's goals for air quality into the state's ongoing planning and development programs.

6. CLM Systems, Inc. *Airports and Their Environment—A Guide to Environmental Planning.* Prepared for U.S. DOT. Cambridge, Mass. (1972).

The purpose of this report is to identify and describe the environmental factors which should be considered in airport planning. Six broad environmental impact areas are addressed—aircraft noise, land use impacts, air pollution, water pollution, hydrologic impacts, and ecological impacts. Suggestions are made for integrating these environmental factors into the regional comprehensive planning process as well as planning, design, and location of airports. The following information is given on each of the six environmental areas: the problem source or generation; the affected environment; measurement and standards; proposed solutions to the problem; and considerations at the system planning and master planning levels during construction and for the operational stage. Case studies of three airports and their current attempts in developing solutions to the range of environmental problems are also given.

7. Highway Users Federation for Safety and Mobility. "Land Use and Transportation." *Technical Study Memo No. 11* (1975).

This report examines the recent experience with techniques to coordinate development of transportation facilities with surrounding land use. It focuses on those planning and land reservation methods that will disrupt the surrounding community the least, while at the same time helping to provide other desirable community facilities. The techniques of planning for land use and transportation coordination; joint development; public service corridors; and preserving rights-of-way by advance acquisition, advance reservation, and excess condemnation are overviewed and evaluated toward this purpose.

8. Paul, Roy A. *Planning for Environmental Quality—Phase I Progress Report.* State of North Carolina Planning Division, Raleigh (1972).

This is a report on the initial efforts of the State of North Carolina to develop environmental indicators—indices of environmental quality. These statistics will then be used by state agencies in decision making. Four major applications of environmental indicators are envisioned: (1) provide a working definition of environmental quality; (2) chart trends or changes in environmental quality; (3) provide a simple format for communication; and (4) provide a format for operational goals and objectives. Plans are to compile data on the indicators (81 have been proposed) and place it at the disposal of all state agencies through the State Planning Data Bank and computer files. Indices of environmental quality will be promulgated after research and study. Operational goals and policies should be established by the state government.

9. Schechter, Bernard. "Implications for the States," *Land Use Management.* Proc. National Symposium on Resources and Land Information. Council of State Governments, Lexington, Ky. (1974).

Article presents suggestions on state institutional responsibilities for planning information. Also outlines concept and technical elements of a proposal for a state resource and land information system.

ADMINISTRATIVE

10. *Land-State Alternatives for Planning and Management.* Council of State Governments. Task Force on Natural Resources and Land Use Information and Technology. Lexington, Ky. (1975).

State planning and management programs for land use and natural resources have taken a variety of approaches. These can be grouped into four general methods:

1. Statewide, comprehensive land use management.
2. Management of selected activities according to functional criteria.
3. Management of specific geographic or critical environmental areas.
4. Management of uncontrolled areas.

The particular method or combination of methods which states utilize reflects specific needs and objectives. Regardless of the method used, major issues must be reconciled. The Task Force has identified the most important of these in six problem areas:

1. Intergovernmental relations.
2. Organizing, managing, and financing the program.
3. Involving the public in the planning process.
4. Conducting critical areas programs.
5. Identifying and meeting manpower needs.
6. Determining what data are needed and obtaining adequate information.

The difficult questions of allocating responsibilities and powers among levels of government, and of structuring the interaction between levels which must result, pervade any effort to improve management of land and natural resources. Once these issues have been addressed and resolved, states can begin to shape the mechanisms which they need to play their role in the intergovernmental process of land and resources management.

11. New York State DOT. "Capital Projects: An Information Manual for Applicants." Albany (1974).

12. Premo, J. C. "Evolving Federal Role in Transit Planning," *Hwy. Res. Record No. 475* (1973) pp. 1-4.

Federal support for transit has increased significantly in recent years. In 1972, UMTA issued guidelines intended to spell out the criteria by which grant requests are evaluated for three categories of urban areas: those with under 250,000 population; those with 250,000-1,000,000; and those with more than 1,000,000 population. Transit investments are directed to objectives which relate to mobility for nondrivers, congestion and land use patterns, and environmental conditions. Effort is being made to relate comprehensive regional planning, including transit planning, to those capital projects for which assistance is requested. Major policy and system recommendations, together with supporting technical documentation, are expected to emerge from the planning process. The observation is made that the planning process is not comprehensive and that it has been confined, for the most part, to highway planning. The meager influence wielded by elected officials and the lengthiness and costliness of the process is commented on. The

background to UMTA's evolving participation in the planning process is reviewed. The important factors in structuring UMTA's study program policies in a comprehensive framework are outlined. Transit planning must be integrated into a region's comprehensive and transportation planning and network and must be supported on a continuing basis. The importance of cooperative arrangements is emphasized, and FHWA and UMTA efforts which encourage cooperation in planning are reviewed.

13. SPROLES, MAX R. "Discussion of Resource Paper—Workshop 3A: Systems Planning and Programming Methodology—Passenger Travel," *TRB Spec. Rep. 146* (1974) pp. 147-148.

The article reviews the paper presented by Wayne Pecknold. It was felt that the questions of environmental quality and equity of investments in transportation should receive greater emphasis. A major consideration is the inclusion of citizen participation in the state planning development stage. It is important to develop a method for soliciting opinions of those who do not feel it is worthwhile to participate in the process, as well as to develop a procedure for integrating citizen-participation into the political decision making process.

The author feels that the statewide transportation planner needs a wide range of methodologies to deal with transportation planning issues. The main objective of developing methodologies should be to establish an overall framework with as much sophistication as can be justified but with specific emphasis on the ability to answer as quickly as possible the daily questions regarding policy. This will require, in his opinion, the development of a new set of methodologies other than those that have been adopted from the urban transportation planning process. An important aspect is to develop methodologies at the appropriate scale; that is, that the data collection requirements do not exceed the information needs of the procedure and that the modeling techniques are not more complex than the decisions they were designed to assist. In addition, the new methodologies should facilitate the integration of private transportation and land use planning into the public planning process.

14. THOMAS, NICHOLAS P., and JEFFREY J. ORCUM. "Workshop 4: State and Regional Development," *TRB Spec. Rep. 146* (1974) pp. 186-194.

This study of regionalism and transportation issues looks at both the state and multi-county levels. It is mostly a discussion of public policy at all levels of government concerning regionalism. There is a need to link transportation policies, plans, and programs with comprehensive planning. Under the discussion of regional transportation processes, they look at multimodal programs and linkages.

15. WATT, PAUL, and LAWRENCE D. DAHMS. "Relationships Between the Transit Operator and the Regional Planning Agency in a Large Metropolitan Area," *Hwy. Res. Record No. 475* (1973) pp. 14-17.

The respective activities of the Metropolitan Transportation Commission (MTC) and the regional transit agency, BART, are reviewed. The creation of the MTC with its powers to plan and allocate resources for both transit and highway modes may hold implications for other metropolitan areas as well. The enabling legislation of the MTC dictates that it cooperate for the time being with other regional agencies with related responsibilities for land use planning, air quality, and other specialized matters. It is empowered to plan and set priorities for transport investment, and these must be adhered to by the local and state government. Among the innovative powers of the MTC is the responsibility to plan for major highways according to regional priorities. The MTC interrupts established funding patterns by providing a new level of decision making between local transit operating agencies and their formerly direct dealings with Washington. The willingness of the well-established transit agencies and BART to financially support and plan with MTC has been invaluable. BART's role as a transit operation agency is reviewed, and the role that it will play in the growing presence of MTC is explored. BART is willing to recognize the prime responsibility of MTC to conduct system-level planning, presuming MTC will be able to demonstrate its abilities and powers to do such planning.

FINANCE

16. CALIFORNIA HIGHWAY COMMISSION. "Statement of the California Highway Commission on the Problem of Financing Transportation in California" (Nov./Dec. 1975).

The California Highway Commission presents evidence and arguments to the Senate and Assembly Transportation Committee supporting their views that:

1. Additional funding is needed for state highways in California.
2. Funding should be separate for highways and transit.
3. The public should be informed of the operating costs of transit before considering it a panacea.
4. Highways will continue to be the vastly predominant mode in California no matter what investments are made.
5. The legislature should declare its intent that matching funds for federal aid will be made available.

17. HARTEEN, D. T., and S. M. HOWE. "Transit Deficits: A Projection for New York State." New York DOT (July 1975).

This paper summarizes recent work at the New York State Department of Transportation on the future of transit operating deficits. Transit cost projections are made for three inflation levels for each of 13 transit properties in the state. Aggregate demand models relating ridership to fare and service levels are calibrated for each operation and are used to forecast ridership and revenues to 1980 under a series of fare and service assumptions. The results of the analysis prove to be useful in estimating the need for a public transportation assistance program in New York and in determining the structure of this program.

18. ILLINOIS TRANSPORTATION STUDY COMMISSION. "The Current Highway Situation in Illinois 1974/1992." (March 1975).

This document includes an analysis of the capability of the state to meet gross and priority highway construction

needs from 1975 to 1992 under alternative revenue-generating options. Needs are expressed in dollars and assumptions are made about:

1. The rate of inflation.
2. Motor fuel tax receipts.
3. Available federal aid.

19. NEW YORK STATE DOT. "Public Transportation Operating Assistance: Evaluation and Options." (Feb. 1975).

This report includes:

1. A summary of the benefits of public transportation and government's role in providing transit service.
2. Discussion of the results of a statewide opinion survey on public transportation.
3. Evaluation of the current programs.
4. Public transportation operating statistics and a technique for projecting future deficits.
5. Discussion of issues and options for executive and legislative consideration.

20. TRI-STATE REGIONAL PLANNING COMMISSION. "Maintaining Mobility." September 1975.
21. VOORHEES, ALAN M., & ASSOCIATES, INC. "Summary of State Legislation Providing Mass Transportation Funding Assistance." McLean, Va. (1973).

This report identifies possible sources and summarizes state legislation (enacted, pending, and proposed) to provide assistance to mass transportation.

PLAN AND PROGRAM EVALUATION

22. BREUER & SCHAD. "Resource Paper for Workshop #2 (Policy Planning)." *TRB Spec. Rep. 146* (1974) pp. 64-88.

This paper discusses the importance of policy planning and its role in the over-all state planning process. It indicates and discusses issues in a number of policy areas.

23. CAMPBELL, E. WILSON. "Workshop #2 Report," *TRB Spec. Rep. 146* (1974) pp. 39-64.

This paper defines policy planning and identifies four types of policy issues: (a) arrangement of institutions, (b) integration of privately-provided transportation into transportation system, (c) changes in transportation demand, and (d) funds and charges for transportation. For each type of issue, this paper discusses:

1. Technical capabilities useful for analysis and evaluation.
2. Who should do policy planning.
3. Skills and background needed.

Also, a set of recommendations applicable to policy planning in general is provided.

24. CREIGHTON, ROGER L., and JOHN R. HAMBURG. "Current State of the Art in Statewide Transportation Planning," *Hwy. Res. Record No. 401* (1972) pp. 21-27.

This article presents an overview of statewide transportation planning (STP) in the United States and offers:

1. A definition of statewide transportation plans in terms of the purposes of the activities included within the planning process.
2. A translation of the definition into product outputs of STP in the U.S.
3. Three major ways in which the need for the STP recommendations are demonstrated.
4. Very general discussion of the state of the art in STP formulation.
5. General recommendations for statewide transportation planning in terms of organization, the process, and modal priorities.

25. KENTUCKY, COMMONWEALTH OF. "Kentucky's Future Transportation Needs." Legislative Research Commission, Frankfort (Sept. 1975).
26. LOCKWOOD, STEPHEN C. "Transportation Planning in a Changing Environment," *Traffic Quarterly,* Vol. 28, No. 4 (Oct. 1974) pp. 521-536.

The article deals with the need for the transportation planning and design process to be flexible and broad enough to be integrated into the complex environment of which transportation is a part. The existing process is not able to deal with recurring major issues in the field of transportation, hence, a new process is suggested. This new process differs from the old in terms of several characteristics. Transportation planning must be participatory, thus incorporating a full range of values, priorities, and issues. However, decision making authority should be held by an identifiable individual who is responsive to the political process; i.e., an elected official. Transportation planning and plan evaluation should be closely integrated with other related planning activities. The process must also be concerned with the external effects of the transportation improvement. These unintended by-products may include disruption to community cohesion, environmental effects, and housing and job supply. Regional and subregional planning should be concurrent and iterative. The plans should also take into consideration the range of mode alternatives and technologies that are available, in order to develop a plan that can be most responsive to user needs and provide the greatest number of benefits. Finally, an effective planning process must be equally concerned with both short- and long-term effects. Short-term problems are generally of more concern to the users of a system than are the long-term effects which are the traditional focus of the planner. The new planning process will, however, require the development of new techniques and procedures which will facilitate broad evaluation and the inclusion of concern for benefits and impacts over time.

27. NEW YORK STATE DOT. "Statewide Master Plan for Transportation in New York." (July 1972).

This document provides balanced discussions of the issues; in most cases, the recommended policies and actions are the result of real choices rather than endorsement of "Motherhood" objectives. Techniques which serve the information needs for policies and actions are useful.

Uncertainties regarding the availability of resources in the future are handled by defining a "total" plan and a "minimal objective" plan requiring about half the resources of the total plan.

PART II—TECHNIQUE RELATED

TRAVEL

28. BAKER, ROBERT W., and JAMES D. GRUENDLER. "Case Study of the Milwaukee-Green Bay Interstate Corridor Location," *Hwy. Res. Spec. Rep. No. 138* (1973) pp. 51-54.

The paper describes a computer program developed for a corridor location study. It simultaneously weights social, economic, and environmental factors. A data bank capable of a quantitative and qualitative inventory of existing and future resources in the study area was included. The determinants and the data items were arranged in a matrix used to group the variables into broad influences commonly used in highway location studies.

29. BEVILACQUA, MICHAEL, and JOHN PEERS. "Structural Travel Demand Models: An Intercity Application," *AMV Tech Notes,* Vol. II, No. 5 (Oct. 1974) 9 pp.

Structural aggregate direct demand models were developed for the Sacramento-Stockton-San Francisco Corridor Study to assess the feasibility of alternate forms of transit systems and the evaluation of their impacts across a wide range of issues. Mixed form (linear and nonlinear functions) mode-specific models using nonlinear regression programs were developed. The generic form of all models was:

$$(a_1P_1 + a_2P_2)(b_1A_1 + b_2A_2)Z_1^{c_1}Z_2^{c_2}X_1^{d_1}X_2^{d_2}e^{f_1X_1}e^{f_2X_2}$$

where:

P_1, P_2, A_1, A_2 = extensive production and attraction variables describing zone size, e.g., zonal population, employment, etc.
Z_i = intensive production and attraction variables, e.g., cars/worker, retail jobs/area
X_i = interchange service variables by mode, e.g., in-vehicle time, out-of-vehicle time, out-of-pocket costs
i = 1, 2, etc.
a_i, b_i, c_i, d_i, f_i = model parameters

The coefficient of determination, R^2, values ranged from a low of 0.43 to a high of 0.72. Sensitivity analysis was conducted by applying the concept of elasticities. The elasticity to transit demand for income/household ranged from —.05 for "other" trips to 2.07 for work (park-ride) trips.

30. *California Statewide Transportation Study—1966 Base Year Calibration Report.* California Urban Planning Department, Division of Highways. (1972) 37 pp. + appendixes.

The State of California, Urban Planning Department, Division of Highways, is in the process of developing a statewide travel forecasting model. This report reviews the calibration of the 1966 base year model and the inputs thereto. The model is designed to predict average daily traffic (ADT) on a seven-day basis. A standard gravity model formulation was utilized to develop a statewide travel forecast. The primary input base was derived from the 11 regional transportation studies. Three home-based trip purposes—work, shopping, and other—as well as recreation and other trip purposes were utilized. Travel mode was limited to autos and pickup trucks; however, there is capability to expand to multimodal analysis.

A total of 1,488 analysis zones was developed for the statewide model. Of these, about 1,150 are aggregations of zones from urban areas which already had transportation study zones; about 280 zones were developed for areas outside urban study area boundaries using similar criteria. There were 18 zones designated "special recreation" zones.

31. CARTER, EVERETT. "Discussion of Resource Paper—Workshop 3B: Systems Planning and Programming Methodology—Freight Movement," *TRB Spec. Rep. 146* (1974) pp. 178-181.

The author diagrams a state goods movement system to:

1. Define goals and objectives.
2. Evaluate alternatives.
3. Select system.

Inputs and outputs, constraints, and impacts are included in the model. Subsystems are divided into human, activity, and concomitant (environmental, social, and economic impacts). He also warns that special attention must be paid to data requirements prior to data collection efforts.

32. DRAKE, JOSEPH S. "Resource Paper—Workshop 3B: Systems Planning and Programming Methodology —Freight Movements," *TRB Spec. Rep. 146* (1974) pp. 151-176.

The author discusses the state of the art in statewide freight transportation planning and programming. The level of sophistication varies from state to state but nowhere is it very comprehensive. States have four basic instruments for resource allocation: direct investment; subsidies and tax advantages; regulation of the private sector; and promotion. The largest problem is the lack of data. The discussion of analytical techniques for estimating system performance and related impacts is a review of the state-of-the-art in various states. It covers such aspects as user vs. operator behavior; aggregate vs. disaggregate behavior; sequential vs. direct demand analysis; statewide activity allocation models, and environmental impact analysis.

33. *Integrated Analysis of Small Cities Intercity Transportation to Facilitate the Achievement of Regional Urban Goals.* Prepared for the Iowa DOT by Engineering Research Institute, Iowa State University (June 1974) 625 pp.

This research focuses upon intercity transportation and its relationship to socioeconomic characteristics in essentially rural regions. The study area consists of the nine administrative planning regions in Iowa that do not include a community of 50,000 population or more. The research objective was to relate the intercity transportation system of small urban communities to their ability to attract and absorb growth. This relationship, as established, suggested a structured set of conditions regarding transportation planning, regulation, policies, and programs that would be supportive of growth in the study regions and in similar rural regions in other states. Using a form of rank-size analysis, regions were typed as semi-urban (centralized or localized) and rural-country (transitional or stranded). This typology utilized data for population, patterns of employment and

economic activity, and the supply of selected (health and education) social services. The bases for this typology of rural regions suggest that transportation policy strategies should differ significantly with the type of region. The transportation system in each study region was then typed by utilizing adjusted transportation indices and a rank-size analysis. A positive relationship was evident between the regional socioeconomic typology and that based on transportation variables.

34. ILLINOIS DOT. *Analysis of Data Alternatives and Management Procedures for Rail System.* (April 1975).

Volume I of the report evaluates a statewide freight survey of shippers conducted by Illinois DOT and identifies a number of ways in which the survey could be improved.

Volume II identifies needs for the following data and how the data may be obtained:

1. Freight movement data.
2. Inventory of rail services and facilities.
3. Carrier operating data.
4. Spatial activity data.
5. Service quality data.

Techniques presented include:

1. A procedure for obtaining data on freight movements from rail carriers.
2. Two models for predicting rail freight movements from projections of economic activity.
3. Development of a machine-readable system for coding a rail network.
4. Use of SYMAP, a computer program for producing maps and diagrams on line printers.

35. ILLINOIS DOT. "Illinois Rail System Plan—Phase II." (Sept. 1975).
36. KENTUCKY DOT. *Kentucky Statewide Traffic Model Study—Technical Report No. 4: Zone and Network Development.* (1976).

The report describes the development of the instate and outstate networks and zones. Included in the traffic zone development for both instate and outstate zones are: criteria, special analysis, zonal structure, centroids, zonal areas, and zonal equivalents.

The network development includes: objectives, definition, instate network, outstate network, network plotting, tuning, and statistics.

37. KOPPLEMAN, FRANK S. "A Model for Highway Needs Evaluation," *Hwy. Res. Record No. 314* (1970) pp. 123-134.

The highway needs evaluation model is designed to provide the policy determination of the suitable level of highway investment in a large, primarily urbanized region and the allocation of this investment to subareas based on a common set of social and economic values. The influence of variations in expressway supply on the volume and distribution of travel and certain measures of travel cost, specified through regression analyses, is used to evaluate the overall effect of increasing the level of expressway supply. It was found that increases in expressway supply lead to increases in total travel volume and reductions in average travel cost per mile. This benefit to the highway user is balanced against the costs of increased supply in order to select the level of capital investments that provides maximum satisfaction of the established regional objectives. Sensitivity analysis is used to consider the effect, in terms of the investment supply level, of changes in the values placed on specific objectives included in the model. Those values to which the results are most sensitive are the value of travel time and the opportunity cost of capital. A brief discussion of suitable directions for future research and development is included.

38. MCLYNN, J. M., and T. WORONKA. "Passenger Demand and Modal Split Models." Bethesda, Md. (1969).

This report represents the passenger demand and mode split models prepared for the Northwest Corridor Transportation Project. These models are to be used for estimating the patronage on intercity transportation systems in the time period up to 20 years in the future. The uniqueness of these models is that they can be used to estimate patronage on many existing new modes simultaneously and consistently, ensuring the compatibility of the several estimates.

39. MARTIN, B. V., F. W. MEMMOTT, and A. J. BONE. *Principles and Techniques for Predicting Future Demand for Urban Area Transportation.* The MIT Press, Cambridge (March 1970).
40. MARYLAND DOT. "Air Carrier Demand Distribution and Alternative Evaluation, Maryland Aviation System Plan Working Paper No. IV." (Oct. 1975).

This report describes and presents the results of the modeling procedures used to distribute passengers among airports in the Washington-Baltimore region for several airport development and accessibility alternatives. The procedure developed aircraft schedules based on preliminary demand forecasts at each airport and then redistributed passengers using an iterative process. The procedure takes into account airside capacity limitations but does not reduce access travel speeds in response to increased congestion. A logit model was used to combine travel times and costs into a single index of disutility (for a particular airport and trip) and split passengers among airports.

41. Maryland DOT. "General Aviation Demand Assignment and Alternatives Evaluation, Maryland Aviation System Plan Working Paper No. VI." (Nov. 1975).

This report describes and evaluates three alternative future aviation systems. A general aviation assignment model is used to forecast demand for each airport and identify unsatisfied demand. The model takes as input demand for each of four types of aircraft for each of 50 analysis zones and assigns this demand using a computer program which takes into account capacity limitations at each airport. The report contains estimates of capital improvement costs and operating and maintenance costs (by airport) for each alternative.

The environmental analysis technique used involved drawing 65 decibel noise contours around airports on land use maps. The noise analyses were accomplished using noise

contour sets developed for several typical system airports. Data on the number and types of aircraft operations and summary utilizations (assuming straight-in-straight-out flight paths) was used in preparing the contours for typical airports.

42. Michigan Statewide Interagency, Procedures and Development Section. *Statewide Transportation Analysis and Research,* 17 volumes. Lansing.

The statewide transportation analysis and research is documented in a 17-volume series of reports. Three basic files were prepared to provide the groundwork for the development of a statewide modeling system:

1. Statewide socioeconomic data file (contains over 700 items).
2. Statewide transportation network file.
3. Statewide public and private facility file.

The statewide modeling system contains four basic types of processes:

1. General utility.
2. Basic traffic forecasting and evaluation tools.
3. Specific-impact modeling process.
4. Continuing processes.

The statewide modeling processes can be used in the daily operations of many areas within the department with special emphasis on planning. The statewide modeling system is operational at the 547-zone level and is under development at the 2,300-zone level.

Particular volumes cited with reference to the following models mentioned throughout the text are:

a. Michigan Air Pollution Model, Vol. I-F.
b. Michigan Noise Model, Vol. I-F.
c. Gasoline Consumption Model, Vol. I-M.
d. Environmental Sensitivity Computer Mapping, Vol. VI-A.
e. Proximity Analysis, Vol. I-D.
f. Statewide Mobility Indicators, Vol. X-B.
g. Psychological Impact Model, Vol. I-G.
h. Railroad Community Impact Analysis, Vol. XV-B.
i. Corridor Location Dynamics Model, Vol. VI.
j. Michigan Statewide Model, Vol. V-A.
k. Effective Speed Model, Vol. I-K.
l. Level of Service Model, Vol. I-H.
m. Capacity Adequacy Forecasting Model, Vol. VII-A.
n. Passenger Demand and Modal Split Model—Intercity, Vol. XIII.
o. Statewide Commodity Flow Matrix, Vol. XIV-A.
p. State Trunkline Establishment, Vol. I-C.
q. Railroad Financial Impact Analysis, Vol. XV-A.
r. Cost Benefit Analysis, Vol. I-E.
s. Dial-A-Ride City Selection, Vol. XVI.

43. Mikolowsky, William T., et al. *The Effectiveness of Near-Term Tactics for Reducing Vehicle Miles Traveled: A Case Study of the Los Angeles Region.* The Rand Corporation, Santa Monica, Calif. (1974).

44. Mix, Charles S., and John W. Dickey. *Analysis of the Need for a Rural Transportation System.* U.S. DOT. (1974).

Travel in rural localities has received little attention to date. Recent legislation has pointed to the possibility of financial aid to public transit systems set up in such areas. It thus is the intent of this study to define more precisely and start to develop tools for analyzing the "need" for rural public transportation.

Using Madison County, Virginia, as an example case, this study first defines travel demand, latent demand, travel "wants," and diverted travel. Five techniques then are analyzed for making demand and need forecasts (accessibility, gap analysis, attitude surveying, committee estimates, demonstration projects). It is concluded that full-scale O-D surveys and analyses are too expensive and that a combination of committee estimates and demonstration projects may be the best forecasting method.

45. Moran, James. "Connecticut Recreational Model." Connecticut DOT. 29 pp. + appendixes (unpublished).

This study presents the methodology followed by Connecticut to calibrate and forecast Sunday statewide peak-hour travel patterns. Surveys were conducted to obtain information on Sunday travel. An activity model based on regression techniques and a travel model (gravity model) were developed. Nonrecreational travel was grouped into two purposes—home-based and nonhome-based. Trip production and attraction equations were developed for these two purposes. All recreational travel was grouped into one purpose. A trip production model was developed, but an adequate trip attraction model could not be developed. Actual trip attractions, as determined in the home interview, were used. Trip attractions for a proposed site could be obtained by comparison with an existing site.

A recreational activity model was developed for five activity groupings, i.e., boating, swimming (salt water), swimming (fresh water), picnicking, and exploring.

46. New York State DOT. "Concept Study: High-Speed Rail Service in New York State." (April 1970).

This study made order-of-magnitude estimates of the potential market and economic viability of high-speed rail service in three corridors. The analysis identified "completely divertible" trips as those for which high-speed rail would be both faster and cheaper and "possibly divertible" trips as those for which high-speed rail would be either faster or cheaper (but not both). In effect, this resulted in upper and lower bound ridership estimates.

47. Oregon DOT, Aeronautics Div., and Peat, Marwick & Mitchell & Co. "Oregon Aviation System Plan." (Nov. 1974).

Airports within the State of Oregon were evaluated for whether they should be in the state airport system and whether state or local ownership was appropriate. Ninety-nine out of the 200 airports in the state were recommended for inclusion in the Oregon Aviation System Plan. It was recommended that 22 of the 42 state-owned airports be transferred to local control. Eight new general aviation airports were recommended for 1990 (3 as replacements). A total of 421 airport improvement projects were recommended out of 466 requested. Cost-effectiveness models were used for evaluating airport inclusion in the plan and

airport improvement project inclusion. Federal funds are expected to provide 70 percent of the costs, local governments and private owners 21 percent, and the state 9 percent. To finance the state's share, it was recommended that the aviation gas tax be increased from 2¢ to 3¢ per gallon, and annual aircraft registration fees go from $20 to $40. No change was recommended in the ½ cent jet fuel tax, which provides 75 percent of current aviation system funds, or in the $2 pilot registration fee.

48. PEAT, MARWICK, LIVINGSTON AND CO. "Access and Demand Data Used in the Development and Calibration of the Northwest Corridor Transportation Models." Washington, D.C. (1970).

This report concerns the review and development of data that have served as inputs to the transportation modeling effects of the Northeast Corridor Transportation Project. The data items discussed include times and costs associated with the access, terminal and line haul segments of intercity travel as well as the frequency of scheduled trips. Estimates of the magnitude of travel by mode by area units have been made, including those for proposed modes. Data sets have been prepared for model calibration.

49. PENNSYLVANIA DOT. "Rural Public Transportation Guidelines." (1975).

The report presents guidelines for rural public transportation planning for the regional planning commissions in Pennsylvania. The guidelines include:

1. Study organization.
2. Inventory and evaluation of existing rural public transportation services.
3. Demand forecasting.
4. Service concept.
5. System operating requirements.
6. System financing.
7. Organization and management.
8. Implementation plan.
9. Plan maintenance.

50. STEIN, M. M., M. KOWAL, and R. R. SCHMITT. "Assessing Transportation Submarkets of the Elderly and Handicapped for Statewide Planning." Prepared for presentation at Transportation Research Board Annual Meeting, Washington, D.C., Jan. 1976.

This paper suggests a procedure for considering the elderly and handicapped, suitable for integration into the statewide transportation planning process. The process provides inputs relevant to the elderly and handicapped in the development of general transportation investment strategies, and develops special investment strategies with other agencies to provide specialized service for the transportation disadvantaged. The process consists of:

1. Performing comprehensive assessment of the needs and services of the transportation disadvantaged.
2. Identifying transportation submarkets.
3. Matching local submarket with the appropriate type of service.

This process does not define the magnitude of need for local innovations in transportation service. A four-stage process is recommended for the development of a statewide investment strategy, where service priorities among jurisdictions must be delineated.

1. Data collection and assessment of existing services.
2. Identification of areas with high demand for transportation service innovations using the Priority Transportation Submarket Index.
3. Identification of stable areas with the Neighborhood Social Interaction Index.
4. Evaluation of individual service programs with the Matrix of Service and Submarket Classification.

51. SWERDLOFF, CARL N. "Discussion of Resource Paper —Workshop 3A: Systems Planning and Programming Methodology—Passenger Travel," *TRB Spec. Rep. 146* (1974) pp. 145-147.

This article reviews the resource paper done by Wayne M. Pecknold; the subject of the paper was methodology for statewide planning of transportation systems. The reviewer notes three major themes that should be discussed: current evolving statewide methodology has and will continue to have a basis in the methods and techniques developed in urban transportation planning; evolving statewide methodology should be flexible, open, and responsive to a wide range of issues; and a primary target for improving methodology is better methods for predicting travel demand on a statewide basis. On the first point, the author's bias is toward a planning process that focuses on the evaluation of system investment alternatives. However, it is clear that competition for capital resources in the future will be more intense; hence, transportation will be forced to make more efficient use of its infrastructure. Pecknold's recommendations are also public-sector oriented. Consideration should be given to a structure which reflects the interactions with privately-supplied transportation service.

The reviewer accepts the suggestion that the planning process should develop a variety of tools for examining a wide variety of issues at different spatial and temporal scales. One such set of tools are the sketch-planning or macro-analytic models, which rely on aggregated relations between the transportation system supply and demand.

Finally, the reviewer identified three other research areas that were not addressed in the paper: methodologies that permit better estimates of the influence of transportation improvements on the nature and location of economic activity; investigation into normative planning and modeling; and better fiscal and financial planning methodologies.

52. VOORHEES, ALAN M., & ASSOCIATES, INC. "Kentucky Statewide Traffic Model Study." McLean, Va. (1971) 73 pp.

This study design is for the development of a statewide highway traffic model to produce traffic estimates for rural segments of alternative highway plans. The modeling approach includes the development of zone-to-zone trip tables for four trip purposes and computer assignment of these trip tables to alternative highway networks. Interesting features of the approach include (a) a land activity allocation model which will be responsive to highway service availability and (b) the capability of defining fine-grained networks and zones for conducting subarea studies.

53. VOORHEES, ALAN M., & ASSOCIATES, INC. "Simplified Statewide Travel Forecasting Procedures Including Supply-Demand Relationship." Prepared for U.S. DOT. McLean, Va. (1973).

The report describes a relatively efficient and inexpensive statewide travel forecasting model. The model is sensitive to the quality and quantity of the highway system and provides estimates of travel demand by highway link and trip purpose. There are two component submodels. The first is a system sensitive total trip generation model which is developed using linear regression analysis. The second submodel estimates network trip productions and is based on linear regression techniques and probability concepts. Total trips are split into those on and off the statewide network; network trips are then assigned using standard procedures.

54. VOORHEES, ALAN M., & ASSOCIATES, INC. "Statewide Travel Forecasting Procedures Including Activity Allocation of Weekend Travel: Weekend Travel Model." Prepared for the U.S. DOT. McLean, Va. (1974).

This report presents findings of analysis of weekend vehicular travel characteristics. In addition, interrelationships between weekend vehicular travel and influencing factors are analyzed through the development of a sequential weekend travel demand model (consisting of trip generation, trip distribution, and trip assignment) for peak period and average daily traffic. Peak-period trip generation rates were obtained using cross-classification techniques. An innovative stochastic simulation model (a technique to simulate travel characteristics based on probabilities of trip generation by land use type and trip length frequency distributions) is used to distribute weekend vehicular trips by different time periods. The model was applied to the State of Connecticut weekend travel as a test case.

DEVELOPMENT

55. ARGONNE NATIONAL LABORATORY. "Illinois River Basin Pilot Project (Appendix C)." Illinois (1973).

Argonne National Laboratory has developed a package of programs in conjunction with the Illinois River Basin Pilot Project to forecast and allocate activities to counties and municipalities in Illinois. The program package description suggests that the state should be divided into subregions consistent with past growth trends, i.e., fast, stagnant, or independent. Projections based on historical data for each activity (stratified to the extent data are available) are then made for each municipality, county, and subregion. The procedure assumes that subregion projections are more accurate than county projections, and county projections are more accurate than municipality projections. Therefore, normalization of county to subregion totals and municipality to county totals is performed in pyramid fashion.

56. GOLDNER, WILLIAM, ET AL. "PLUM/SD—Volume II, The Urban Development Model." San Diego, Calif. (1972).

PLUM or the Projective Land Use Model is a static equilibrium Lowry-type model with a deductive theoretical base. PLUM provides an option for highly disaggregate output (if stratified input data are available) and a land use accounting system is integrated into the structure of the main model. Submodels are also available in the PLUM package for the projection of socioeconomic data. PLUM suffers from the same disadvantages as other Lowry models in that the basic-service employment split is difficult to determine and the model requires exogenous allocation of forecast year basic employment by small areas.

The travel time probabilities are obtained by integrating a probability density function over small-time intervals. The PLUM calibration process involves the selection of travel parameters for the probability density function on the basis of base year data.

57. KOCHANOWSKI, ROBERT, and GEORGE WICKSTROM. "On Improving the Transportation Planning Process," *Hwy. Res. Record No. 309* (1970) pp. 8-12.

This paper maintains that transportation forecasts are too dependent upon the assumptions involved and thus usually reflect the assumptions rather than the impact of alternatives. The existing models do not adequately incorporate nontransportation factors and are not well-coordinated with good comprehensive regional planning.

Suggestions:

1. Start with Regional Transportation Planning, which only deals with the proper spacing of major transportation facilities.
2. Next, do corridor planning within the context of the regional transportation system using existing models and manageable land use, objectives, etc. Use existing models.
3. Project planning can then be undertaken in more detail for a manageable size area.

58. MISSOURI STATE HIGHWAY DEPARTMENT. "Projections of Socioeconomic Data to 1967, 1975, and 1990." (1968).

This manual describes the methodology used in developing socioeconomic data at the 536 traffic zone level of analysis in Missouri. Population projections for counties and urban places with more than 10,000 population are obtained via a component method. That is, birth, death, and migration rates are applied to the base county of urban place population to obtain the forecast population. The population of smaller urban places is projected on the basis of a 1950-1960 trend analysis. Counties are then divided into four groups: metropolitan, urban-rural, rural, and mining. The allocation process to zones within each county differs according to the type group of the county. In general, however, county control totals are allocated to zones (after subtracting out urban place totals) on the basis of the 1960 levels of zonal population. Employment by type is projected by state, county, and urban places on a trend line basis and is then allocated to nonurban places based on the future population level of the zone. Both school enrollment data and auto ownership data are projected at the zonal level on the basis of the future populations.

59. PEAT, MARWICK, MITCHELL and COMPANY. "Empiric Activity Allocation Model Summary." (May 1972).

The basic structure of the EMPIRIC model is a set of 3-15 simultaneous equations, depending on data availability

and desired disaggregation of the output. The dependent variables in these equations represent changes in shares of activities over the forecast interval. The estimation of coefficients for the model variables is a complex procedure which requires a highly trained analyst. However, the package of data manipulation programs which accompanies the basic model facilitates the calibration process. EMPIRIC activity output is generally disaggregated, i.e., population by income group and employment by SIC group, and subordinate models are available for projecting land consumption and socioeconomic variables.

60. STANFORD RESEARCH INSTITUTE. "Methods of Evaluation of the Effects of Transportation Systems on Community Values." Prepared for HUD, Washington, D.C. (April 1971).
61. NEW YORK STATE DOT. "Highway Standards Project." Unpublished memorandum (Dec. 1973).
62. SWEENEY, J. L. *A Vintage Capital Stock Approach: The Demand for Gasoline.* Unpublished draft report from FEA, Office of Systems Modeling and Forecasting.
63. VOORHEES, ALAN M., & ASSOCIATES, INC. "Application of the Urban Systems Model to a Region—North Central Texas, Vol. I and Vol. II." Prepared for North Central Texas Council of Governments. McLean, Va. (1972).

The USM or Urban Systems Model is a Lowry-type static equilibrium model which produces the most probable distribution of population and service employment under given travel and activity system constraints. A holding capacity constraints procedure is an integral part of the model formulation.

The USM program package presently includes activity evaluation measures such as market potential, accessibility, and density indices. It also provides activity measures such as air pollution exposure indices and airport noise intensity levels, given the environmental characteristics of the urban area.

The USM calibration process is a well-defined and relatively simple procedure compared with those of other Lowry-type models. It involves the comparison of the trip length distribution curves produced by the model with real world trip length distributions. The calibration parameters of the functions are modified until the shape and mean value of the distribution approximate the real world curves.

64. VOORHEES, ALAN M., & ASSOCIATES, INC. "Statewide Travel Forecasting Procedures Including Activity Allocation and Travel." Prepared for FHWA. McLean, Va. (Aug. 1974), 86 pp. + appendixes.

A policy-sensitive economic activity allocation model was developed which provides information to assist state decision-makers in evaluating the impacts of alternative transportation and land use policies. The Statewide Activity Allocation Model (SAAM) is a Lowry Model descendent and incorporates the mover/nonmover stratification scheme and the Central Place factors. The model provides information on population and employment activities by analysis area for a particular forecast year. The model was calibrated for the State of Connecticut and the statistical and logic checks showed that the model adequately represented the spatial distribution of population and employment activities.

65. WENDT, PAUL F., and MICHAEL A. GOLDBERG. "The Use of Land Development Simulation Models in Transportation Planning," *Hwy. Res. Record No. 285.* (1969) pp. 82-91.

The Bay Area Simulation Study or BASS Model is a large complex of computer models that has as its goal forecasting future growth within the San Francisco Bay Area. The BASS model is composed of three distinct submodels. The first of these is the employment and population projection submodel that forecasts employment by 21 categories and population totals for the Bay Area over the period from 1970 to the year 2020. The results or the output of this submodel are fed into the two other submodels that allocate projected employment, population, housing, and land development in 777 subareas of the region.

The time required to travel from one place of employment to alternate places of residence is a key determinant of estimated future land use and development in the BASS model. These estimates are made through the use of a time-distance matrix assumedly portraying the time required to travel from the center of any one of the 777 tracts to each of the other tracts in the 13-county Bay Area.

The influence of public policy variables is reflected primarily in the assumptions concerning the usable supply of land and the transportation facilities that will be made available.

66. WISCONSIN DOT, Div. of Planning. "Wisconsin Place Classification for Transportation Planning." (1973).

Wisconsin has developed a framework for ranking activity centers via a composite index of economic importance. Activity centers are classified by the following six identifiers:

1. Urbanized area.
2. Metropolitan center.
3. Regional center.
4. District center.
5. Area center.
6. Special center.

The classification procedure is based on the activity center ranking as determined by the following variables: full valuation, sales tax, population, employment, selected services, retail sales, and wholesale trade. The place classification methodology has been applied in ranking Wisconsin activity centers in 1966 and has been updated for 1970. These rankings have been used in determining the level, location, and type of airports and highways needed in the prime market centers of the state. It is anticipated that the place classification will also be useful in the development of a statewide development and/or land use plan.

67. U.S. DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT, Office of International Affairs. *Major Airports and Their Effect on Regional Planning.* U.S. GPO (1974).

SOCIAL

68. PLANNING ENVIRONMENT INTERNATIONAL (ALAN M. VOORHEES & ASSOCIATES, INC.) and HAMMER, SILER, GEORGE ASSOCIATES. "Workbook and Resource Guide. Social and Economic Considerations in Highway Planning and Design." Prepared for U.S. DOT. McLean, Va. (1976) (Draft).

This workbook was prepared for a practical training course designed to supplement the professional skills of highway personnel who gather, prepare, analyze, and/or evaluate social and economic data. The workbook presents an understanding of what social and economic impacts of highways are, how impact occurs, the state-of-the-art in analysis, and the mitigating measures which may be applied.

The available tools for social impact identification/evaluation are described including the input data requirements, the output information, and the limitation on use of tools.

69. U.S. DOT, FHWA. "Social and Economic Effects of Highways." Washington, D.C. (1974). Supplement (1975).

This report of the effects that modern highways have on individuals, communities, and regions shows some of the problems as well as the progress of social and economic studies. The report includes a narrative portion summarizing papers by five consultants and several Federal Highway Administration participants at a 3-day pilot course in December 1973, on social and economic effects. This portion also draws on other experience and research, primarily 200 or more highway impact studies. The report also includes abstracts of 76 of these studies completed from 1969 to 1974. An index by subject matter and by author and research agency is included.

The report offers tentative conclusions on several aspects of highway experience. For example, residents displaced by highway right-of-way are being relocated satisfactorily. However, residents in close proximity to highways may have noise, air pollution, or safety problems, and these disadvantages may be reflected in lower property values.

Accessibility effects of highways, unlike proximity effects, are ordinarily positive. The benefits of highway accessibility often outweigh the disadvantages of highway proximity, even for residential property.

ECONOMIC

70. CALIFORNIA AIR RESOURCES BOARD. *Economic Analysis for the Land Use Planning Program.* Sacramento (1974).

71. CHAPIN, F. STUART. *Urban Land Use Planning.* (1965).

72. HARRIS, CURTIS C., JR., STANLEY J. HILLE, CHARLES E. OLSON, and MARTIN M. STEIN. "Long-Range Transportation Investment Planning: A Forecasting Approach for Assessing the Impact of Alternative Highway Systems of Regional Development." *Hwy. Res. Record No. 458.* (1973) pp. 13-20.

This article introduces a model which is aimed towards measurement of the effects of highway improvements on the distribution of industrial output, employment, payrolls, population, labor force, unemployment, and personal income within the nation, divided into 173 regional sectors.

The model is composed of a multiregional and industrial forecasting model, a linear programming transportation model, and the TRANS network planning model. A recursive method is used which forecasts regional industrial supply and demand, employment, population, income, etc., in the year T + 1 as a function of (1) those same factors with the year T, (2) long-term growth rates, and (3) transportation variables, over a period of 20 years.

The two types of transportation variables used are: (1) shadow prices which reflect the minimum inter-regional cost of goods movement, by weight class and (2) a congestion index which reflects the quality of the highway system within each region. Highway improvements affect regional competitiveness in attracting industry by resulting in cost savings in inter-regional freight rates and reduction in congestion. These are reflected in the model by adjustment to the transportation variables and result in a redistribution of industrial output, employment, etc. A side effect of highway improvements is a temporary increase in demand for industrial output of highway construction materials, industries and consumer goods industries (due to purchasing power of construction workers).

73. HILLE, STAN, CHARLES TAFF, ET AL. *The Economic Impact of the Baltimore-Washington International Airport on Maryland.* University of Maryland, College Park (Oct. 1974).

This study develops the economic and employment impacts of Baltimore-Washington International Airport and then calculates future impacts. Impacts include economic impacts, employment, and taxes which were distributed to the state and local jurisdictions. The forecasts of air cargo and passengers were used to estimate future impacts based upon the current relationships.

74. HILLE, STAN, CHARLES TAFF, ET AL. *The Economic Impact of the Port of Baltimore on Baltimore and Maryland.* University of Maryland, College Park (April 1975).

This report identifies the direct and indirect economic impacts of the Port of Baltimore by cargo type and also apportions the impacts to local government units. Direct impacts quantified (in dollars and jobs) are: (1) vessel disbursement, (2) crew expenditures, (3) surface transportation, (4) insurance and international bank, and (5) port services. Indirect impacts included: (1) primary metals processing, (2) other port-dependent processing, (3) shipbuilding, repairs, and dismantling, and (4) government expenditures. Monetary and employment multipliers were also estimated.

75. INSTITUTE FOR DEFENSE ANALYSES. "Economic Characteristics of the Urban Public Transportation Industry." Washington, D.C. (1972) 442 pp.

The main contribution of this report is that for the first time economic statistics for the entire transportation industry were collected, computerized, and compiled to reveal the economic intricacies of the industry. Statistics are examined to uncover relationships among similar firms as to size, public or private ownership, geographic location, cost structure, etc.

76. NEUMANN, LANCE A., and WAYNE M. PECKNOLD. "Application of Time-Staged Strategic Approach to System Planning," *Hwy. Res. Record No. 435* (1973) pp. 20-31.

This article discusses the use of time staging analysis in making near-term decisions on long-term projects. An application to a highway location and design study in Santa Barbara, California, is presented where probabilities assigned to uncertainties in later stages of the project are used to calculate the present net value of each near-term decision, so that they may be compared.

This technique can be applied to any resource allocation problem of a statewide or regional nature, where the allocations are to be made in separate stages and reevaluated each time.

77. O'FLYNN, J. A. "An Economic Evaluation Framework for Regional Highway Planning Studies." University of Waterloo, Ontario, Canada (1968).

This report discusses some aspects of pre-1968 economic analysis of alternative highway investments in Ontario, Canada. It suggests an improved methodology composed of the following stages: (1) problem statement; (2) solution generation; (3) solution analysis; (4) solution evaluation; (5) optimization; and (6) implementation. The problem statement is of particular importance and is to have explicitly spelled out: (1) objectives; (2) constraints; (3) inputs; (4) outputs; (5) decision criteria; (6) value functions. The objectives should be broad enough to encompass socioeconomic and environmental concerns, as well as transportation benefits. The report recognizes that many of the outputs are nonquantifiable and that typical methods of economic evaluation (e.g., cost/benefit ratio, rate of return, net present worth) will have to be supplemented by subjective value judgments. However, the author makes the point that explicit criteria for making these subjective judgments should be spelled out in advance. The methodology was illustrated briefly as applied to a specific proposed highway center-city bypass.

78. U.S. DOT, Office of Technical Assistance. *Preparation and Appraisal of Transport Projects.* Washington, D.C. (June 1968).

79. PERLOFF, HARVEY S. "Regional Research and Highway Planning," *Hwy. Res. Bulletin 190.* (1958) pp. 14-19.

ENVIRONMENTAL

80. BATTELLE COLUMBUS LABORATORIES. "Environmental Assessment of the System Plan for the U.S. Railway Association." Columbus, Ohio (1975) 69 pp. + appendixes.

The broad objective of this study was to provide USRA with information and analysis relevant to environmental impacts which may arise from implementation of The System Plan for planning, financing, and restructuring the railway system in the Northeastern U.S. The study was to consider matters usually evaluated by environmental impact statements under the National Environmental Policy Act of 1969. Specific objectives of the study were to:

1. Prepare an overview of the environmental problems in the Northeast Region with respect to the development of a railroad system plan.
2. Prepare an environmental assessment using existing information for use in the Preliminary System Plan and in the Final System Plan.
3. Recommend directions for continuous assessments after the Final System Plan has been formulated.

Specific procedures for estimating the environmental impacts are given in an extensive set of appendixes.

81. BIGELOW-CRAIN ASSOCIATES. "State and Regional Transportation Impact Identification and Measurement." Menlo Park, Calif. (1975).

This report focuses on the identification and evaluation of techniques that can be used to identify and measure the impacts of alternative transportation systems at the state and regional levels. The review covered all transportation modes in terms of the following areas of impact: social, economic, environmental, and energy. The scope of the report is very broad and it consequently suffers from generality in the discussion of the relevant techniques. While the section on social impact does not reflect the current state-of-the-art, it does pick out a series of issues that should be addressed in the area of social impacts.

82. ENVIRONMENTAL IMPACT CENTER, INC. *Review and Bibliography of Secondary Impacts of Major Investments: Highways, Mass Transit, Interceptor Sewers.* Report for Council on Environmental Quality, Newton, Mass. (1974).

83. U.S. DOT. "Special Area Analysis." Washington, D.C. (1973) 167 pp.

This manual deals with four evaluation criteria which can be used at the systems level of planning to assess some of the social and environmental impacts associated with proposed transportation systems. The four criteria selected for Special Area Analysis (SAA) are accessibility, air pollution, noise pollution, and dislocations. For each of the criteria, the manual will present: (1) an introduction in using the criteria; (2) the methodology developed for SAA; and (3) reporting guidelines for SAA participation.

84. VOORHEES, ALAN M. & ASSOCIATES, INC. *Baltimore Regional Environmental Impact Study—Eight Technical Memoranda.* Prepared for Interstate Division of Baltimore City. McLean, Va. (1974).

ENVIRONMENTAL—AIR QUALITY

85. ARGONNE NATIONAL LABORATORY. "An Air Pollution Impact Methodology for Airports—Phase I." Prepared for U.S. Environmental Protection Agency. Argonne, Ill. (1973).

This report provides a methodology to estimate airport and related land use air pollutant emissions. The emissions can be transformed into air quality estimates through the use of "rollback" analysis or atmospheric dispersion models. The methodology uses readily available information and is applicable to proposed or existing airports.

The impact assessment methodology is based on an approach which can be adapted readily to other media and to various categorical pollutants. This flexibility is achieved through a general protocol for identifying, isolating, and

quantifying an array of airport-related and urban activities which provide environmental insults. The impact assessment methodology is intended to be general and is applicable to either existing or proposed airport facilities. It was developed and field tested using data from the proposed St. Louis airport at Waterloo-Columbia, Illinois, from Chicago O'Hare International Airport, and from several other existing facilities.

86. BUSSE, A. D., and J. R. ZIMMERMAN. *User's Guide for the Climatological Dispersion Model.* Research Triangle Park, N.C. (1973).

87. California Air Resources Board. *Air Quality Land Use and Transportation Models—Evaluation and Utilization in the Planning Process.* Sacramento, Calif. (1974).

88. California Air Resources Board. *Assessment of Air Quality Impact of Two Scenarios for the Development of the State of California.* Sacramento, Calif. (1974).

89. CALIFORNIA AIR RESOURCES BOARD. *Emissions Forecasting Methodologies.* Sacramento, Calif. (1974) 79 pp.

A methodology for forecasting emissions for any future year is described. Techniques and specific emission factors for 1975, 1985, and 1995 are given for both mobile and stationary sources. Motor vehicle emissions are based on the CVS-2 test cycle and on a data base specific for California. A discussion of current and developing approaches and driving cycles used to quantify motor vehicle emissions is presented including a discussion of speed adjustment factors. Stationary sources are divided into power plants and other stationary sources; power plant emissions are based on projections of electrical energy generation and other stationary source emissions are based on normalized projection of total earnings by source category (e.g., petroleum refining, mineral extraction). The base year for stationary source emissions is 1972.

90. CALIFORNIA AIR RESOURCES BOARD. *Introduction to Manual Methods for Estimating Air Quality.* Sacramento, Calif. (1974).

The need for future year air quality estimates has been recognized in air quality/land use planning activities. The total process for air quality estimates includes estimating future year air polluting emissions and relating the emissions to air quality. This document concentrates on describing currently available manual methods for relating emissions to air quality.

The pollutant species of interest and approaches to quantifying ambient concentrations are described in light of the ambient air quality standards. The important factors in estimating air quality are identified and described. Two statistical models, the Proportional model and Larsen's model, are described and the underlying assumptions are discussed. Examples of the Proportional model from the California State Implementation Plan are presented. Diffusion models based on the Gaussian plume assumptions are discussed.

This paper is intended to serve as a general introduction to manual methodologies for land use planners for estimating air quality and to indicate the levels of complexity of these methodologies.

91. CALIFORNIA AIR RESOURCES BOARD. *Recommended Responses of Air Resources Board to Local Planning Agencies.* Sacramento, Calif. (1974).

92. CALIFORNIA AIR RESOURCES BOARD. *Summary Report on Current Methodologies for Determining the Spatial Distribution of Air Polluting Emissions.* Sacramento, Calif. (1974).

93. DABBERDT, W. F., W. B. JOHNSON, and F. L. LUDWIG. *Validation and Applications of an Urban Diffusion Model for Vehicular Pollutants.* Stanford Research Institute, Menlo Park, Calif. (1972).

A practical, multipurpose urban diffusion model (APRAC-1A) has been developed and evaluated for predicting concentrations of inert, vehicle-generated pollutants. The model requires only routinely available meteorological and traffic data to give the following outputs: (1) areal concentration isopleths, (2) sequential hourly point values, and (3) frequency distributions. An extensive field experiment was conducted in San Jose to evaluate and refine all components of the model. A street effects submodel was developed to account for the high concentrations and large gradients observed in urban street canyons. Results are presented from a second experimental program conducted in St. Louis to further evaluate the performance of the model. Predicted and observed concentrations of carbon monoxide (CO) in St. Louis differ by root-mean-square values of the order of 3 ppm (parts per million), while frequency distributions of hourly concentrations are given within 2 to 3 ppm. Along-street observations of CO concentrations show variations generally less than 1 ppm.

94. DARLING, EUGENE M., JR. "Computer Modeling of Transportation-Generated Air Pollution: State of the Art." U.S. DOT, Transportation Systems Center, Cambridge, Mass. (1972).

This report surveys the state-of-the-art in air pollution modeling with particular emphasis on the modeling of dispersion from transportation sources. Models which have actually been implemented are stressed and the computational aspects of these models are treated in detail. Applications are discussed and validations are critically assessed. It was found that Gaussian and conservation of mass models are currently the most widely used tools for analyzing the dispersion of pollutants in the atmosphere. Models presently in operation are run on medium- to large-scale computers of the IBM 360/50 class or greater and nearly all of these models are programmed in FORTRAN IV. Although existing models have been applied to a wide variety of air pollution problems, their performance has not been adequately evaluated. This deficiency is primarily due to the fact that, until recently, instrumented transportation test sites have not existed and hence very little validation data have heretofore been generated. However, such test sites do now exist and data from them is beginning to become available, hence the validation of dispersion models will soon be feasible.

95. ENVIRONMENTAL RESEARCH AND TECHNOLOGY, INC. "Development of Procedures to Simulate Motor Vehicle Pollution Levels." Washington, D.C. (1973).

This report presents the results of a program performed

to develop procedures to predict motor vehicle air quality concentrations in the vicinity of highways as a function of highway design configuration, traffic characteristics, and meteorological conditions. The study consisted of several phases involving: (1) the development of both a numerical simulation, conservation of mass dispersion model for the study of vertical cross-sections of concentrations very near the roadways, and a Gaussian plume diffusion model for plan view, corridor, and regional-scaled analyses; (2) field measurement program for model evaluation purposes at six different roadway sites in Washington, D.C., including the measurement of carbon monoxide on both sides of the road, measurements of traffic volumes, speed distributions and vehicle mix and continuous meteorological measures of wind speed and direction; (3) a detailed validation of the models and the calculation of statistical factors quantifying model accuracy; and (4) implementation of the modeling capabilities and graphical display programs on DCDHT computer facilities, including the preparation of a User's Manual, training staff in model usage, and a case study demonstrating model applications. The models developed are shown to predict air pollution potential very well over a wide range of input quantities.

96. Environmental Research and Technology, Inc. "Hackensack Meadowlands Air Pollution Study—Air Quality Impact of Land Use Planning." Prepared for Environmental Protection Agency, Research Triangle Park, N.C. (1973) 148 pp.

The Hackensack Meadowlands Air Pollution Study consists of a summary report and five task reports. The summary report discusses the procedures developed for considering air pollution in the planning process and the use of these procedures to evaluate four alternative land use plans for the New Jersey Hackensack Meadowlands for 1990. The task reports describe (1) the emission projection methodology and its application to the Hackensack Meadowlands; (2) the model for predicting air quality levels and its validation and calibration; (3) the evaluation and ranking of the land use plans; (4) the planning guidelines derived from the analysis of the plans; and, (5) the software system.

97. Eschenroeder, Alan Q., and Jose R. Martinez. "Concepts and Applications of Photochemical Smog Models." Santa Barbara, California (1971).

98. Hagevik, George, ed. *The Relationship of Land Use and Transportation Planning to Air Quality Management.* New Brunswick, New Jersey: Rutgers University, Center for Urban Policy Research and Conferences Dept. (May 1972) 287 pp.

The papers in this volume define the issues involved in air quality management. The first five papers establish the relationship between the air pollution official and the planner. Legislation is reviewed and the role of the states in providing leadership in new approaches to environmental planning and management is discussed. Air pollution considerations in transportation planning is the theme of seven papers. The last section discusses point and area sources in a planning context, and reviews research projects which aim to provide decision-makers with guidelines on the impact of alternative land use plans on air quality.

99. Hanna, Steven R. "A Simple Method of Calculating Dispersion from Urban Area Sources," *J. Air Pollution Control Assoc.*, Vol. 21, No. 12 (1971).

100. Lamb, D. V., et al. *A Critical Review of Mathematical Diffusion Modeling Techniques for Predicting Air Quality with Relation to Motor Vehicle Transportation.* Seattle, Wash. (1973).

101. Martin, Delance O. "An Urban Diffusion Model for Estimating Long-Term Average Values of Air Quality," *J. Air Pollution Control Assoc.*, Vol. 21, No. 1 (1971).

102. Martin, Delance O., and Joseph A. Tikvait. *A General Atmospheric Diffusion Model for Estimating Effects of One or More Sources on Air Quality.* Cincinnati, Ohio.

103. Mikolowsky, William T. *The Motor Vehicle Emission and Cost Model (MOVEC).* The Rand Corporation, Santa Monica, Calif. (1973).

104. Mikolowsky, William T., et al. *The Regional Impacts of Near-Term Transportation Alternatives: A Case Study of Los Angeles.* The Rand Corporation, Santa Monica, Calif. (1974).

105. Zimmerman, John R., and Roger S. Thompson. *User's Guide for HIWAY, A Highway Air Pollution Model.* Research Triangle Park, N.C.: U.S. Environmental Protection Agency (1975).

ENVIRONMENTAL—NOISE

106. Bolt, Beranek & Newman. "User's Manual for the Prediction of Road Traffic Noise Computer Program." Cambridge, Mass. (May 1972) 146 pp.

This manual is a guide for using a computer program for prediction of noise from freely flowing road traffic. The program is written in FORTRAN IV for use on the IBM-7094 computer at the Transportation Systems Center.

The manual consists of four parts. In the introduction, the limitations of the computer model are described. In the second part, acoustical properties of the traffic and sound propagation model are developed, and the analytical expressions used in the computer program are described. The third part contains a description of the structure of the computer program, and of the detailed calculation procedures. The fourth part gives practical guidelines for use of the computer program.

107. Schultz, T. J. "Development of an Acoustic Rating Scale for Assessing Annoyance Caused by Wheel/Rail Noise in Urban Mass Transit." U.S. DOT, Transportation Systems Center, Cambridge, Mass. (Feb. 1974).

A number of recent studies of the impact of train noise on the community are reviewed. From this information and the results of other noise-annoyance studies, a scale for rating the annoyance of urban transit system operators and patrons, as well as the surrounding community, caused by wheel/rail noise is recommended. In general, the peak A-weighted sound-pressure level for the given exposure should be used, with an additional 5 dB if there are pure tones present (squeal). If in comparing the different kinds of train noise (squeal, impact, wheel roar, etc.) the *total* exposure is to be assessed, an additional term, 10 log T,

should be added to the mean peak noise (where T is the total exposure in seconds during any 24-hour period).

108. U.S. ENVIRONMENTAL PROTECTION AGENCY, Office of Noise Abatement and Control. *Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare within an Adequate Margin of Safety*. Arlington, Va. (1974).

109. WESLER, J. E. "Manual for Highway Noise Prediction." U.S. DOT, Transportation Systems Center, Cambridge, Mass. (March 1972).

This manual is intended for use as a tool in predicting the noise which will be generated by freely-flowing vehicle traffic along a highway of known characteristics. The manual presents two separate approaches to the prediction problem. The first approach utilizes a simple nomograph to provide first-approximation solutions to the traffic noise prediction problem. The second approach utilizes a computerized traffic noise simulation model, for more accurate and more flexible noise level predictions. This volume contains an explanation of the bases for both approaches, to indicate the assumptions and limitations inherent in the prediction procedures, and a User's Manual for the computer.

110. WILSEY AND HAM. *Aircraft Noise Impact—Planning Guidelines for Local Agencies*. Washington, D.C. (1972).

ENVIRONMENTAL—WATER

111. HYDROLOGIC ENGINEERING CENTER, THE. "Urban Storm Water Runoff 'STORM'." Davis, Calif. (Jan. 1975).

This computer program represents a method of analysis to estimate the quantity and quality of runoff from small, primarily urban, watersheds. Land surface erosion for urban and nonurban areas is computed in addition to the basic water quality parameters of suspended and settleable solids, BOD, total nitrogen, and orthophosphate. The purpose of the analysis is to aid in the selection of storage and treatment facilities to control the quantity and quality of urban storm water runoff and land surface erosion. The program is a continuous simulation model but may be used for selected single storm events as well. Output reports are quantity analysis, quality analysis, pollutograph analysis, and land surface erosion analysis for runoff/erosion volumes only.

112. HYDROSCIENCE, INC. "Simplified Mathematical Modeling of Water Quality." Westwood, N.J. (March 1971).

This report presents a general framework for the methods of application of mathematical models to the analysis of water quality. These models relate wastewater discharge to water quality in the receiving body. The modeling effort is considered to be a part of the overall water quality planning operation. The types of models necessary to address various water quality problems in streams and estuaries are discussed.

113. LAGER, JOHN A., and WILLIAM G. SMITH. *Urban Stormwater Management and Technology: An Assessment*. Cincinnati, Ohio (1974).

114. METCALF AND EDDY. "Storm Water Management Model—Vol. I." Cincinnati, Ohio (July 1971).

This model was developed under the sponsorship of the U.S. Environmental Protection Agency. It is a comprehensive mathematical model capable of representing urban storm-water runoff, storm sewer discharge, and combined sewer overflow phenomena. The SWMM has been demonstrated at more than 20 sites throughout the country ranging from 76 to 8,100 ha (187 to 20,000 acres). During demonstration, the SWMM has been verified to be capable of representing the gamut of urban stormwater runoff phenomena for various catchment systems. This includes both quantity and quality from the onset of precipitation on the basin, through collection, conveyance, storage, and treatment systems, to points downstream from outfalls that are significantly affected by storm discharges. The SWMM is intended for use by municipalities, governmental agencies, and consultants as a tool for evaluating the pollution potential of existing systems, present and future, and for comparing alternative courses of remedial action. The use of correctional devices in the catchment, along with evaluation of their cost effectiveness, has also been demonstrated.

115. VOORHEES, ALAN M., & ASSOCIATES, INC. "Sewer System Cost Estimation Model." Prepared for Regional Planning Council, Baltimore, Md. McLean, Va. (1969).

ENVIRONMENTAL—ENERGY

116. CAMBRIDGE SYSTEMATICS, INC., and ALAN M. VOORHEES & ASSOCIATES, INC. "Draft Report on Carpooling Energy Submodel." Cambridge, Mass.

117. HANSON, M. E., and J. W. MITCHELL. *A Model of Transportation Energy Use in Wisconsin: Demographic Considerations and Alternative Scenarios*. University of Wisconsin, Madison (Dec. 1975).

118. KLD ASSOCIATES and ALAN M. VOORHEES & ASSOCIATES, INC. "UTCS-1/Fuel." (Unpublished draft).

119. U.S. DOT, Transportation Systems Center. *Report No. DOT-TSC-OST-73-43*. Washington, D.C.

120. VOORHEES, ALAN M. & ASSOCIATES, INC. "Baltimore Regional Environmental Impact Study—Technical Memorandum No. 8: Analysis of Energy Consumption." McLean, Va. (June 1975).

The purpose of this document is to describe the assessment of the impacts of alternative transportation and land use plans on energy consumption in the Baltimore Region. The focus is on short-term (1980) and long-term (1995) regional energy consumption.

Principal highway-related regional energy consumption was analyzed into two major sectors: transportation energy consumption and land use related energy consumption. Land use sectors were further grouped by type of use into three categories: residential, commercial, and industrial. Methodologies were developed to analyze the energy consumption in transportation and land use sectors. The analyses of transportation energy consumption were based upon the data obtained from the Travel Simulation and Traffic Analysis. The land use related energy consumption was based on the employment and population projected in the Socioeconomic and Land Use Analysis.

121. YUNKER, K. R., and K. C. SINHA. "Energy Considerations in Urban Transportation Planning," *Traffic Quarterly*. (Oct. 1975).

ENVIRONMENTAL—NATURAL ENVIRONMENT

122. ROCKWELL INTERNATIONAL, Space Division. *Louisiana Environmental Management System, Vol. I, II, and III.* Louisiana Joint Legislative Committee on Environmental Quality, Baton Rouge (July 15, 1973).

The purpose of the Louisiana Environmental Management System (LEMS) is to gather, process, store, and make available environmental information and environmental impact assessments for decision-makers throughout the region. Such a system will provide for informed, coordinated decision making.

Long-term objectives of the Louisiana Environmental Management System are:

1. To develop a comprehensive, statewide environmental management system and implement such a system at the state and regional level.
2. To provide decision-makers within the State of Louisiana and associated regions timely access to information pertaining to the condition of the natural resources and the dynamic processes associated with them; further, to provide models and methodologies for environmental cross-impact analysis.

These reports give a description of the LEMS program and approach to date. Detailed computer program information is presented.

123. SALMEN, LARRY J. "Status and Applications of the Composite Mapping System." Federation of Rocky Mountain States (Dec. 12, 1972).

The Composite Mapping System (CMS) is a large-scale computer software package designed for graphic representation of socioeconomic and physical information over large or small areas. CMS was originally developed by a Washington, D.C., consulting firm for the Department of Commerce (Economic Development Administration) in the 1960's. Its initial application was to display social and economic data for the Department of Commerce to facilitate its allocation of EDA funds throughout the nation. This nationwide macro-scale analysis was the first application for CMS; however, more micro analysis can also be performed by the Composite Mapping System. The CMS software was initially programmed and developed for the UNIVAC 1108 computer hardware in Washington, D.C.

124. SMITHSONIAN INSTITUTION, Center for Natural Areas. "Planning Considerations for Statewide Inventories of Critical Environmental Areas: A Reference Guide." Washington, D.C. (Sept. 1974).

This report reviews the state-of-the art of environmental inventories, environmental inventory methodologies, and environmental inventory evaluation systems. It identifies and examines planning considerations for statewide critical environmental area programs. The report seeks to guide the reader through logical and necessary operational procedures for defining, inventorying, evaluating, and delineating critical environmental areas. It points to sources of information about CEA's and about previous and current efforts of others relating thereto.

To further point up the overview and information-service function of the present report in contrast to a more complete examination of procedures, techniques, and recommended approaches, there is developed an information-rich set of appendixes which summarizes or reproduces, often verbatim, information on federal sources of environmental inventory information (Appendix A), selected sources of federal funds applicable to critical environmental areas efforts (Appendix B), selection and classification criteria (Appendix C), rating systems and capability classification schemes (Appendix D), selected studies of information handling and sources of data (Appendix E), and an overview of selected resource inventory and critical area programs (Appendix F).

125. WILLIAMS, DONALD L. "Natural Systems Integrated with Transportation Planning." Urban Studies Center, University of Louisville, Louisville, Ky. (1972) (draft).

This paper outlines a systematic procedure for using natural science information to locate urbanization. Specifically, the use of this procedure is demonstrated in the locational analysis for a major airport facility in the Louisville-centered region.

ADMINISTRATIVE

126. BRONITSKY, LEONARD, and JOSEPH MISNER. "A Comparison of Methods for Evaluating Urban Transportation Alternatives." U.S. DOT, Transportation Systems Center, Cambridge, Mass. (1975).

127. CREIGHTON, ROGER L. "Measurements and the Regional Planning Process," *Hwy. Res. Record No. 229.* (1968) pp. 1-4.

A brief summary is given of the methods used in highway transportation planning. A preliminary PERT diagram of a regional planning process in three-dimensional form was developed. The regional planning process consists of three major elements: transportation and land use taken together, housing and social condition, and economic and population forecasting. The regional planning process contains five computer simulation models. These simulate (1) the growth of the population, (2) the growth of the economy, (3) the addition of housing and building to the present supply, (4) the migration of population within the stock of present and future buildings, and (5) the daily movements of people throughout the metropolitan area. It is suggested that the data needs for regional planning will consist of: (1) land use, (2) transportation facilities, (3) daily travel, (4) population data, (5) building survey, (6) migratory travel, (7) daily movement of goods, and (8) the economy. The necessity is emphasized of a systematic regional planning process.

128. ILLINOIS DEPARTMENT OF CORRECTIONS. "Zero-Base Budgeting." (no date).

Zero-base budgeting is a procedure which requires the annual evaluation of all functions of government in order to identify and evaluate different ways of performing the function and to identify and evaluate different levels of effort of performing the function. The department or di-

vision then ranks the best way of performing the function (at a minimal level) and at higher levels with other functions which have been similarly identified and evaluated. Thus, hypothetically minimum maintenance might be ranked #1, minimum interstate construction #2, . . . planning #14, . . . maximum maintenances #26, etc. Forms were developed to assist in the evaluation and development of "decision packages" which were ranked.

129. MARYLAND DOT. "Systems Planning Report for Highway Route 36." (Dec. 1975).

This is a sample of the report which is prepared for proposed projects to serve as the transition from systems planning to project planning. The report:

1. Summarizes existing information and prior decisions related to the project.
2. Identifies transportation and environmental issues raised by the project.
3. Recommends the general scope and approach of the project planning stage which follows.

130. NEW YORK STATE DOT. "Draft Environmental Action Plan." (undated).

131. NEW YORK STATE DOT. "Interim Guidelines for Preparation of the 'Problem Definition and Project Proposal'." Unpublished memorandum from Project Development Bureau (Nov. 1975).

132. PEAT, MARWICK, MITCHELL and COMPANY. "Development of a Multi Project Programming and Scheduling System." Georgia (1973) 108 pp.

The report documents the results of the first phase of a two-phase program to develop a "Multiproject Programming and Scheduling System" in the Georgia Department of Transportation. During Phase I, all Department activities involved with highway program planning, development, scheduling, and budgeting were studied. Interim improvements that might be effected in the Department's existing programming/scheduling system were considered; the conceptual framework for a proposed Multiproject Programming/Scheduling System (MP/SS) was developed; the current operations and capabilities of the Department were evaluated in relationship to those required for effective and efficient operation of the proposed system; and an "action plan" for Phase II, system implementation, was prepared. The conceptual description of the system is presented in terms of the four basic elements of the MP/SS: (1) priority development, (2) multiproject programming and financial management, (3) multiproject scheduling, and (4) financial accounting. Discussed are the procedures involved with each element; their data requirements; their interrelationships; and the necessary report inputs and outputs. A proposed organizational plan for MP/SS and specification of necessary inter-unit relationships is given. Alternative plans for system implementation are discussed, along with a detailed description of the tasks and estimated times necessary to carry out the recommended plan.

133. THOMAS, EDWIN N., and JOSEPH L. SCHOFER. "Strategies for the Evaluation of Alternative Transportation Plans." *NCHRP Report No. 96* (1970) 111 pp.

This report presents the concepts of systems analysis that are pertinent to the transportation planning process. It provides an awareness of the broad spectrum of consequences that results from providing new or modifying existing transportation services. Approaches are presented that consider all factors involved in the planning process, and strategies are developed for improving the evaluation techniques for comparing alternative transportation plans.

134. TRANSPORTATION RESEARCH BOARD. "Statewide Transportation Planning Needs and Requirements." *NCHRP Report No. 15.* (1972) 42 pp.

Presents a set of definitions for statewide transportation planning with an emphasis on the need for a multimodal approach and the need for coordination with other statewide agencies. It is concluded that long-range multimodal statewide transportation planning should be the function of one office. Special concerns such as goals, citizen participation, and data requirements, forecasting requirements and procedures, and plan generation and evaluation are discussed. The trip interchange model for improving the highway assignment process is presented as is a description of goods movement simulation.

135. UNDERWOOD, BENNETT and HOLEC. "Procedures for the Financial Analysis of Transit Operating Assistance Programs." Prepared for presentation at Transportation Research Board Annual Meeting, Washington, D.C., 1975 (draft).

This document suggests that limit values be designated for each transit operating expense category and compared with the current year and prior year expenses for each property. It shows how properties can be classified based on this comparison as a basis for administrative action. There is no discussion of how limit costs might be developed and, if necessary, modified to suit the circumstances of individual operations.

FINANCE

136. CONNECTICUT DOT. "Connecticut State Rail Plan—Phase II." (1975) 181 pp.

On the basis of the data gathered, an analysis was conducted of the statewide rail system to determine how well the existing and USRA-proposed system met the goals of the state. Where deficiencies were perceived, recommendations for correcting the deficiencies were made. Special studies of rail passenger and piggyback services and operations were conducted. The demands, both current and future, for these services were analyzed. The impact on state rail operations of this potential demand was identified and courses of action recommended. The branch line analysis consisted of a thorough review of existing (1973) traffic and service levels, costs and revenues, facility conditions, community impacts, and alternative mode possibilities. Where extenuating circumstances, which could justify subsidization, were found, they were documented, as were perceived alternatives to subsidization.

137. JUSTER, RICHARD, and WAYNE PECKNOLD. "Improving the Process of Programming Transportation Investment Under Funding, Legislative and Community Constraints." Prepared for presentation at Transportation Research Board Annual Meeting, Washington, D.C., January 1976.

This paper discusses a methodology developed originally for the Massachusetts Department of Public Works which can be used to generate multiple period investment programs from a large list of candidate projects. The program generation procedure is based on marginal analysis and is heuristic in nature. It takes into account project benefit interdependencies, multiple funding sources, regional expenditure minimums, and functional classification constraints. It utilizes a measure of benefits, the capital costs, and an estimate of political acceptability for each proposed investment to determine its suitability in comparison with all other alternative projects.

138. MARYLAND DEPARTMENT OF TRANSPORTATION. "Short-Range Capital Resource Availability Model." (June 1975).

This model (SCRAM) was developed to aid the Department in analyzing its capability of using debt financing and the implication of alternative financial policies on revenue requirements and total operating and capital programs. Linear mathematical programming is used to select values of bond issues in each of *n* years to either minimize required revenues or maximize the funds available for capital or operating expenditures (subject to the Department's requirements for maintaining coverage of its debt service). SCRAM is coded in FORTRAN IV and a user's manual is available.

139. NEW YORK STATE DOT. *Commuter and Intercity Rail Passenger and Freight Capital Facilities and Equipment Projects: An Information Manual for Applicants.* (April 1975).

140. NEW YORK STATE DOT. "Public Transportation Operating Assistance Program: 1975 Annual Report." (Oct. 1975).

The state program is described and the federal program is evaluated as it relates to New York State. Among the topics covered are:

1. Maintenance of fare and service.
2. Impact on ridership.
3. Impact on transit finances.
4. Validity of the distribution formulas.

The results of technical and financial analyses undertaken by NYSDOT are presented. These included an analysis of the relative productivity of various transit operations and an analysis of the equity of current fares. Program objectives and proposals for actions to be implemented are discussed. Four alternative program approaches are described and evaluated.

PLAN AND PROGRAM EVALUATION

141. BARTON-ASCHMAN ASSOCIATES, INC. "North Carolina Statewide Transportation Plan, Phase I, Interim Report." (1975) 34 pp.

This document outlines a rationale for future transportation service decisions within North Carolina State. Three areas of information are stressed: (1) the components of a new statewide transportation planning process; (2) the range of transportation and development issues which must be addressed by the process; and (3) the range of feasible "futures" for North Carolina and the manner in which they will impact future transportation needs and services.

142. BREEN, FLORENCE L. "Calibration of Priority Analysis Model for Highway Improvement Projects." Ga. (1975) 163 pp.

This research is the second part of a two-phase study. In the first phase, a priority analysis model was developed for the Georgia Department of Transportation. This phase tests and calibrates that model for implementation. The procedure used for this work is partially based on the Delphi Technique. A team of experts (Delphi group was organized to evaluate a sample of projects which were also scored through the model. The Delphi scores were iteratively evaluated by the group until the weaker opinions gave way to the stronger opinions. The "optimized" Delphi scores were then compared to the model scores. Adjustments were made to the model until the squares of the score differences were minimized. A computer program was developed for implementation of the model.

143. CALIFORNIA DOT. *California Transportation Plan.* Vol. 1. (July 1975) (draft).

144. CONNECTICUT DOT, Division of Transportation Planning. "Available Statewide Data." (March 1973).

Report contains the statewide data available with Connecticut Department of Transportation. Also included are the survey forms.

145. ERNST & ERNST. "A Transportation Resource Allocation System for North Carolina." (June 1972).

The report describes:

1. Twelve measures of effectiveness which can be used to evaluate transportation projects.
2. A computer-based technique for selecting a set of projects which "maximizes" a weighted sum of the effectiveness measures subject to a number of budget constraints (using an integer programming heuristic).

Except for travel time and cost, the effectiveness measures are highly subjective in nature, e.g., for "air, water, noise pollution and unpleasant visual effects, program users are asked to rate projects from −5 ("project causes 100 percent or greater degradation") to +5 ("project causes 100 percent or greater improvement") and multiply by the percentage of the state population affected.

A major problem with the computer program is that it assumes the effectiveness of each project can be evaluated independently—without considering whether or not other projects will be implemented.

146. GEORGIA DOT, OFFICE OF PLANNING, and ROY JORGENSEN ASSOCIATES, INC. "Review, Analysis, and Conclusions Concerning Planning Data Systems and Organization." (Oct. 1972).

The highway planning process in the State Highway Department of Georgia is reviewed from an overall systems approach. A suggested planning system is developed as a guideline for reviewing activities. The objectives of the planning group are identified and defined.

Current planning data usage and organization are reviewed with respect to the suggested overall planning system and associated objectives. Methods of structuring a typical

data system and organization are reviewed. A suggested planning group reorganization is developed and explained.

147. GRUVER, J. E., and FRED PATRON, U.S. DOT, FHWA. "Highway Investment Analysis Package." Prepared for presentation at TRB 55th Annual Meeting, January 1976.

148. HIGHWAY RESEARCH BOARD. "Statewide Transportation Planning Needs and Requirements." *NCHRP Report No. 15.* (1972) 41 pp.

This report focuses on a rather detailed discussion of the statewide transportation planning process—presenting first an overview and then a more detailed discussion of each of the steps in the process. Some emphasis is given to the techniques and data that are needed to develop the long-range transportation plan and to evaluate various plan alternatives that are generated. The report deals with planning methodologies that relate to a variety of modes. It stresses the need for an organization that can integrate the various modal and functional aspects of a complete statewide transportation system.

149. HUMPHREY, THOMAS F. "Report on Workshop 3A: Systems Planning and Programming Methodology —Passenger Travel." *TRB Spec. Rep. No. 146.* (Feb. 1974) pp. 91-100.

The article presents the summary of findings of the workshop group which had as its objective the identification and evaluation of current techniques used to develop statewide multimodal transportation plans, priorities, and programs for both people and freight. The first finding was that existing urban and regional methodologies are not appropriate for statewide planning and programming in their current form—they are too limited in scope. It was concluded that transportation planning has become so much more complex and encompassing that a new look must be taken at the requirements of methodologies for accomplishing statewide planning. It is imperative that statewide planning go beyond traditional approaches and develop new techniques for predicting a wide range of impacts including environmental, social, and economic; evaluating tradeoffs among modes and multilevel objectives; programming and fiscal planning that can respond to uncertainties; and recognizing a variety of political and institutional constraints. A second finding was that the present system of models was too cumbersome and expensive for use by the states. There is an immediate need for a set of techniques to be used by statewide system planners as policy-sensitive analysis tools similar to the sketch planning techniques used at the urban level. A third major finding was the current lack of effective ties between planning and programming. Currently state planning has very little impact on what actually gets programmed in a state. One way to improve the process is to begin to develop system plans as time-staged investment sequences in which long-range systems plans are related to short-term programs, and to recognize budget constraints and uncertainty early in the process.

The group felt that the statewide planning and programming process should have the following characteristics:

1. The actions in statewide planning must involve alternative time-phased courses of action and include short-run as well as long-run options.
2. The process should evaluate alternative strategies and should provide statements of the impacts of policy on goals and objectives for different state programs.
3. The process should provide information necessary to establish priorities and recommend transportation programs.
4. It should provide a mechanism for monitoring system performance over time.
5. It should provide interface for planning among different agencies.

In addition, the group evaluated existing methodologies for their adequacy. Generally, the findings were that existing techniques and procedures could not really be applied at the statewide level and that other methodologies were necessary. Five basic sets of methodologies were defined and for each a set of high priority research needs was developed.

150. KNOX, RONALD R., THEODORE K. MARTIN, and WILLIAM J. YUSKUS. "Programming Highway Improvements in the New Funding Environment." Prepared for presentation at Transportation Research Board Annual Meeting, Washington, D.C., January 1976 (draft paper).

This paper identifies pitfalls in highway programming, features of an idealized programming process, and techniques developed to improve the programming process. The techniques include:

1. A statement of anticipated program accomplishments over a five year period for use in programming at the district level.
2. A one-page Transportation Improvement Proposal form which summarizes the problem underlying a proposed improvement, type of improvement proposed, cost, and status.

151. MAK, KING K. "Priority Analysis for Ranking of Transportation Improvement Projects." Prepared for Georgia DOT, (Aug. 1973) 210 pp.

This research describes the development of a priority analysis procedure designed to suit the needs of the Georgia State Department of Transportation. The procedure is based on a "scoring model" approach. It allows highway projects to be evaluated in terms of up to 26 factors that are divided into eight groups: need, deficiency, continuity, benefit-cost, local opinion, economic, social, and environmental factors. The improvement projects are categorized according to 10 functional classes and eight types of improvement. Factor selection and a preliminary set of weighting factors were determined from responses to questionnaires distributed to State Transportation Board members, Department of Transportation officials, and regional and local planners. The individual factors are combined by the model into one or two indices that can then be used to rank the projects within each category. This research developed a complete framework for a priority analysis procedure. However, more work remains to be done in developing units of measure and criterion values for the evaluating factors. The procedure was subsequently tested and calibrated. (Florence L. Breen. "Calibration of Priority Analysis Model for Highway Improvement Projects," Georgia, 1975.)

152. MARYLAND DOT, Division of Systems Planning. "Transportation Economics and Railroad Branch Lines." (Feb. 1975).

This report presents a priority ranking of branch lines in Maryland based upon a forecast of the costs and revenues of all branch lines in Maryland. The report also discusses some possible sources of funds to keep the branch lines operating. It is the first step toward the development of Maryland's rail plan for distribution of federal rail operating funds.

153. MINISTRY OF TRANSPORTATION AND COMMUNICATIONS, ET AL. "Development of a Methodology for Planning Improvement Priorities." Ontario, Canada (Aug. 1972) 3 v.

The selection and timing of large-scale transportation investments should be undertaken using a cost-effective technique within a framework of clearly stated objectives and assumptions. Such a technique should serve as a "bridge" between current long-range planning and project implementation, so that transportation improvements may be implemented in such a sequence as to optimize over-all benefits to the public and simultaneously achieve horizon year plans.

The priority planning methodology discussed in this paper identifies and assesses transportation improvement impacts affecting both transportation users and the community at large. Such impacts, benefits, and disbenefits are evaluated and used to develop time streams of present work of benefits as functions of the year of implementation. The functional benefit and cost time streams are combined with future budget estimates and subjected to linear programming analysis. The linear program selects the stages of mix of transportation improvements so as to maximize the total present work of benefits capable of being realized, given the assumed budgets. The methodology has important potential uses as both a management decision-making tool and as a readily accessible transportation planning data source.

154. NEUMANN, L. A., and W. M. PECKNOLD. "Application of the Time-Staged Strategic Approach to System Planning." *Hwy. Res. Record No. 435.* (1973).

155. OREGON DOT. "Report on the 1973 Deficiency Study." Unpublished report.

156. PECKNOLD, WAYNE M. "Workshop 3A: Systems Planning and Program Methodology," Resource Paper, *TRB Spec. Rep. 146.* (1974) pp. 101-144.

This paper focuses primarily on passenger travel demand forecasting methodology, but includes consideration for statewide multimodal aspects as well. It presents a state-of-the-art discussion, outlining a program for long-range research and identifying immediate methodological applications.

This paper presents recommendations for 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 tradeoffs 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, low-capital transit or paratransit alternatives, and the more traditional longer range capital-intensive investments. In addition, a more strategic planning approach than has been used in the past is recommended. Staging strategies are to be evaluated not only for economic and environmental impact 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 the 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 spent on transportation to date.

157. PENNSYLVANIA DOT. "Review of United States Railway Association Preliminary System Plan." (April 1975).

The Preliminary System Plan of USRA was reviewed in detail. This review is presented in the report. Penn DOT conducted its own analysis based on extensive shipper/receiver surveys, analysis of railroad operation, impacts on rail users, and communities. Included is an economic analysis using the USRA and the Penn DOT methodologies, as well as community impact summaries for all branch lines.

158. RIHANI, F. A., L. H. SAMS, and R. E. TAGGART, JR. "Statewide Transportation Planning: The North Carolina Experience (1974/75)." Prepared for presentation at the Transportation Research Board 55th Annual Meeting, Washington, D.C., January 1976.

The North Carolina experience in statewide transportation planning represents a new attempt to deal with comprehensive multimodal transportation planning at the statewide level through the use of sketch planning techniques. The characteristics and relationships of the social, economic, political, and environmental systems affecting the state are described and analyzed. Four different futures for the state are identified with corresponding development patterns. All feasible modes of transportation are considered and transportation requirements are defined for each future. The elements common in all or most of these requirements are screened and formulated into low-risk, short-range (5 years) action programs. The programs are grouped into four major classes: capital improvement, operating, regulatory, and promotional. Similar classes are used to identify mid-range (10-15 years) conceptual programs. These, however, are policy directions rather than project-specific and are addressed to each of the different futures separately. At the end, an attempt is made to define the next steps in the planning process. The entire effort was carried out with the participation of the private and public sectors.

This paper presents an overview of this process and preliminary comments on its use to statewide transportation decision-making. The effort indicates that sketch planning can be effective and economical as a planning approach. As a decision-making tool, it seems that more time and better reconciliation of conflicts in the public and private sector are needed before full usefulness is accomplished.

159. SHAFER, J. H. "Interim Guidelines for the Preparation of the 'Problem and Project Proposal'." New York State DOT (1975).

160. TRW SYSTEMS GROUP and WILBUR SMITH and ASSOCIATES. "California Transportation System Evaluation Project." (Dec. 1971) 227 pp.

This Procedural Guide has been prepared to assist state and regional officials in transportation decision making and planning. The procedure takes into account increased social awareness and environmental sensitivity, together with new analytical techniques. A broad range of options can be considered including what will happen if nothing is done. The options can be screened using transportation, land use, social, economic, and environmental factors. The procedure requires a recognition that all transportation planning must identify and involve those interests affected by the proposed policy or action. The procedure will provide the decision-maker with a broad understanding of available choices and their consequences. Application of the new procedure should help transportation system development become more responsive to the broader transportation and social needs in the area served.

161. UTAH DOT. "The 1990 National Highway Functional Classification and Needs Study: Capital Improvement Programming Methodology." Unpublished report.

162. U.S. DOT, FHWA, Statewide Highway Planning Division, Office of Highway Planning. *Highway Needs Evaluation Model.*

163. U.S. DOT, FHWA. "Objective Priority Programming Procedures." *Rep. No. DOT FH-11-7882* (March 1973).

164. WEST VIRGINIA DEPARTMENT OF HIGHWAYS, Advanced Planning Division. "STAM Socio-Economic and Land Use Data File for the State of West Virginia." Charleston, W. Va. (Nov. 1974) 212 pp.

The report contains the following:

1. Various data items that are included in the statewide traffic assignment model (STAM) socioeconomic and land use data file.
2. Documentation of the data collection methodology.
3. Presentation of the final data file at the zonal level.

165. WISCONSIN DOT. "Rail Planning Procedures Report." Madison (Sept. 1975) 196 pp.

This report is a compilation of documentation on the methodologies of state rail planning in Wisconsin and Michigan. The report is structured so that the reader can go through the rail planning process and select a particular step for in-depth study. Beginning with goal development and constituency identification, the report details the collection, use, and analysis of data relating to rail traffic and costs and to the existing rail plant. Two different approaches towards analyzing the prevailing problems endemic to light-density branch lines are given. A discussion of evaluating the need for rail passenger service is also included.

APPENDIX C

ISSUE/TECHNIQUE/DECISION RELATIONSHIPS

The following sections elaborate on the material presented in Figure 2 for each issue area. In selecting experiences from individual states to present for each issue area, an attempt was made to focus on specific decisions that states made in the recent past or will have to make in the near future. A number of examples are cited where states found individual techniques to be particularly useful in guiding decisions. Also cited are instances in which states perceive a need for information to guide decisions but the techniques necessary to generate the information are not currently available to them.

REVENUE SHORTFALL

Twelve of the thirteen states visited specifically identified some form of revenue shortfall as a major issue confronting the transportation agency. Although Massachusetts did not specifically cite this as one of its most important concerns, its construction and maintenance costs have rapidly inflated during the past three years like those of the other states, and one key transportation official voiced concern about the state's continued reliance on the use of bond financing to support its capital programs. Specifically, the following issues were cited by certain states:

1. Financial squeeze may eliminate all capital improvements and reduce operating and maintenance budgets and staff (California).
2. Funding uncertainty due to elimination of dedicated revenues; must now compete with all state programs for general revenues (Connecticut).
3. Lack of multiyear forecasts of available resources hinders planning and programming (Georgia).
4. Shortfall in highway funding due to drop in growth rate of motor fuel tax revenues (Georgia).
5. Past reliance on bonds to finance highway program is

putting state in financial squeeze because of current difficulty of getting bonds approved and financed (Illinois).

6. Revenue shortfall causing drastic reductions in highway capital improvements (Kentucky).

7. Maintenance needs rising rapidly (particularly for coal-haul roads), while funds available for maintenance are declining (Kentucky).

8. Lack of funds reducing highway capital program (Maryland).

9. Forecast revenues far short of projected needs for long-range highway program (Michigan).

10. Lack of funds for meeting identified planning needs in all modes (New York).

11. Need to obtain funds from general revenues or new transportation sources because of inflation, new programs, and diminishing real-dollar highway fund revenues (Oregon).

12. Lack of funds for capital projects and operations (Pennsylvania).

13. Need to obtain funds from general revenues because of inflation and diminishing real-dollar highway fund revenues (Utah).

14. Imposition of highway tolls to raise revenues (West Virginia).

15. Growing backlog of highway projects to be implemented as a result of reduced revenues (West Virginia).

In most states, a need for information about the consequences of reducing levels of expenditure (particularly for highways) was identified. The highway mode appears to be hardest hit by the revenue shortfall for several reasons:

1. Much slower growth in motor vehicle user tax revenues during the past three years.

2. High degree of inflation in costs of building and maintaining roads over the same period of time.

3. Rapid growth in maintenance requirements because of the rapid increase in the lane-miles of highways that have to be maintained.

4. Increasing responsibility for and investment in other modes, drawing on funds that previously would have been available for highways.

Because much of the revenue shortfall problem could apparently be solved by raising motor vehicle user taxes or allocating general funds to supplement highway user revenues, the needs of many of the states center on developing the kind of information that can convince a legislature of the desirability of increasing highway funding.

The specific natures of the issues and, hence, the information needs vary from state to state. For example, in California, Kentucky, West Virginia, and Maryland, it is perceived that the revenue shortfall might result in deterioration of existing highways, and the need to show the effects of deferred maintenance was identified. California and Maryland have experienced rapidly rising demands for nonhighway uses while their revenues, based largely on motor vehicle use taxes, remained relatively fixed. Kentucky, the nation's leading coal-producing state, has benefited tremendously from the increased usage of coal that resulted from the shortage of petroleum several years ago. However, state roads in mining areas are being systematically destroyed by overloaded coal trucks. The last Kentucky General Assembly allocated general funds to maintain these roads, but this year's priorities were for education and health facilities (with the Governor's promise of no tax increases) and no general funds were made available for highway maintenance.

Other states, such as Oregon, Utah and Georgia, also have dedicated motor vehicle use taxes, but the revenue shortfall coupled with inflation and other demands has already convinced the legislatures in these states to augment the budgets with general revenues. Much of the success of these states in getting general funds can be attributed to their ability to convincingly present the benefits of project implementation to their legislatures. Oregon is focusing more attention on the general economic benefits of projects; Utah has worked closely with the Legislature to develop projects having its support; Georgia conducted an in-depth study on the travel, safety, and economic benefits of completing its interstate system at a faster pace than motor vehicle use taxes would allow. In addition to the use of general revenues for highway purposes, the Georgia Legislature passed a bond issue to pay for completion of interstate routes at the fastest rate feasible under the federal authorizations.

In Connecticut, dedicated revenues were eliminated, so that the DOT now must compete with all other state programs for allocations from general revenues, creating hard-felt new demands for comprehensive socioeconomic justification of transportation programs.

The justification of individual program elements can be vitally important, as illustrated in Maryland where approval of the entire state budget was delayed by opposition to the Baltimore subway system. One of the stipulations for budget approval obtained in the compromise that resulted was the creation of a legislative committee which would review and assess any future plans to expand the initial 8-mile subway system.

Illinois, Kentucky, and New York are feeling the financial squeeze to a large extent because of their past reliance on bond programs, which in the last few years have become increasingly difficult to get approved by the legislature and financed. Kentucky is paying the price for previous bond issues—revenues from toll facilities have been insufficient to pay off the revenue bonds used to build them, and the state has been forced to use road fund monies for that purpose.

In these and several other states, much greater emphasis is now being placed on cost effectiveness in project definition and execution.

As shown above, the impacts of revenue shortfall vary among the states as do the responses of the states and the information needs caused by the issue. However, in general, certain conclusions appear to be particularly relevant to the revenue problem. In the future, transportation agencies will have to more systematically:

1. Develop information on the benefits and costs of projects, particularly as they pertain to the economic health of the state.

2. Forecast state and federal revenues likely to be available under alternative future scenarios.

3. Identify potential social, environmental, or other problems with individual projects early in the planning process.
4. Schedule and manage project development, maintenance, and operations more efficiently and effectively.

DEVELOPMENT OF MULTIMODAL TRANSPORTATION POLICIES, PLANS, AND PROGRAMS

This is the only issue area for which some significant information need was identified in every state concerned. The major specific issues identified by the states are:

1. Reorganization of the multiyear programming process to integrate policy development, long-range planning, programming, and program evaluation (California).
2. Adoption of a state transportation plan (California).
3. More focus on problem solving than on merely satisfying federal requirements in urbanized area transportation planning programs (Illinois).
4. Development of improved linkage between long-range planning and programming to provide basis for tradeoffs among modes and criteria for each program category (Illinois).
5. Development of a sufficiency rating system that provides selective information on the specific deficiencies of a roadway section to guide programming (Kentucky).
6. Lack of a close link between highway system planning and programming (Kentucky).
7. Link between multimodal system planning and modal priorities appearing in five-year program (Maryland).
8. Achieving more objective basis for allocation of resources among modes (Maryland).
9. Development of statewide highway improvement priorities from priorities established for each region (Massachusetts).
10. Development of a closer link between highway planning and programming (Massachusetts).
11. Establishment of priorities among various modal improvements (Michigan).
12. Development of state transportation policies to improve interaction with the legislature and guide programs of the department of transportation (Oregon).
13. Allocation of resources to highway resurfacing and reconstruction projects to achieve cost effectiveness (Pennsylvania).
14. Subsidies for competing goods movement modes (waterways, rail) versus abandonment (West Virginia).

The most frequently expressed general need in this area is for some common means of assessing programs in the various modes. This is a need that is not going to be readily satisfied because of the inherent technical difficulty in establishing comparable units of assessment other than costs of construction and operation. None of the states surveyed seems to have developed a satisfactory practical methodology.

Many states do not feel the need for common means of assessing programs, either because their programs are overwhelmingly highway programs, or because the funding and programming of different modes are treated separately by the legislature and others involved. Maryland has perhaps the greatest need for comparable multimodal program assessment because of (a) the comprehensive scope and relative dollar balance of its program responsibilities, (b) the common funding for all modes from a single transportation fund, (c) the lack of statutory or legislatively determined formulas or constraints on allocations among modes, and (d) the fact that the program and budget are handled in a common manner by both the executive and legislative branches. These factors make programming a more purely multimodal DOT function than in other states.

States such as Illinois, Massachusets, Michigan, and Oregon still feel the need to develop more common evaluation methods for planning and programming, although they have somewhat more restricted responsibilities and more restricted use of earmarked funds.

Connecticut and New York, which have two of the older departments of transportation, appear to place more emphasis on the need for evaluation of programs in terms of general effects on the state's economy, rather than evaluation in terms of transportation benefits and costs. This may be partly because these states have already established methods of program evaluation in transportation dimensions, but are now both facing increasing demands from their legislatures and others for evaluations that permit comparisons with other state programs. Both states are dependent on general revenues now, whereas they were not earlier.

Massachusetts and California are two states that have moved in the direction of relying on regional planning agencies to establish multimodal priorities within regions, thus the states tend to focus more attention on the difficult problem of establishing priorities among regions—for state highway improvements primarily.

Another common problem within this general issue area is the development of closer linkages between long-range planning and multiyear programming. In some cases they appear to be completely separate functions; the encouraging observation is that more states are recognizing this as a deficiency and seeking to overcome it. Illinois is involved in an intensive system planning process involving models and analyses which, it expects, will provide a common basis for examining tradeoffs among modes and more systematic evaluation criteria for modal programs. California is reorganizing its planning and programming process as an integrated centralized function.

Maryland and New York are placing increasing emphasis on the short- to medium-range future in their process of putting together state transportation plans. Both states have moved away from the "master plan" concept of a one-shot, long-range, fixed-target plan. The plans will be frequently updated (annually in Maryland) and will focus on policies and multiyear programs. They will deal with the longer range in less detail and place greater attention on alternatives and on meeting possible contingencies (e.g., fuel shortages, demographic or economic growth trend changes). Other states, such as Connecticut and Oregon, may also be moving in this general direction with their state planning process.

In California, a process of this type appears to have been contemplated by some of the key persons involved in preparing the legislation that created CalTrans. This legislation defines the (annual) plan-making process in greater

detail than any other state visited. However, the first attempt at preparing and adopting a plan has been a difficult process for CalTrans and the State Transportation Board, due in large part to political and institutional factors. Of common interest, however, is the fact that the legislature made the plan-adoption process a focal point for contention of differing interests and philosophies by specifying that the plan, once adopted, would control subsequent multimodal program decisions, and would place adoption authority in the hands of a limited-purpose board comprised of people from outside the transportation profession.

In California particularly, but in other states as well, state departments of transportation have had difficulty in fulfilling their mandates to plan in areas of common carrier regulation. Often the problem stems from very broad legislative mandates to "plan" in these areas, with little direction and no authority to gather data from private carriers or to otherwise intervene in their affairs.

In Illinois, a general statewide problem with urban transportation planning programs was cited that may be common to other states, although no other state stressed the issue: efforts tend to be devoted to satisfying federal requirements for data collection, network analysis, and reports. Too little attention is given, because of these burdens, to the identification and resolution of real urban transportation problems.

States all recognize that highway sufficiency rating systems cannot be relied on mechanically as a device for programming, even if factors such as road condition, road life, and accident experience are properly measured and incorporated. Additional considerations such as continuity, environmental considerations, geographic balance, community objectives, and other legitimate political considerations must be weighed judgmentally.

Several states have adopted or are considering different perspectives on the highway programming process. In Pennsylvania, a user cost analysis is performed to provide an estimate of the transportation user cost savings due to each candidate resurfacing or reconstruction project. Georgia has had some experimentation with a comprehensive system for ranking candidate projects based on the aggregation of weighted scores for each of 32 factors. Georgia's project ranking system has been developed into a practical, easy-to-use manual similar to sufficiency rating systems, but which covers many more factors. However, this technique is not currently in use in Georgia because it is believed that legislators and other public officials should have more direct input in establishing programs. Illinois has broken its rating system into several problem categories (e.g., structural problems, geometric deficiencies, safety and congestion). Critical ratings are defined in each category, with careful analysis given to tradeoffs among the categories. Programming staff then defines the type of project improvements that best fit each condition, rather than applying uniform standards for improvement regardless of the particular problem. Kentucky's staff has expressed interest in an approach to sufficiency ratings that is similar in concept.

Oregon is going through a systematic process of defining issues and policies. As a major first step, a director's report on major state transportation issues was widely distributed recently for discussion purposes and to solicit input from all interested groups. An internal DOT formal structure has been established to identify, research, and evaluate policy options. This work is performed by an executive committee composed of all top staff and operating division heads, chaired by the deputy director and reporting to the director. Their work is accomplished by task forces on particular issues utilizing a systematic process of analysis and interaction with the full executive committee. A major summary product of this work will be a program plan report to the legislature in the near future. This report is intended to shape state transportation policy and legislative programs and form the basis for the state transportation plan to be submitted soon thereafter (a legislative requirement).

West Virginia does not have a department of transportation, but it does have a relatively complex network of goods movement and passenger modes in the state, operating with a system of user charges, tolls, and operating subsidies that has never been subjected to any systems analysis. The state is concerned about the relative efficiency of the subsidies for the competing modes, the effects on each mode and on the state's economy.

ORGANIZATION AND MANAGEMENT

As revenue growth has slowed and construction and maintenance costs have inflated, the need for efficient management of personnel and careful review of the effectiveness of over-all organizational arrangements has been reinforced in state transportation agencies. In particular, the following pertinent issues were highlighted during the state visits:

1. Reorganization of CalTrans and its governing policy-making bodies (California).
2. Development of an improved management information system for programming and project management (Illinois).
3. Assignment of planning and programming responsibilities within the state's department of transportation (Oregon).
4. Procedures to expedite capital projects implementation (New York).
5. Project management to assure timely completion of project plans with focus on objectives of project (Utah).

Staffs of departments in Illinois, New York, and Utah identified issues related to project or program management. In Utah, the principal priority-setting responsibility of the Utah Department of Transportation is the distribution of funds to candidate projects in different parts of the state for road safety improvements, road maintenance, and new road construction. The key management issue confronting the state's highway program is how to ensure that the decision process leads to maximizing over-all program benefits over time, rather than maximizing the benefits of individual projects. To accomplish this goal, Utah is attempting to very specifically define the purpose of projects (e.g., improve safety, improve pavement, increase capacity) and just accomplish that specific objective, rather than rebuilding every road to the highest standards. Also, Utah has developed a computerized project management system to

compare actual and planned progress as well as expenditures on individual projects and entire programs. Continual monitoring of projects is a management necessity because the local people and the individual designer working on a project will often desire to expand the scope of a project in order to maximize that project's transportation objectives.

Connecticut has decided that publication of its DOT work schedule in the annual update of the state transportation plan will tend to increase the department's credibility and provide an extra incentive for getting projects completed on schedule.

The New York DOT has had significant problems expediting (as opposed to selecting) individual projects in the state program. These difficulties have arisen as a result of the complex procedures that must be followed in order to implement a project. For example, a number of projects have been delayed by environmental requirements which could not be adequately identified at the time projects entered the state program. New York has established a new unit, the Capital Projects Coordinating Bureau, to stay on top of projects as they move through the pipeline, but so far this group has had only limited success expediting projects.

In California, a major organizational issue has concentrated on the preparation of the state transportation plan. When the old California Division of Highways was reorganized as the Department of Transportation (CalTrans), the new agency was directed to prepare a state transportation plan for adoption by the state transportation board (appointed by the Governor to advise the Secretary of the Business and Transportation Agency, of which CalTrans is part). This plan was then to be submitted by the state transportation board to the legislature by January 1, 1976. The schedule was not met and the board recommended that a special task force be appointed to redirect development of the plan. CalTrans was asked to assist the task force with specific items, but otherwise was relieved of responsibility for preparing the plan.

The Oregon DOT is currently analyzing the roles and responsibilities of its system planning staff, programming staff, modal divisions and districts in over-all planning, programming, and implementation. Intra-agency discussion has also focused on the integration between system planning and programming for the various modes. Oregon DOT has taken a great deal of care to develop policies and assign staff responsibility for all steps in the state's transportation planning and programming process.

Other states grappling with organization and management issues include Illinois, Maryland, and Massachusetts. Illinois is trying to develop a project information system that will provide up-to-date information on all projects. Maryland DOT is trying to resolve the internal relationships necessary for orderly functioning of the department's state plan preparation and update process. On the first round of what is to be an annual process, difficulties were experienced because the system planning unit that was responsible for developing policies and assembling the state's multimodal plan had to depend on the operating administrations that had developed the modal plans and programs which were basically just being assembled into the plan. It became a lengthy, slow process in developing consensus, common terminology, balance in emphasis and overcoming many of the constraining single-mode features of prior plans. All of this is a necessary prelude to a real multimodal planning process.

In Massachusetts, the Department of Public Works is attempting to establish a closer tie between highway system planning, capital programming, and project planning. One of the problems that needs to be overcome is the lack of guidance that system planning currently provides for programming. A second problem is that the program is not used as effectively as it might be by management to assure that priority projects are moved forward as rapidly as possible in project planning activities. Too often other nonpriority projects receive equivalent attention in location and design studies.

In summary, it is obvious that carefully thought out organization structures and thoughtful, systematic management of the entire planning, programming, and project implementation process are major factors affecting the success of a state transportation agency. The area of organization and management appears to be one in which great opportunity exists for exchange of information among the states. For example Oregon, developing policies to guide its planning and programming, may benefit from Maryland, which has completed its initial cycle of policy development. Likewise, Illinois could draw on the experiences of Utah or Massachusetts in setting up a project information system. The results of Oregon's step-by-step definition of planning and programming responsibilities and assignment of these responsibilities to staff units may be helpful to other states having problems because responsibilities were not clearly defined and assigned. Several general points are true for all states:

1. Internal organization responsibilities must be clearly defined so there is no misunderstanding about who has what role.
2. Relationships with other state agencies and review boards must likewise be carefully defined and understood.
3. To avoid wasting time and money on projects that may be difficult to implement, early assessment of social, economic, and environmental impacts is needed.
4. A management information system that informs on the progress of projects through the pipeline and enables a comparison of actual and forecast costs is a necessity for every state transportation agency.

COORDINATION WITH OTHER STATE AND REGIONAL PROGRAMS

Many of the states visited identified problems in their relationships with other state agencies having control over programs affected by transportation or influencing the need for transportation. A more common concern focused on the changes taking place in the state/regional relationship in the planning and programming of transportation improvements. Specific issues brought out by the interviews were:

1. Role of regional plans in the state transportation plan (California).

2. Achieving agreement on state versus regional system responsibility (California).

3. Achieving agreement on highway improvement priorities for metropolitan Atlanta (Georgia).

4. Achieving consistency in transportation policies among different state and regional agencies (Georgia).

5. Shift of priority-setting and programming responsibilities to metropolitan planning organizations in urbanized areas (Kentucky, Maryland).

6. Complexity of the programming process as it relates to preparation of regional transportation improvement programs (New York).

7. Coordination of state transportation planning with other agencies responsible for planning and controlling development (Oregon).

8. Coordination with other state and local agencies on environmental concerns related to resource development projects (Utah).

9. Coordination of transportation actions with other public actions such as health care, education, emergency services, promotion of tourism, economic development (West Virginia).

As might be expected so soon after a major change in federal policy, one of the major issues relating to coordination of state transportation programs with other state and regional programs is the result of the joint FHWA/UMTA policy requiring that metropolitan planning organizations (MPO) prepare transportation improvement programs (TIP) in the urbanized areas. This policy change, because it gives priority-setting and programming responsibilities to the MPO's threatens the states' control and flexibility for programming transportation improvements made by the states in their urbanized areas. Kentucky and Maryland, in particular, voiced their concerns that programming responsibilities should not be taken away from the agency responsible for project implementation. These fears had no particular precedent, but were based more on doubts that MPO's will be able to take a "statewide" perspective and will represent a parochial viewpoint to the detriment of the rest of the state.

More forceful concerns were voiced in Georgia, where there is a history of disagreement between the state and the City of Atlanta. Both the City of Atlanta and the MPO want to emphasize efficient use of existing highways through priority treatment for high-occupancy vehicles and other noncapital-intensive projects. The state wants to implement capital projects that will increase highway capacity. As a result, the two sides have had difficulty reaching agreement.

In California, state/regional coordination became a major issue as a result of the legislative requirement that CalTrans prepare a California Transportation Plan. A "bottoms-up" approach was mandated by law: forty-one regional transportation plans were to be submitted for assimilation into a state transportation plan. The regional plans were required to be submitted to the state by April 1, with public hearings on the state plan in July. Not all regions' plans were submitted on time, nor in the same format, and CalTrans was left with insufficient time to make a meaningful aggregation of the regional plans into a state plan. The whole "bottoms-up" approach was misunderstood by some of the regions, the state transportation board charged with adopting the state plan, and other observers and participants. The plan was never intended to be a mere aggregation of regional plans, as there clearly had to be a state interest in the plan.

Oregon and Utah both identified issues relating to coordination with other state and regional agencies with an interest in control of land development. In Oregon, there are new departments of state government with some authority over transportation. The Land Conservation and Development Commission is drawing up guidelines, which include transportation among other matters. The Department of Environmental Quality issues indirect source permits for all facilities that generate significant numbers of auto trips. Oregon DOT intends to assist these agencies in developing guidelines that affect transportation. Oregon DOT also is in need of state and local plan inputs to its transportation planning process to provide a basis for population and economic forecasts for all areas of the state and to provide guidelines on environmental constraints for transportation improvements in the plan.

In Connecticut, coordination with other state and regional programs is handled through a state planning council. The council is chaired by the Governor or his (her) designee and includes the heads of major agencies responsible for planning, development, economic and human resources, conservation and environmental protection. The multiagency cooperative process effectively functions as a "3-C" process for all areas of the state. It provides a high degree of coordination between state and regional plans and among state agencies responsible for different functional programs.

In Utah, there is concern over the environmental impacts of several proposed coal and other resource development projects in remote areas of the state. The Utah Department of Transportation gets involved in planning and programming of highway access to these sites. Environmental impacts are the concern of elected officials and various federal and state agencies having responsibility for parklands, natural resource development, and environmental protection. Utah DOT must concern itself with the impacts of the highway access improvements and coordinate with other concerned agencies. Time pressures and the importance of the environment will almost certainly make this coordination effort increasingly important to Utah.

In summary, the coordination achieved between the state transportation agency and other state and regional programs can significantly affect the successful implementation of the state transportation program. The need for coordination and the shift of responsibilities to MPO's in the urbanized areas have increased the importance of the state transportation agencies doing their planning and programming work carefully. In particular, the states should give more emphasis to the development of information showing state-level requirements for transportation service and more complete cost-benefit measures for projects. There should be early and on-going communication with other state and regional agencies so that this information influences decisions.

DEVELOPMENT OF ENERGY POLICY, PLAN, AND PROGRAM

Among the thirteen states visited, only in three instances was energy conservation specifically identified as a planning issue:

1. Development of transportation component of state energy conservation plan, including access to all energy resources of the state (Illinois).
2. State role in controlling energy consumption (Maryland).
3. Response to future gasoline shortages, particularly a problem because many miners drive 30 to 50 miles to work (West Virginia).

Illinois appears to be one of the first states to initiate a work program for the preparation of a state energy conservation plan. (The new federal program is described at the end of this section). In fact Illinois DOT had anticipated the need for energy studies by conducting various inventories to provide the data base for planning long before the passage of the 1975 Energy Act. One important component of this data collection was an inventory of all coal resources potentially mineable, together with an analysis of the existing quality of access to them. Illinois DOT has made special efforts to closely follow developments in national energy policy, legislation, and federal agency initiatives.

Maryland's statewide transportation planning staff has also conducted some analyses of energy conservation trends and has been attempting to identify the appropriate state role. Numerous actions have been taken that partially or entirely stem from energy conservation objectives, including strict enforcement of the 55 mph speed limit, a major carpooling effort, and various traffic control measures to give priorities to buses. Energy studies are included in the continuing, annual Maryland transportation plan revision process.

West Virginia was particularly hard hit by the energy shortage in the winter of 1973-74 because many of its miners and other workers were completely dependent on auto commuting over long distances from scattered rural mountainous areas. Emergency plans to cope with possible future shortages are an important need and concern of the planning staff of the West Virginia Highway Department.

Many states have special concerns about future energy availability and prices because revenue for their programs is completely dependent on motor fuel taxes. Oregon was among the worst affected by the decline in recreational travel and revenues derived therefrom. The staff of Oregon's DOT believes trends and effects of federal policies on Oregon's revenues are particularly difficult to plan and program because of recent events and the continuing uncertainty over national conditions.

California has performed an analysis of the energy consumption consequences of a far-reaching range of multimodal transportation development options. This analysis shows the great difficulty in achieving large percentage reductions in energy consumption even with rather drastic increases in transit operations and disincentives to auto use. The staff of CalTrans has experienced some problems in obtaining acceptance of findings of this type (and in related air quality impact assessments), probably because many people want to believe that auto usage can be curtailed more readily than can realistically be expected based on empirical evidence on demand elasticity.

As has been mentioned previously, Utah has been involved with the provision of access roads for resource development projects—coal mining being the most important. As in Illinois, Utah DOT has done some analysis of access problems to such resources. The potential cost of provision of access is much greater, however, because of the remoteness of many potential sites. Utah DOT finds it difficult to effectively anticipate these costly access needs, in part because of the complete lack of advance plan information from private resource developers, and in part because of the lack of a state plan to guide or control resource development.

State Energy Conservation Plans

The 1975 Energy Policy and Conservation Act authorized $50 million for each of the fiscal years 1976, 1977, and 1978 to prepare "state energy conservation plans." The plans, which may be prepared by each state, must include two transportation measures: (a) programs to promote carpool, vanpool and public transportation, and (b) right-turn-on-red, and perhaps other transportation actions. Other actions that might be included in a state plan could be any plan, procedure, method, or arrangement, or any system of incentives, disincentives, restrictions, and requirements designed to reduce transportation energy consumption with the exception of fuel rationing.

In order to receive federal funds for implementation of these plans, the governor of the state must first submit to the Federal Energy Administration (FEA) a state energy conservation feasibility report, which shall include an assessment of the feasibility of saving 5 percent of the state energy consumed by 1980 and a preliminary list of programs and activities to be included in the proposed plan (along with the estimated cost of preparing the plan). FEA will allocate $5 million to assist the states in preparing the plans. The plan must then describe how the energy will be saved.

FEA is responsible for prescribing guidelines for the feasibility report within 60 days of the enactment of the Energy Act (December 22, 1975). The feasibility report is supposed to be submitted within three months of the effective date of the guidelines. Guidelines for the state energy plans are to be developed within six months of the Act and state plans submitted within five months of the effective date of the guidelines.

At this time (April 1, 1976), only proposed guidelines for the feasibility reports have been published in the *Federal Register.*

RELATIONSHIP BETWEEN TRANSPORTATION IMPROVEMENTS AND DEVELOPMENT

Three major issues were identified under this general issue area by the persons interviewed:

1. Control of access on state primary highway system (Maryland).

2. Control of land use around highway interchanges and airports (Pennsylvania).

3. Provision of access roads to resource development sites (Utah).

Maryland is developing a definitive policy on control of access on its primary highway system in order to protect the investment in the major improvements that are made to these routes. The issue is well-defined in a basic policy direction statement in the January 1976 Maryland preliminary transportation plan:

> *In order to preserve the functional role of primary highways and their present and future vehicle carrying capacity and safety, the Department shall emphasize appropriate control of access to the Primary Highway System.* Faced with decreasing revenue growth and increasing construction costs, the Department must preserve and maximize the efficiency of its existing primary highways. In the past, adjacent land development has grossly impaired their capacity and safety. Today, almost 60 percent of the State Primary System has some degree of access control. The Department must take steps to protect the remaining 40 percent, as well as new future mileage, to preserve the investment of the State and its residents in these facilities. The Department presently is developing a detailed policy on Primary Highway System access control.

Pennsylvania has been focusing attention on a closely related problem—that of controlling development around highway interchanges. Pennsylvania DOT has available a model to predict development intensity in highway interchange areas in order to provide the basic planning information needed to anticipate problems that are likely to occur because of over-development. Land-use controls are needed to limit the intensity, type, and specific location of development in order to avoid overloading the traffic carrying capacity of cross-routes, particular turning movements, or entire interchange areas.

Pennsylvania is likewise concerned about development controls around airports because of noise impacts and encroaching development.

The need for access roads to resource development sites in Utah has been discussed in the previous two issue areas, as related to environmental impact and coordination with other agencies and to the need for a statewide energy resource development plan. Access road needs in Utah are a more major concern than elsewhere because major coal deposits and other resources that are in increasing demand have been found in parts of the state so remote that there is no existing highway access whatsoever—nearly half of the state's land area is more than five miles from a paved road.

Lacking either a firm state resource development plan or equivalent information from private developers, Utah has been confronted with major unexpected road and other public facility demands as a condition for the development of these resources. To resolve this problem, a new state law was recently passed which permits the state to enter into an agreement with a resource developer. If a developer's proposed project is in the public interest, then the state will apply the prepayment of the firm's sales and use taxes to the construction of roads and schools needed to serve the development project. This amounts to a transfer of general revenue taxes to highway use but allows the development to proceed on the basis of the firm's finances rather than the state's.

In California, the experience in evaluating long-term transportation development alternatives has convinced some of the staff of CalTrans that they must examine in more depth key relationships between transportation and development:

1. The auto dependency of most contemporary development—to what extent can this be changed within a given time horizon and to what extent must land development patterns and controls change to bring about specific degrees of change in auto dependency?

2. The dependency of major California industries, such as agriculture, lumber, and food processing, on the maintenance of current levels of service for highway goods movement—what are the economic consequences on these industries if significant deterioration of the level of service occurs in the future?

3. Similarly, how important is port access and efficiency to these industries?

All of the seventeen eastern and midwestern states involved in the Conrail reorganization have had to concern themselves with the dependency of industries on the continuation of rail service. The plans that had to be prepared to qualify for federal assistance to retain branch lines not on the "final system plan" required a benefit-cost analysis of each line's continuation versus abandonment. This was a difficult requirement because of lack of readily available data on the costs of alternative modes of transportation, if any, that were available to the industries served. Some states, such as Illinois, found that it often was not possible to obtain such data from firms.

Illinois also has been interested in the effects of airport access and levels of service on localities' development potential.

Kentucky has been faced with an increasingly serious problem in trying to maintain its coal-haul roads. These routes have been undergoing substantially greater wear because of expanded coal operations and difficult-to-enforce weight limitations. This has occurred at a time when inflation and revenue shortfall problems have forced reductions in available funds for maintenance. In part, the proper solution requires better knowledge of the effects of varying levels of maintenance and weight enforcement on coal mining enterprises. These data are necessary to establish what levels of maintenance are warranted and to aid in determining what level of taxation on the industry would be offset by the benefits it would receive from improved maintenance.

New York has undertaken a comprehensive study of economic development benefits of a possible major new north-south freeway through the central part of the state. As part of this study the DOT examined the relative roles that transportation and various other state programs could play in achieving development in the corridor. A general finding was that a large-scale transportation investment would be difficult to justify on its own, but that coupled with other public development efforts, far greater economic benefits

could be realized which would make the over-all program package an attractive investment.

As mentioned previously under "Coordination with Other State and Regional Programs," the Oregon DOT is seeking to cooperate closely in its state transportation planning process with other agencies that control development in one way or another. In addition to merely assuring that plans are coordinated, the department feels it is important to:

1. Use other state and local plans to provide the basis for forecasts of population and employment distribution for travel forecasts.
2. Provide environmental and other constraints on transportation projects based on conservation plans, open space reservation plans, and the like.
3. Use its expertise on transportation considerations to aid other state and local agencies in preparing sound, workable plans.

West Virginia's Highway Department is likewise interested in becoming more involved in transportation aspects of such other programs as location decisions for major public facilities such as hospitals. Concerns include the impacts of resulting traffic on existing roads and programmed improvements and the additional highway and public transportation requirements of the new facilities.

MAJOR CORRIDOR IMPROVEMENTS

Important issues regarding major corridor improvements identified in interviews include:

1. Choice of mode to improve in several major interregional corridors (California).
2. Reduction in the number and scale of new highway links on the supplemental freeway system (Illinois).
3. Major reconstruction of an urban highway as a catalyst for redevelopment of central city areas (New York, Massachusetts).

In those states where interviews were conducted, a primary consideration in deciding whether to undertake studies of major corridor improvements has been the availability of federal aid. This is a result of revenue shortfall created by recent energy and economic conditions. In California, the definition of construction for federal aid purposes has been expanded to include a number of projects which were previously considered maintenance. In Maryland, there will be no new highway construction after 1976 if existing revenue trends continue. In Utah, motor fuel taxes cover only administration, maintenance, and funds distributed to counties. No new highways are constructed except those that are federally aided and general revenues are used to provide the state match.

A large number of the major corridor improvements carried out in the 1960's were accomplished with 90-10 federal aid as part of the interstate system. Most states have completed the rural portions of the interstate system (an exception is Georgia, as discussed below). The remaining links of the interstate system fall mostly in urban areas, and there is frequently considerable local opposition to their implementation. As a result, several states have used the recently enacted interstate transfer provision to use their interstate funds for transit.

Unlike most states, Georgia constructed its urban interstate segments first; most of the remaining mileage is rural. Georgia has passed a bond issue to accelerate completion of the missing segments.

A general conclusion regarding the states in which interviews were conducted is that, as a result of the revenue shortfall, the winding down of the interstate program and increasing local opposition, there will be fewer major corridor improvement projects oriented primarily toward serving the demand for highway travel twenty years in the future. Instead, the emphasis in most states is on looking carefully at planned improvements in terms of their cost effectiveness and, in many cases, reducing the scale of these improvements.

For example, due to a substantial shortfall in available revenues, Illinois is considering, among other things, abandoning substantial portions of their supplemental freeway system or constructing large portions of it to less than full freeway standards. The supplemental freeway system was developed in the 1960's to link parts of the interstate system and to provide major 4-lane limited-access highway connections between rural and metropolitan areas. Illinois is currently reviewing each segment of the system in terms of its cost and benefits. Important considerations include local economic impacts, efficiency of people and goods movement, safety, and energy conservation.

In those states where major corridor improvements are currently under consideration, there is often heavy emphasis on achieving a broader range of objectives than just safer, more efficient travel. For example, both Massachusetts and New York are considering plans to replace elevated highways—the Central Artery in Boston and the West Side Highway in Manhattan—with depressed facilities. In both projects, the removal of the elevated structure and the creation of new land for open space and development is seen as a possible catalyst for redevelopment of adjacent central city areas. A key consideration in these and other projects is how to best obtain economic benefits associated with improved accessibility without the adverse effects of increased auto travel on energy consumption and the environment.

California has used direct demand models for forecasting travel in the Sacramento-San Francisco and San Diego-Los Angeles corridors. The Sacramento-San Francisco model was used for evaluation of alternative improvements in highway, intercity rail, and the BART extension. The San Diego-Los Angeles model focused on air and automobile travel. In these models, the total amount of corridor travel was viewed as dependent upon transportation system characteristics rather than as a fixed quantity. This type of model is useful in planning to manage transportation demand because it enables a better understanding of those factors influencing demand.

COST EFFECTIVENESS IN HIGHWAY STANDARDS AND MAINTENANCE

All states in which interviews were conducted are responsible for allocating resources available for maintenance and

for resurfacing, reconstruction, and new construction on the state's highway network. Major issues identified in interviews include:

1. Achievement of cost effectiveness in highway programming and in standards used; broadening the range of minor improvements eligible for federal aid (Illinois).
2. More cost-effective methodology for programming highway maintenance (Maryland).
3. Greater flexibility in use of federal funds for modest reconstruction (Maryland).
4. Use of federal aid for minor reconstruction (Massachusetts).
5. Development of a general policy and cost-effectiveness guidelines for maintenance of highways and other modes (New York).
6. Reassessment of highway design and tolerable standards to economize and increase cost effectiveness (Oregon).
7. Establishment of new design standards to maximize multiyear program benefits under funding constraints (Utah).
8. Revisions of highway standards and design criteria to be more cost effective (West Virginia).

Most of the states have physical standards to identify deficient highway segments and to determine what has to be done to eliminate the deficiencies. These procedures work reasonably well when states have adequate revenues to maintain the highway system to standards. However, in the recent past, all states have experienced a decrease in the amount of revenue available relative to the cost of eliminating serious deficiencies.

This has resulted in states having to make increasingly difficult decisions in allocating highway funds. Individual projects must be reduced in scale, postponed, or deleted from multiyear plans and programs. Techniques commonly in use to rate the adequacy or sufficiency of individual highway segments based on existing uniform high standards do not provide the information required to compare the costs and benefits of carrying out individual projects at varying scales or different points in time.

In response to this problem, several states have developed new approaches or techniques to replace or extend past procedures. In Oregon, an effort is being made to perform a statewide rating of needed improvements at a much more gross level than sufficiency ratings are usually applied—at the level of entire intercity routes. This rating system, performed as part of the statewide long-range planning process, will be based on a comprehensive cost-effectiveness index. Considerable effort is being placed on devising ways of using community input, state plans, and the like to guide this cost effectiveness evaluation. The results of this work are expected to form a basic framework for programming. In contrast, project-level sufficiency ratings will be viewed as scheduling procedures within an over-all set of priorities determined by this general framework.

Utah uses ratings on accident experience, road condition, traffic, and geometrics to define what needs to be done on a particular project rather than rebuilding to uniform standards in each case of intolerable deficiency. This approach, implemented through a computer-based project management system, enables available resources to be focused on more critical needs. Utah DOT emphasizes that it is attempting to define projects in a manner which maximizes multiyear program benefits under the given budget constraints rather than maximizing individual project benefits. Illinois is following a similar approach.

A number of states are considering the lowering of uniform statewide standards so that identified needs are more in line with available resources. This approach is being followed in New York, Oregon, and Maryland. For example, in the 1972 New York statewide plan, identified needs for eliminating substandard rural highways over a twenty-year period were estimated to be $5 billion, an impossible amount to finance. In response to this problem, New York developed a computer-based technique for estimating the costs associated with alternative sets of standards and incrementally reduced standards until costs were in line with available revenues.

To summarize, in developing and in evaluating possible changes in highway standards and maintenance levels, the primary information needs are to know what cost savings can be achieved and what are the effects on safety and highway user travel times and costs. These questions will grow in importance as a result of the increasing reliance of many states on the use of general revenue funds for transportation purposes. As the total amount of resources available for transportation purposes becomes less tied to the proceeds of pre-established motor vehicle use taxes, the need for practical techniques to assess the consequences of alternative funding levels for all types of highway improvement projects will increase.

IMPROVEMENT/ABANDONMENT OF RAIL SERVICE

One of the major statewide transportation planning concerns over the last few years has been the reorganization of the entire private railroad system in the industrial states of the Midwest and East. The climax of this planning activity has been the preparation of state rail plans in late 1975 in the seventeen states affected by the reorganization under the Final System Plan. This plan was prepared by the U.S. Railway Association (USRA), approved by Congress and implemented with the creation of the Consolidated Rail Corporation (Conrail) on April 1, 1976.

The types of issues faced in these states are all very similar. Even in other states not directly affected, many of the issues are similar. The list of major issues identified in the thirteen states visited follows:

1. Preservation and rehabilitation of rail freight system (Connecticut).
2. Subsidy versus abandonment of rail passenger lines (Connecticut).
3. Implementation of state rail plan, including development of rail data management and research programs in the Department (Illinois).
4. State role in coal shipment by rail (Kentucky).
5. Improved cost allocation methodology for commuter rail subsidy program (Maryland).
6. Appropriate state role and level of funding in rail freight and passenger service (Massachusetts).

7. Level of rail service, both freight and passenger, to be funded by the state (Michigan).

8. Abandonment versus improvement of rail passenger and freight service (New York).

9. Rail abandonment versus improvement versus changes in passenger and freight schedules (Pennsylvania).

The Regional Rail Reorganization Act of 1973 authorized $180 million to be distributed among the states affected by the reorganization plan, provided that the states prepared rail plans following certain requirements of the Act. These plans were to provide the basic framework for use of each state's formula share of $90 million, matched with 30 percent state funds. The other half of the total was to be allocated on a discretionary basis by the Secretary of Transportation to states, local governments or regional authorities "for the purpose of continuing local rail services. . .". Funds could be used over a two-year period for operating subsidies and rehabilitation of branch lines that would otherwise be abandoned because they were not included in the USRA's Final System Plan for Conrail, nor would be continued in service by other solvent railroads.

In many cases, the preparation of these rail plans has provided states the first real opportunity to examine their railroads as a system. Most prior planning had been spotty —based on reaction to threatened or actual bankruptcies and abandonments.

The USRA plan itself, was the result of the nation's first serious rail system planning effort on a multistate regional basis. However, its basic objective was to create a viable, integrated system which could operate profitably over the long run, after most of the unprofitable branch lines were eliminated (or taken over by other solvent railroads), and after substantial federal funds and borrowed capital were used to rehabilitate the network. Fortunately the reorganization act recognized that this could result in the abandonment of many branch lines that should not be abandoned when considered from a broad public-interest standpoint.

Several states found serious problems with USRA's Final System Plan and the constraints on use of federal assistance in the act. Connecticut, for example, found that it would be left without through mainline service that it had seen as a cornerstone of its transportation system. The state would be left with service by branch lines from New York and Massachusetts through too few gateways. This would severely restrict intrastate movement and make service too subject to interruption by storms or other events that might prevent continuing use of some part of the system. It also would diminish the amount of service through many important areas of the state, and increase the linehaul time of shipments to a high proportion in the state.

Pennsylvania, like Connecticut, sought greater competition than would be provided under USRA's more monopolistic plan for Conrail. Penn DOT could attract 20 percent greater market share than Conrail, equivalently greater revenues, and could operate at 4 to 7 percent lower unit operating costs. Net income of the three new private railroads was estimated to be $175 million for 1973 versus only $47 million for Conrail.

The central focus of most of the state rail planning programs, however, has been on determining which branch lines threatened with abandonment under the Final System Plan should be preserved. The federal program required the plan to demonstrate a justification for subsidy in a benefit-cost evaluation, taking into account "lost jobs, energy shortages, and degradation of the environment." States all had difficulty in doing this because of the lack of already available data, the lack of any accepted means of collecting data, and the difficulty of obtaining reliable information from firms potentially affected by the plan. States, such as Illinois, that attempted to collect data directly from plants served by the branch lines, had generally poor response. However, Illinois has diligently worked on building up trust among the railroads and other industries in part to form the basis for a new data management and research program.

A common problem that states face in negotiating with railroads for service contracts is the difficulty of determining an equitable basis for allocating actual railroad costs among the different operating functions—passenger versus freight most commonly, but often in more complex functional splits, such as for new increments of service, or on new routes. No federal guidelines for such analysis have yet been prepared, although they will be developed under recently passed legislation.

Illinois is developing a statewide multimodal freight network and route assignment model for use in its transportation planning process. This model involves a more complex representation of the network characteristics of railroads, waterways, and other modes than has probably been attempted before. In addition, the mode and route assignment algorithm being developed will take into account a variety of factors other than travel-time, presumably including costs, reliability, and institutional considerations.

Many of the states are anxious to develop the capability to evaluate the broad economic consequences of their decisions on rail abandonments, beyond the direct transportation consequences, but none of the states visited has developed, or is developing, methodology of this type.

Although Utah has no major rail abandonment problem or related issue now, Utah DOT anticipates that future federal legislation will cause railroads to want help because of the funds that will be made available for subsidies on a nationwide basis. The DOT recognizes the need, therefore, to begin defining the state interest, the economic criteria, and cost analysis methods that can be used.

The staff of the Kentucky DOT expressed similar concerns. There is a need for dissemination of basic information on rail system planning among all the states, particularly to those states that did not participate in the reorganization planning process. They need basic rail technology information, typical cost factors, methods of analysis, and advice based on experience in dealing with the railroads on data collection, cost allocation among different operations, and negotiations.

Some states, such as Maryland, Massachusetts and Michigan, have been analyzing and funding commuter and intercity rail passenger service improvements. In addition to data requirements and problems associated with rail freight service, these rail passenger studies require data on inter-

city multimodal O-D movements, which are usually not available.

FUNDING OF TRANSIT SERVICES AND IMPROVEMENTS

Major issues regarding the funding of transit services and improvements identified during state interviews or through review of state planning documents include:

1. Means of travel for rural people who are carless, elderly, or handicapped (Connecticut).
2. Determination of a justifiable "basic level of service" criterion for transit operating assistance (Connecticut).
3. Uncertainty about guidelines to use in establishing rural transportation program (Georgia).
4. Level of funding for urban mass transit systems (Maryland).
5. Appropriate supply of public transit service in small urban areas (Massachusetts).
6. Level of transit service to be provided in different parts of the state (Michigan).
7. State operating assistance to public transportation (New York).
8. Public transit for the rural disadvantaged (Pennsylvania).

All of the states in which interviews were conducted provide at least technical assistance to transit planning in rural and small urban areas. In addition, most of the states provide some form of direct financial assistance for transit in these areas:

1. Massachusetts provides capital grants for transit to small urban areas using general revenues.
2. Georgia provides funds for the development of local mass transit outside Atlanta.
3. West Virginia Department of Welfare runs a rural oriented Transit Remuneration Incentive Program.
4. Pennsylvania has prepared guidelines for rural public transportation planning in which the probable role of the state includes, among other things, leases or purchases of vehicles and maintenance costs.
5. Michigan has passed a bond issue which will, among other things, enable the state to provide transportation to less urbanized areas by continuation of dial-a-ride programs and implementation of small bus programs.
6. New York, Illinois, Connecticut, and Maryland provide direct capital and operating assistance for transit in rural and small urban areas.
7. Kentucky provides transit capital grants and is currently running a rural transit demonstration project.

In those states with very large metropolitan areas, there is considerable variation in the role of the states in the planning, construction, and operation of transit:

1. Georgia and California have only limited state involvement in the development of new rail rapid transit systems—the legislatures authorized the use of regional taxes, but there are no state-level executive branch roles in transit.
2. In Pennsylvania and Illinois, the Philadelphia and Chicago transit systems are managed by regional authorities with limited state involvement.
3. Massachusetts provides capital funds for MBTA construction as well as funds to cover 50 percent of the MBTA (the Boston area transit system) operating deficit, and there is substantial involvement of the Executive Office of Transportation and Construction in planning, programming, and finance of transit improvements.
4. New York State administers a Public Transportation Operating Assistance Program, which provides financial assistance for public transportation in New York City and all other major urban areas.

A number of states are attempting to establish standards for transit service, particularly in regard to the needs of those individuals that are dependent on transit for mobility. For example, in Connecticut, operating assistance funds are currently distributed to cover the entire deficit of those operators who can cover 60 percent of their cost from farebox revenues. If farebox revenues cover less than 60 percent of costs, Connecticut covers only half of the additional deficit. While this policy encourages operators to orient services to high demand, there is some concern that this policy neglects the mobility needs of people who are carless, elderly, or handicapped. As a result, Connecticut is seeking to determine a "basic level of service" criterion for transit operating assistance.

As noted above, all states in which interviews were conducted provide at least technical assistance to transit planning in rural and small urban areas. A number of these states (e.g., Georgia, Massachusetts, Utah) have noted the need for improved techniques to assess the need for transit in these areas, and to determine the viability of alternative design concepts. In many cases, this involves predicting the demand for transit in areas where transit services currently do not exist. Predicting the demand for new services is a difficult technical problem since there is no actual transit usage data for developing and calibrating demand models for a particular area.

In addition to providing technical assistance for planning, many states also provide management assistance to local operators. In one case, the state actually operates urban transit itself—Maryland DOT operates the Baltimore area transit system.

One of the major concerns of local transit operators is more productive use of financial resources, personnel, and equipment. States are often called upon to provide advice on this subject. In addition, the manner in which states allocate capital and operating assistance may increase or decrease the productivity of transit operations. Thus, both in terms of how they allocate funds to local systems and in their role as management advisor, states must address questions regarding the productivity of local transit.

In order to guide decisions regarding state operating assistance to mass transit, the New York DOT staff made forecasts of transit deficits under alternative fare and service assumptions for thirteen major transit operations in the state. The analysis was useful—both to the governor's staff and legislature—in establishing and structuring New York's Public Transportation Operating Assistance Program. The analysis used simple linear revenue and operating cost models, which could probably have been improved upon, but which were quite adequate in view of the time

pressures under which the analysis had to be carried out. One of the problems which had to be faced in conducting the analysis was the difficulty of obtaining consistent data on service levels, ridership, and costs from individual operators. However, this should prove to be less of a problem in the future with new federal and state reporting requirements for operators.

AIRPORT CAPITAL IMPROVEMENTS

All states in which interviews were conducted provide financial assistance to airports and technical assistance in applying for Federal Aviation Administration grants. Also, a number of states are the operating authorities for individual airports; for example, Maryland operates Baltimore/Washington International Airport and Connecticut operates Bradley International Airport.

Major issues related to airport capital improvements identified by means of interviews or by review of state planning documents include:

1. Fragmentation of authority for coordinating statewide aviation planning (Georgia).
2. Location of a second major airport to serve the Atlanta metropolitan area (Georgia).
3. Determination of appropriate state role in airport development (Illinois).
4. The need for a third major airport to serve the Chicago metropolitan area (Illinois).
5. Development of a state aviation system plan to guide allocation of resources (New York).

State planning for airport development is heavily oriented toward the inclusion of individual airports in the Federal Aviation Administration's National Airport System Plan. To be eligible for future federal assistance, an individual airport must be included in the National Airport System Plan.

In discussing its planning requirements for individual airports, the FAA defines an airport master plan as "the planner's conception of the ultimate development of a specific airport." However, as noted by the Illinois Transportation Study Commission in its June 1975 report "The Current Aviation System in Illinois," such plans can be grandiose shopping lists since individual airports are in competition for state and federal assistance. Thus, from the states' perspective it is important to ensure that the comparative evaluation of possible improvements in the states is based on realistic demand forecasts. Also, it is important to provide a basis for assessing the relative cost effectiveness of improvements at different airports because the initial identification of needed improvements will undoubtedly exceed available resources.

In response to this problem, New York has developed a three-phase process for preparing its State Aviation System Plan. Phase I is a statewide framework study that will establish a common methodology to be employed in the Phase II regional studies. Phase III will integrate the results of Phases I and II in the form of an aviation plan covering the entire state. However, it has proved necessary to authorize some regional and airport studies prior to completion of the state system plan to avoid delays which might cause major setbacks in airport development.

A major problem in Georgia is the fragmentation of authority for coordinating statewide aviation planning. The Georgia DOT has the legal authority for producing the statewide airport systems plan, which provides the basis for future development and funding. However, aviation plans for metropolitan areas are being developed under direct contracts between the U.S. DOT and metropolitan planning agencies. A specific example is the need for a second airport to serve the Atlanta metropolitan area. The Atlanta Regional Commission adopted a regional airport system plan, which recognized the need for the facility, but also states that it is not possible to locate such a facility within their jurisdiction. During the period of preparation of this plan, the City of Atlanta acquired one potential site, took an option on a second, and is considering a third possible site.

The state will have to face this issue, which may have important consequences for state and local growth and development in updating the statewide aviation plan.

In Illinois, there is a major question of whether a third major airport is needed for Chicago. A study commissioned by the Office of the Governor suggested that O'Hare and Midway Airports may be adequate to serve air transportation needs past 1990. However, critics have pointed out that the study did not adequately consider the "people handling" capacity of O'Hare and questioned the social and environmental impacts of increased use of Midway.

Sophisticated computer-based techniques have been used in a number of states to forecast the demand for air passenger service at individual airports. For example, in forecasting the demand for air travel at Baltimore/Washington International Airport in Maryland, a computer-based model was used to distribute passengers among the three major airports in the Baltimore/Washington area, based on air service at each airport and the relative accessibility of the airport to subareas. The technique generated flight schedules from each airport to other cities based on preliminary demand estimates. Flight schedules and demand were then mutually adjusted to produce forecasts based on realistic measures of air service.

Most air travel demand forecasting models currently in use in states where interviews were conducted related demand to socioeconomic features of subareas—using either a "top down" approach based on local share of national trends or a "bottom up" approach based only on local data and trip generation relationships. A shortcoming common to most of these models is that demand forecasts are not sensitive to variations in the times and costs of intercity travel by air and other modes. A notable exception is the model used in the San Diego-Los Angeles corridor study in which the effect of these variations on demand was taken into account. Air travel demand models which are not sensitive to changes in travel times and costs are of limited usefulness in evaluating policies to control the amount of air travel for energy conservation and environmental purposes.

In addition to demand forecasting, sophisticated tech-

niques are currently used in some states to estimate funding requirements and set priorities for airport capital improvements.

California has a technique for taking the output of general aviation and air carrier demand models and estimating funding requirements over time. For general aviation airports, a computer model translates demand into requirements for physical facilities. For air carrier airports, this step is carried out manually. Then, the costs of providing these facilities are estimated for individual airports and on an aggregated basis to show the total funding needs of the state aviation system.

Oregon uses a cost-effectiveness model for ranking general aviation improvements. This model has been in use for over a year. Judgment is still a major part of decisions regarding state grants to general aviation airports, but the model has proved useful to the Aeronautics Division of Oregon DOT in making these decisions.

APPENDIX D

DOCUMENTATION OF TECHNIQUES

This appendix contains information on documentation of the techniques (see Chapter Two) identified in this study. The techniques can be divided into three categories:

1. Nonoperational.
2. High-priority.
3. Operational.

NONOPERATIONAL TECHNIQUES

The nonoperational techniques are the ones that are under development or that require further development and testing. These techniques are described in a summary form in Tables 1 through 7. They can be identified in the tables by the information provided in the column "Technical Status." For example, in Table 4 the technique "Transportation Demand Model for Manufactured Goods" can be identified as being nonoperational because its technical status is "Under development."

HIGH-PRIORITY TECHNIQUES

The high-priority techniques, the majority of which are operational ones, were further divided into (a) techniques selected for testing in Phase II and (b) techniques for future testing/development.

Techniques Selected for Testing in Phase II

The techniques selected for testing in Phase II are:

1. Highway user revenue forecasting and analysis techniques.
2. Priority programming methodology.
3. Statewide energy conservation forecasting techniques.

The following sections provide descriptions of these techniques. More information can be obtained from the references cited in Table D-1.

HIGHWAY USER REVENUE FORECASTING AND ANALYSIS TECHNIQUES

Two highway user revenue analysis techniques are (a) the Highway User Revenue Model (HURM) and (b) the Short-Range Capital Resource Availability Model (SCRAM). Both techniques have been applied in Maryland and are currently programmed on Maryland DOT computer facilities.

The Highway User Revenue Model forecasts (a) revenues from gas tax collections, motor vehicle registration fees, titling (excise) tax collections and fuel efficiency of new cars; (b) automobile vehicle miles of travel; and (c) new car sales. The Short-Range Capital Resource Availability Model is used by Maryland to analyze the state's capability of using debt financing and the implications of alternative financial policies for revenue policies and total operating and capital programs.

These two revenue analysis techniques are potentially useful to states that derive a large portion of their revenue from highway user taxes and also rely upon bond programs to finance part of their transportation system. Improved techniques for revenue forecasting and analysis would enable states to anticipate future shortfalls and adopt countermeasures and to avoid using scarce staff resources for planning work on projects that cannot be built for many years.

The revenue forecasting and analysis techniques would be field tested in Kentucky, which has generally experienced a shortfall of highway user revenues in the past several years and a growing backlog of capital projects ready for construction. Its highway projects are funded from highway user revenues and it has in the past used bonds to accelerate capital construction. The ability of Kentucky's DOT to fund highway construction has decreased significantly in the last two or three years. It currently has at least twice as many highway projects in each federal-aid

category ready to let for construction as it is capable of funding. As a result of the revenue shortfall, the department's maintenance program has also suffered. The 1975 General Assembly appropriated some general funds for maintenance of coal-haul roads but the DOT request for general funds in 1976 was turned down.

Description of Method. The Highway User Revenue Model (HURM) solves a set of sequential equations to forecast highway user revenues for each year in the analysis period (up to ten years as currently programmed). The input data for each year in the analysis period include population, the wage rate, disposable income, the consumer price index, the unemployment rate, gas price, average speed, and a fuel efficiency index. Based on this input data, forecasts are made for vehicle miles of travel, fleet size, new car sales, sales-weighted miles per gallon, and fleet miles per gallon. Using these forecasts, gas tax collections, motor vehicle registration fees, and titling tax collections are then calculated.

The model requires some preliminary computations to estimate parameters used in the calculation of model variables. The effect of economic conditions (e.g., disposable income, unemployment rate) on vehicle miles of travel, new car sales, and sales-weighted miles per gallon must be determined. This can be done using regression analysis on data from previous years. In addition, several other parameters that must be estimated or postulated are (a) average auto occupancy rate, (b) a factor relating the value of travel time to the wage rate, (c) the vehicle scrappage rate, and (d) the rate at which annual vehicle miles of travel per automobile declines with increasing vehicle age. Finally, the equations used to calculate gas tax collections, motor vehicle registration fees, and titling taxes must be adjusted to reflect local tax rates and collection procedures. All of the parameters noted in this should be estimated using data from local sources. However, in the absence of local data, national data or Maryland data may be used unless significantly different local characteristics would be ignored by doing so.

HURM has been coded in the BASIC language as a program of approximately 240 steps. It requires values for nine variables for each of the years (up to ten) for which a forecast is desired and allows the user to specify a fuel efficiency standard. These variables range widely in terms of the certainty with which they can be postulated. For example, gas tax rates can be precisely defined, whereas such factors as the ratio of population to net disposable income and the unemployment rate are very uncertain beyond the very near future. However, the HURM program has been constructed such that it facilitates making several forecasts using slightly modified data sets, thereby providing a range of revenue forecasts compatible with the certainty of future economic conditions.

Undoubtedly, some modifications to the program may be necessary to make HURM operational in Kentucky. The manner in which revenues are calculated may need to be redefined in terms of more variables or may have to be changed to reflect different factors that taxes are based on, or different methods of revenue collection may be required. As stated above, the constants should be re-estimated using state data if possible. And finally, the HURM program may need to be appropriately modified (from a BASIC programming standpoint alone) to be run at Kentucky's computer center.

The Short-Range Capital Resource Availability Model is an algorithm that determines the value of bonds that should be issued in each of up to seventy-five years by solving linear programs, which minimize required revenues or maximize funds available for capital or operating programs. The linear programs incorporate three constraints for each case. The first represents the basic balance sheet equation that states that all income in a given year must equal expenditures. The second constraint represents the requirement as specified in the bond resolutions of the Maryland DOT, to maintain coverage of debt service payments, and computes in accordance with the criteria set out in those resolutions, the current and future financial capability to make such payments. The last constraint relates revenue, or operating or capital expenditures, to the previous year utilizing relationships defined by the user. In addition, SCRAM incorporates the assumptions that bonds are issued on the first day of the year, principal payments are made on the first day of each year, and that interest is paid every six months.

The SCRAM algorithm has been coded in FORTRAN IV as a main program with thirteen subroutines. It allows great flexibility in the establishment of existing and future financial conditions. It provides for up to twenty-five categories (and growth functions) each of revenue, federal aid, operating expenditures, and capital expenditures as well as for up to 125 existing debt payments and a maximum bond life of fifty years. The SCRAM program produces complete tabulations of all revenue, federal-aid, operating and capital expenditure categories in addition to summary tables of the source and disposition of funds, the new debt service, and current and future coverage over the entire analysis period.

In order to make the SCRAM model operational in a state other than Maryland, three tasks must be accomplished. First and most importantly, the financial structure of the model must be adapted, if necessary, to account for differences between the financial structure embedded in SCRAM and that of Kentucky. Second and most obvious is the formulation and coding of input data. The SCRAM program data requirements are minimal, requiring no special analyses beyond the postulation of basic financial parameters, such as required bond coverage ratios and bond maturity distributions. Last, the model must be made operational from a computer programming standpoint on the locally available computer system.

Priority Programming Methodology

The Priority Programming Methodology, which will be tested in the state of Maryland, identifies and assesses transportation improvement impacts affecting both transportation users and the community at large. Such impacts, benefits, and disbenefits are evaluated and used to develop time streams of present worth of benefits as a function of the year of implementation. The functional benefit and cost time streams are combined with future budget estimates and

subjected to linear programming analysis. The linear program selects and stages a mix of transportation improvements so as to maximize the total present worth of benefits capable of being realized, given the assumed budgets.

The priorities with which this methodology is primarily concerned are planning priorities, which tend to be long-range in nature. Program priorities are short-range and specifically consider the effects of short-term contingencies such as weather, material availability, and contractor capabilities. However, under ideal circumstances these two sets of priorities would be identical. Also, recognition must be given to the fact that the scheduling of certain investments may not be amenable to the priority methodology described here. The situation could arise when investments characterized by highly unusual or sensitive political impacts are being considered. In such cases, the methodology would serve as a guide rather than an absolute prescription.

This methodology was developed by members of the research team in coordination with the Ontario Ministry of Transportation and Communications. The Kitchener Area Highway Planning Study was used as the data base source to test and evaluate the techniques. A broad range of highway and transit improvements was analyzed. The results showed that a high percentage of the individual improvement priorities were logical and meaningful, and these were supported by informational output, which substantiated the priority assignment.

Description of Method. The methodology consists of a linear programming analysis that provides an optimum solution by ensuring that maximum benefit is derived from the expenditures. The linear program rearranges the timing of the improvements and produces an "output" within the budget constraint for each year. In assessing the priorities of transportation improvements, the linear program deals with three basic inputs.

1. Benefits (and Disbenefits)—Benefits, including negative benefits such as social and environmental impacts, were classified in the following categories: regional development, user, operator, social, environmental, and right-of-way. Typical examples of such benefits include travel-time savings, operating cost reductions, and increased transit mobility. Disbenefits include neighborhood disruption, noise, and air pollution. The linear program requires, for each candidate investment, the composite of the present worth of all benefits and disbenefits over the planning horizon for each possible implementation year in the budget period.

2. Costs—Costs include expenditures for capital construction and continuing maintenance. The costs differ for each year of implementation in the planning period and must be supplied to the linear program in base-year dollars for each implementation year.

3. Budgets—Estimates must be made of available budgets for each time period and supplied to the linear program in base-year dollars.

While the quantification of such variables as travel time and cost savings is conceptually a relatively straightforward procedure, variables such as social and environmental impacts present a problem. These impacts can be estimated as:

$$\textit{Benefit or Disbenefit (Value Equivalent)} = QSC$$

where:

Q = quantity—a measure of the amount of change that occurs due to the introduction of an improvement.
S = sensitivity—the relative sensitivity of the community concerned to quantity of the impact.
C = cost—the cost of preventing the impact, replacement cost, or a value judgment.

A priority analysis output contains the optimum schedule, a sensitivity analysis to input data variation, together with a full economic analysis on each improvement relating return on investment to expenditure. Included also is a net value of the benefits foregone or the costs incurred, if an improvement's position in the schedule must be altered. Benefit-cost relationships are fundamental to the product, permitting an economic interpretation of any marginal improvements.

Introduction of a triggering procedure causes improvements whose priorities are sensitive to social and environmental impacts to be flagged and directed for more detailed feasibility and public participation studies.

A budget analysis provides the sensitivity of altering the investment levels in any time period by displaying the corresponding changes in return, as well as the respective improvements deferred or added to the program.

With these outputs, a decision-maker can test alternative strategies, can be made aware of the consequences and, by means of an iterative process, can make decisions on the transportation investment program.

Statewide Energy Conservation Forecasting Techniques

A package of techniques is needed to assist the states in formulating and evaluating the transportation elements of the state Energy Conservation Plans that are required by the Federal Energy Administration (FEA) as a prerequisite for federal grants to implement various conservation measures. The 1975 Energy Policy and Conservation Act authorized $50 million for each of the fiscal years 1976, 1977, and 1978 to carry out the state Energy Conservation Plans, which may be prepared by each state. In order for states to receive federal funds for implementation of these plans, the governors each must submit to the FEA a state energy conservation feasibility report, which shall include an assessment of the feasibility of saving 5 percent of the state energy consumed by 1980, and a preliminary list of programs and activities to be included in the proposed plan (along with the estimated cost of implementing the plan). FEA will allocate $5 million to assist the states in preparing their plans. The plan must then describe how the energy savings will be effected. The Phase II project would consist of two parts:

1. A description of the range of possible transportation actions together with a general assessment of how effective these actions will be, both individually and in combinations, in reducing energy consumption and achieving other state

goals/objectives. The possible transportation actions include programs to promote carpool, vanpool, and public transportation, right-turn-on-red, as well as any system of incentives, disincentives, restrictions, and requirements designed to reduce transportation energy consumption with the exception of fuel rationing.

2. Testing a set of techniques (sketch planning and others) for assessing the impacts (energy, social, economic, environmental, travel) of alternative transportation actions.

Description of Method. The approach to the first part of the project would be to build upon the candidate transportation actions for reducing energy consumption. A range of alternative actions have been identified in literature.* The participants in the development of the actions would include the Georgia DOT and staff of FEA. Experience in the process of selecting combinations of actions would be synthesized to provide a structured method to assist other states.

The second part of the project consists of testing the techniques for evaluating the impacts of alternative transportation actions to reduce energy consumption. These techniques include, but are not limited to:

1. Energy Consumption Methodology—This methodology includes a series of fuel economy equations for various vehicle categories, such as auto, light-duty and heavy-duty truck, as a function of speed and delays. It takes into consideration the outputs of traffic models to estimate fuel consumption at the district and regional level associated with alternative land-use and transportation plans. Specifically, the inputs may include vehicular volume, vehicle miles of travel, vehicle hours of travel, and average speed.

2. Fuel Consumption Curves—These curves are based on the amount of fuel used per passenger-mile traveled for all passenger loading factors for each mode used in each travel pattern. The curves provide the fuel consumption characteristics for the principal modes of transportation found in intraurban, suburban-urban, and intercity travel. These curves can be used as a basis for determining the total transportation fuel consumption for a given mode for a study area, and they also show the effect of passenger load factors on energy-use efficiency.

3. Carpooling Energy Submodel—This model uses the Carpooling Impact Model to estimate regional fuel consumption resulting from alternative carpool/vanpool strategies. This model, however, does not consider the changes in operating speed, vehicle type, and other factors affecting energy consumption.

4. Transportation Model of the Wisconsin Regional Energy Model—The model forecasts annual statewide and subregional energy use and the associated pollutant emission in Wisconsin. The model consists of three submodels: a personal travel submodel, which consists of all automobile travel and local mass transit; an intercity mass transportation (rail, bus, air) submodel; and a freight submodel.

The personal travel submodel computes energy use and emissions by first determining the individual average travel demand in terms of the number of trips per day per person. These trips are then distributed by mode for local and intercity travel. Specific lengths are assigned to each of these trips and the resultant passenger miles by mode are converted to vehicle miles using load factors. Finally, energy use and emissions are determined by the vehicle mileage in each subarea. The intercity mass transport submodel and the freight transport submodel compile energy use assuming a proportion of national demand occurring in the state and the energy intensiveness of transportation.

5. PRIFRE/Energy Model—This energy model computes the composite vehicular fuel economy as a function of traffic flow conditions, vehicle mix, and other characteristics. Based on the PRIFRE model's principal output data, including actual flow rates, speeds, densities, travel times, delays, and queue lengths, this model calculates fuel consumption for each subperiod of time and each subsection of the freeway system. This model also aggregates the total fuel consumption over an entire time period and freeway system.

6. Energy—UTCS-1 Network Simulation Model—This is a vehicular fuel consumption submodel added to the UTCS-1 Network Simulation Model. The submodel estimates vehicular fuel consumption based on vehicle operating conditions and trajectory data simulated by the UTCS-1 model. Three types of vehicles—automobiles, trucks, and buses—are considered. For each vehicle type, the fuel economy (miles per gallon) is computed based on input values of instantaneous speed and acceleration. The fuel consumption (in gallons) with and without traffic controls is estimated for each network link and then aggregated over the network. The submodel has been used to estimate the energy savings resulting from the right-turn-on-red strategy.

7. Estimating Energy Consumption Reductions Due to Transportation Actions—Guidelines are provided for estimating reductions in energy consumption through transportation actions. Sample packages of actions have been developed for areas of different-sized populations. A range of expected percent regional energy reductions due to these actions is also presented.

Techniques for Future Testing/Development

This section contains descriptions of the eighteen techniques that were evaluated and rejected for Phase II testing. The descriptions are not of the techniques per se, but rather of the projects in which they would have been tested or developed further in Phase II. Some of these projects proposed straightforward demonstrations of individual techniques or groups of techniques to verify their transferability from one state to another. Other projects focused more on the development of methodologies responsive to high-priority needs identified during the Phase II state visits. As a result of the diverse nature of these projects, the appropriate approach for testing or developing them will vary on an individual basis. Some could be taken intact and applied by interested states. Others might serve as a preliminary description of future NCHRP projects, while some would be prototypes for development by FHWA, UMTA, or a university research center.

More information on nearly all the techniques described here can be obtained from the references cited in Table D-1.

* See *Guidelines to Reduce Energy Consumption Through Transportation Actions* by Alan M. Voorhees & Associates, Inc.

Simple Transit Ridership, Revenue, and Cost Forecasting Techniques

Description of Project. This project would test a set of simple analytic techniques that forecast ridership, revenues, and costs for local transit systems. These techniques would be useful in estimating the:

1. Subsidies required to maintain transit fares and services at particular levels.
2. Impacts of various types of transit fare and service changes.
3. Impacts of future economic and energy conditions on transit.

The forecasts would be used by states in making decisions about the financial feasibility of possible statewide transit service standards, capital and operating assistance to local systems, and other state policies affecting transit.

Proposed Approach. The preparation of a procedural guide of these techniques would draw upon two primary sources:

1. Analytical work done by New York DOT in which system ridership was predicted for alternative levels of fare and service (measured in transit vehicle miles).
2. Analytical work previously done by members of the project staff as part of a study of energy, the economy, and mass transit for the U.S. Congressional Office of Technology Assessment (OTA).

Also, Pennsylvania's guidelines (including forecasting techniques) for rural and small urban area transit planning and Massachusetts' preliminary efforts to forecast transit ridership in small urban areas are other potential key resources for this project.

The OTA work results would be used to expand the New York models to account for more than just average fare and system vehicle miles. For example, such factors as off-peak fare decreases, changes in parking and gasoline prices, and unemployment rate, and system speed increases can be accounted for in the analysis.

The forecasting models would be designed for manual application using readily available data from local transit operators. To ensure that this condition is met, new federal reporting requirements for transit operators will be investigated prior to the specification of the model.

Multimodal Program Evaluation Methodology

Description of Project. This project would develop and apply a methodology for the evaluation of candidate multimodal programs to provide, insofar as is practical in the operational context, the following desirable characteristics:

1. Common evaluation measures across different modal programs to facilitate comparisons and tradeoffs.
2. Comprehensive treatment of the most important factors involved in programming.
3. Information of importance to all those involved in programming decisions (e.g., state budget office, governor's office, legislature, and top officials of transportation agencies).
4. Effective use of available data and techniques.

A distinction should be made between this project and a project involving the use of an optimization technique or over-all weighting system. The latter type of project would make use of the results of the evaluation that would be conducted as part of this project.

Proposed Approach. A particular state would be selected that has multimodal programming responsibility within a single unit of a DOT. The state selected should already have available a reasonably thorough capability for separate program evaluation within each of the major programs and should be trying to integrate its programming function for all modes.

The evaluation framework established would include the definition of evaluation measures satisfying the information needs of all key decision-makers. Methods would be specified for collecting and analyzing all needed data and providing the required evaluation measures for all candidate elements of programs. Methods used would include several simple sketch-plan techniques such as described in Chapter Two. A work program would be developed assigning responsibilities for tasks, schedules, and manpower requirements. An incremental approach would be taken that would provide in the first year the most comprehensive coverage of all feasible evaluation measures, relying on judgment and approximate evaluation measures as necessary. The results would be documented in a manner most useful to other states.

Technique for Assessing Systemwide Tradeoffs Between Design Standards and Costs

Description of Project. The candidate project, which would be tested in a state other than New York, concerns:

1. A computer program (developed by New York DOT) that estimates the cost of improving the state highway system to meet a predetermined set of standards.
2. Guidelines for using this program and other analytic techniques as part of a process to reduce standards in response to limitations on funds available for highway improvements.

The input to the program includes a predetermined set of highway service standards and data on the condition and use of individual highway segments. The program:

1. Identifies deficient highway segments.
2. Estimates the cost of improving each segment to meet the standard.
3. Summarizes the costs on a statewide basis.
4. Calculates the effects of changes in individual standards on cost.

New York DOT used this computer program, together with subjective judgments about the effect on highway system performance of reducing individual standards, to gradually lower standards to meet a fiscal constraint.

Proposed Approach. A program listing and a description of the program logic have been obtained from New York DOT. Unless a careful examination of the program indicates problems, it is anticipated that no major effort would be required to refine the cost-estimating techniques. However, a problem might arise if a candidate state's high-

way system data are inadequate or are in a format not consistent with the input data requirements of the New York computer program.

Also, it would be necessary to prepare guidelines for estimating performance impacts of reducing individual standards. For some impacts, it may be useful to add subroutines to the New York computer program to calculate performance indices. For example, Pennsylvania has a computer-based technique for estimating the time and operating cost penalties to highway users of deficiencies. Linking the Pennsylvania and New York programs could provide tradeoff information on alternative sets of standards, enabling determination of the cost effectiveness of individual highway projects and the aggregate benefits of highway improvement programs.

Composite Mapping System

Description of Project. The Composite Mapping System (CMS) is a large-scale computer software package designed for graphic representation of socioeconomic and physical information over large or small areas. CMS can accept inputs of any form—tabular, printed maps, or sketch maps. The outputs are cartographic and statistical. It permits any spatial data to be overlaid, with various weights, and readily composed into simulated patterns called "composite maps." Its initial application was to display social and economic data for the Department of Commerce to facilitate its allocation of Economic Development Administration funds throughout the nation. Subsequently CMS was used on a statewide level in Arizona and Colorado and on a regional level by HUD Region VII.

Proposed Approach. The CMS software is available for the UNIVAC 1108 and CDC 6400 computer hardware. The CDC version of CMS with documentation is available from the Federation of Rocky Mountain States. Because many states have IBM systems, efforts are underway to convert CMS to IBM equipment. This can be documented and provided to all interested states.

Methodology for Predicting Statewide Economic Impacts of Varying Funding Levels

Description of Project. This project was developed to provide states with practical methods for evaluating the economic consequences of prospective major program components or entire programs. The need for this analysis capability takes a different form in different states, but it is one of the most common needs expressed in the survey of state planning and programming experience. To a large extent, this need is based on experience in interacting with state budget offices, legislators, governor's offices, and the public in trying to either:

1. Demonstrate the need for additional funds to sustain the transportation improvement program in the face of a severe financial squeeze.
2. Demonstrate that cutbacks in funding will have serious consequences on the state's economic health.

As more and more states seek to use general revenues or increase earmarked taxes, the need for information on economic benefits of transportation programs grows. Efforts to integrate the programming process for different modal programs also contribute to the need for economic impact information as a common evaluation yardstick.

Proposed Approach. A comprehensive economic evaluation methodology does not exist and its development is beyond the scope of this research project. Any Phase II project must be limited significantly. Development of a comprehensive economic evaluation methodology, covering all major economic effects beyond the direct-user effects, should be identified as a major future research need.

At the modest level of resources available for projects in Phase II, the emphasis would be on practical applications that produce major needed economic information. Attention would be focused on predicting impacts on a small number of major industries in a state that are most substantially affected by changes in the transportation system. Available economic data would be used to identify these industries. They would be analyzed to assess their dependence on each mode of transportation in terms of:

1. Costs and proportion of expenditures.
2. Relative importance of reliability, safety, and perishability.
3. The role that capacity or congestion plays.
4. The role that transportation plays in competition among firms in different locations.

Changes due to transportation would be measured in terms of employment, dollar volume of business, and effects on consumer prices. Transportation system changes to be investigated include effects of reduced maintenance expenditures of costs of truck operations, costs of changes in congestion levels due to system improvements or lack thereof, and effects of changes in user charges.

Rail System Planning Methods

Description of Project. This project would document and make available the most useful experience from states that have recently developed and applied techniques in state rail system planning. Most of the seventeen midwestern and eastern states directly affected by the Regional Rail Reorganization Act of 1973 have completed an intensive analytical effort culminating in the preparation of State Rail Plans in late 1975. These plans had to show that federal aid to branch lines to be subsidized was justified, based on a benefit-cost evaluation taking into account "lost jobs, energy shortages, and degradation of the environment." In addition to the branch-line evaluations, many states performed a variety of complex analyses of their rail networks and major components thereof.

This experience will be potentially useful for states in other regions as well as in the seventeen-state Conrail region in several ways:

1. When future abandonment cases arise.
2. When considering continuation of subsidy beyond the two years provided for in the Rail Act.
3. When considered a part of comprehensive multimodal statewide planning programs.
4. When responding to possible future legislation making

federal-aid funds available nationwide for rail improvements or operating subsidies.

Proposed Approach. Contacts would be made with FRA, the staff who worked with the U.S. Railway Association in preparing the Final System Plan, Conrail, and selected states that have recently developed and applied techniques in state rail system planning. Additional state rail plans and other source material would be assembled and analyzed. Based on this review, documentation would be provided concerning experience with data collection, methods, cost-benefit analysis, economic and social impact evaluation, and all other important planning activities of potential value to other states.

Planning for Elderly and Handicapped

Description of Project. This project would provide a procedure for considering the transportation needs of the elderly and handicapped and would be suitable for integration into the statewide transportation planning process. The technique would determine the magnitude of markets and costs for various types of service improvements. Based on the costs and benefits to riders, as well as to the system, the most attractive alternative can be selected for each community.

Proposed Approach. A procedural manual would be developed for this project. It draws on two major sources:

1. The study by the Maryland DOT in association with the University of Maryland and Johns Hopkins University.
2. The study by UMTA and TSC for U.S. DOT.

The Maryland DOT study developed techniques for identifying transportation submarkets and the potential and priority of areas by intensity of need for services and is easily adaptable for incorporation into the statewide planning process. The study for U.S. DOT identified costs and benefits of service improvements.

The procedural manual developed would be tested in an appropriate state.

Statewide Activity Allocation Model (SAAM)

Description of Project. SAAM is a policy-sensitive economic activity allocation model, which provides information to assist state decision-makers in evaluating the impacts of alternative transportation and land-use policies. SAAM is a Lowry-model descendant, which incorporates entropy-maximizing allocation functions and a mover/non-mover stratification scheme proposed by A. G. Wilson. SAAM also includes population holding capacities and service employment minimum thresholds (or central place factors). The model is designed to accept input requirements available to most state planning agencies. The output information includes population, employment, labor force, residential density, auto ownership, and median-family income for each small area of the state for a particular forecast year.

Proposed Approach. This model has been calibrated in the State of Connecticut by the research team. The documentation of the model including its description and the user's manual is complete. However, the model has to be tested further and applied in another state. This model includes four submodels, two of which are based on regression analysis. These two submodels need to be calibrated so that they may be applied in any state.

Emissions and Air Quality Projection Methodologies

Description of Project. Three specific methodologies are included in this project:

1. Emissions forecasting methodology (developed by the California Air Resources Board) that provides future-year emissions for both mobile (highway, transit, rail, and air modes of transportation) and stationary (power plants) sources.
2. Emissions projection methodology (developed by Environmental Research and Technology) that provides quick evaluation of land-use patterns in the plan development stage. The methodology is based on the use of annual emissions per unit area for each land-use category (or emissions per unit activity in the case of motor vehicles).
3. The proportional model, which relates emissions to air quality assuming a linear relationship between the concentration and the emissions rate of the pollutants.

Proposed Approach. These methodologies appear to be potentially useful for estimating gross air pollution impacts of alternative transportation and land-use plans. The second methodology has been applied in the Hackensack Meadowlands area in New Jersey, whereas the other two methodologies have been applied in the State of California. A procedural manual will be developed using the references available, and application of methodologies will be made in a state other than California (California emission standards are different from those of other states).

The test application will result in the evaluation of the projection methodologies and may result in generalized emission factors, eliminating the need for development of new factors for every application.

Air Carrier Demand Distribution

Description of Project. This technique involves the use of a modeling procedure to distribute passengers among airports in the Baltimore/Washington region for several airport development and accessibility alternatives. The procedure develops aircraft schedules based on preliminary demand forecasts at each airport and then redistributes passengers using an iterative process. This procedure takes into account airside capacity limitations but does not reduce access travel speeds in response to increased congestion. A logit model combines travel times and costs into a single index of disutility (for a particular airport and trip) and distributes passengers among airports.

Proposed Approach. This procedure is potentially very useful in metropolitan areas having competing airports or considering construction of an additional major airport. However, the number of situations where the procedure could be usefully applied is limited and the resources required puts it beyond the scope of Phase II testing.

Aviation System Cost-Effectiveness Analysis

Description of Project. This project would test in another state the methodology used in 1974 by the State of Oregon and Peat, Marwick, Mitchell and Company to develop a plan for general aviation airport improvements within the State of Oregon. The method includes:

1. Compilation of data on general aviation airports, operations, and proposed improvements at general aviation airports in the state.
2. A cost-effectiveness analysis to judge whether airports and improvements should be included in the Oregon Aviation System Plan.
3. Recommendations for additional financing.

The output of the method is a candidate statewide plan of state system general aviation airports, recommended improvements, and financing recommendations.

Proposed Approach. A procedural guide would be prepared showing other states how to compile the necessary data and choose a cost-effectiveness model with appropriate parameters. Oregon's implementation experience, since publication of their Aviation System Plan in 1974, would be fully documented.

The methodology is appropriate for sketch planning but requires the development of good information on likely costs and performance measures. The availability of consistent comparative information would make the cost of implementation reasonable. Without such information, considerable data gathering and engineering cost estimates would be necessary before results could be obtained.

Documentation of this work in Oregon is sufficient to allow similar methodology to be used elsewhere with adaptations.

Evaluation Reporting Methods in the Plan Development Process

Description of Project. One problem in statewide plan evaluation has been putting evaluation information into a format which clearly communicates issues and choices. In some of the states visited, much evaluation information was generated but was not communicated to, or not used by, decision-makers and the public in developing their views on the plan alternatives.

A well thought-out planning process is a prerequisite to a valid examination of the appropriate role of sketch-plan techniques in the successful development of a state transportation plan. Several states presently developing or updating state transportation plans are utilizing a systematic and comprehensive process of alternatives development, analysis of effects, citizen participation, and evaluation. For example, a plan development process has been outlined, work programs have been prepared, and divisions of responsibility agreed upon between the planning, programming, and modal implementation units by the Oregon Department of Transportation.

The planning process being implemented by Oregon includes twenty steps in the over-all system planning/system programming process, which precedes modal project implementation. The process deals with goals, issues, criteria, social, economic, environmental and land-use information, transportation technology, identification of transportation corridors and problems, and the development and evaluation of plans and programs.

Proposed Approach. A guide would be prepared describing evaluation formats and reports useful for communicating sketch-plan evaluation information, focusing principally on the means of communicating that information about choices to decision-makers, the public, and other staff groups.

Because a well thought-out, over-all plan process has been developed by some states, an opportunity exists to examine the means by which the steps in the planning and evaluation process are communicated to others. Formats and techniques for communicating information about policies, issues, and plan alternatives would be developed for state staff to utilize in all steps where evaluation information is to be communicated. These sketch-plan evaluation techniques will rely on textual, visual, and verbal information.

TSM—Packaging and Evaluating Alternatives

Description of Project. Common guidance is needed to assist the states and metropolitan planning organizations (MPO's) in formulating and evaluating TSM's and TIP's required under the recent FHWA/UMTA regulations. The state interviews showed that states and MPO's often went their separate ways on this issue. What appears to be needed is guidance on how TSM's and TIP's should be formulated and evaluated and what role the states and MPO's should play in providing information to assist in the process. The guidance should take the form of:

1. A methodological approach on the range of actions possible, the interrelationships of TSM's and TIP's to state energy conservation plans, and other programs.
2. Ways that actions can be packaged.
3. Specific tools for areawide and micro-assessment of packaged and individual TSM/TIP actions.
4. Criteria/standards to assist with evaluation.

Proposed Approach. An approach to carrying out this project would be to contact FHWA and UMTA in regard to what, in detail, they will be funding with respect to research. FHWA, for example, has programmed research in measures of effectiveness (MOE's) for TSM-type actions. Care would be exercised to assure no duplication of effort. After this consultation, states experiencing difficulty in the TSM/TIP process would be identified and two would be selected as test sites in which to carry out the research project described above. The product of the effort would be a report providing guidelines on the first three items in the project description.

Freight Transportation Demand Analysis

Description of Project. This methodology forecasts the demand for freight by three modes—rail, truck, and barge. Using the product of an input/output analysis, the methodology provides the following information:

1. Transportation expenditures by mode for fourteen manufacturing sectors.

2. Tons of freight by rail, truck, and barge.
3. Ton-miles by rail and truck.
4. Intercity VMT for truck.
5. Intracity VMT for truck.

Proposed Approach. The methodology was developed for the state of Kentucky. A procedural manual would be developed based on the available references and then tested in a candidate state. The drawback to the application of this methodology is the need for input/output analysis.

Port Commodity Flow Analysis

Description of Project. This project would make available to other states the method used in upstate New York to analyze waterborne commodity flows. The method includes:

1. Extensive collection of origin-destination and route data for present commodity flows.
2. Identification of least-cost alternative routings based on fully allocated costs rather than current rates and practices.
3. Estimation of the market potential for individual ports if least-cost alternative routings were used by shippers and consignees.
4. Calculation of regional economic benefits as the difference between present routings and least-cost alternative routings.

The output of the method—the market potential of ports and regional economic benefits—can be used, together with information about the constraints which prevent ports from realizing their market potential, in developing and assessing policies related to waterborne commerce and in port planning.

Proposed Approach. Current documentation of the method is inadequate for preparation of a procedural guide to implement this method in states other than New York. Considerable communication with Frederic R. Harris, Inc., would be necessary before a procedural guide could be prepared. This method does not qualify as a sketch-planning technique because it involves considerable data collection and manipulation to determine present commodity flows and to estimate the costs associated with current and alternative routings. Thus, a major resource commitment would be required to test the method. It is unlikely that any state would make such a commitment unless it is currently engaged in or plans to initiate a major port planning effort.

An alternative approach would be to generalize the method so that it can be applied to all commodity movements. The product of such an effort could be a procedure for developing a commodity origin-destination table and assigning the table to a multimodal commodity flow network. While this would broaden the range of applicability of the method, it would require an even greater data collection and manipulation effort by the state (given the generally poor data on goods movement by truck) and a major effort in technique development. Further, while the product of this approach might be useful in a comprehensive state-level goods movement study, it would be of limited usefulness in rapid sketch-planning testing of policies, plans, and programs.

Combine Performance Effectiveness Analysis with Project and Program Monitoring System

Description of Project. This candidate project would integrate into a single analysis package computer techniques for developing and listing cost-effective plans and programs as well as procedures for monitoring how well current agency expenditures are leading towards implementation of such plans and programs.

This work could be done as an adjunct to work on further development of sketch planning methods of cost effectiveness or performance effectiveness analysis.

Proposed Approach. The primary sources for development of these techniques would include the work of AMV for the Province of Ontario (*153*), the cost effectiveness and project rating programs developed or under development by several states, and the Utah project management system.

Alternatively, program monitoring could be done manually and fed into the rating process as another factor representing current estimates of uncertainty in terms of project costs and completion dates.

Project Management System

Description of Method. Utah's computerized project management system keeps track of planned versus actual progress on Utah's federal-aid highway programs. The system monitors man-days spent on each project and current expenditures on each project. This enables top management to keep up-to-date on how manpower and dollar resources are being expended. The information provided by the system is critical to management efforts to maximize over-all program benefits by keeping track of whether particular projects are remaining within their intended scope and budget.

Proposed Approach. The Utah project management system would be implemented by another state, drawing heavily on interaction with Utah staff in order to provide guidance. In addition, interaction might be necessary with the consultant personnel who assisted Utah in the development of the information system.

At the time of initial visits to Utah (January 1976), the project management system was not completely operational due to computer program difficulties. It is not known whether or not the system can be guaranteed to be fully operational for adaptation by another state.

Methodology to Link Highway System Planning and Project Planning

Description of Method. The transition of a highway project from the stage at which a need is first identified or a proposed project first appears on a system plan to the stage where detailed route location/preliminary engineering work is to begin is a very important process to a state transportation agency. Scarce agency resources can be wasted if the proper information to facilitate this transition is not available.

Several states, most notably Maryland and New York, have developed techniques useful in moving a project from the system planning level to the project planning level in such a way that information developed at the systems stage is used to guide the project planning work.

The New York report is more limited than the Maryland report in that there is no environmental overview like the one in Maryland's system planning report. However, the New York report identifies the transportation problem and related factors, possible transportation solutions, the specific project proposed to solve the identified problem, and a preliminary evaluation of the project.

Proposed Approach. Working with a state, a method can be implemented that combines the best features of both the Maryland and New York procedures. The project would include testing of sketch-planning techniques that could be used at the system planning level to develop the information needed to define the scope of the project planning study. Such techniques might include:

1. The direct traffic estimation method.
2. The traffic forecasting technique used in the "Guide to Forecasting Travel on the Interstate System."
3. A computerized environmental mapping system, which is being used in Maryland.
4. Quick and approximate air quality and noise quality forecasting methods.

The techniques would be reviewed and evaluated and the most desirable techniques would be described in the procedural guide.

The second important component of the research project will involve preparation of a reporting format that contains all the best features and information found in both the Maryland and New York reports. The purpose of the proposed system planning report would be to:

1. Clearly define the objectives of the proposed project (transportation problem).
2. Early in the planning process define potential social and environmental problems that could hinder project development.
3. Define the scope of the project (including mapping) in sufficient detail to serve as the basis for the project planning work program.

OPERATIONAL TECHNIQUES

The purpose of this section is to identify fully operational techniques for use in statewide transportation planning and programming and to provide references to guidelines for their implementation.

Those techniques particularly useful in responding to specific information needs are given in Tables 1 through 7 (Chapter Two). The list ranges from techniques that have already been applied in many states to those currently under development and which have never been applied. Between these two extremes there are many techniques that have been applied in a few states and which represent a significant improvement over current practice in other states. The highest priority, fully operational techniques (along with other high-priority techniques under development) were incorporated in candidate projects for Phase II testing. However, there are other fully operational techniques which, although they did not qualify as high-priority techniques for Phase II testing, could nonetheless prove useful in other states.

A listing of fully operational techniques is presented in Table D-1. This listing includes fully operational techniques that are incorporated in Phase II candidate projects as well as other fully operational techniques useful in statewide transportation planning and programming. The first column of the listing identifies where the technique is described, the second column names the technique, and the third column indicates a reference where more detailed information on the technique can be found.

TABLE D-1

LIST OF REFERENCES FOR OPERATIONAL TECHNIQUES

TABLE[1] REFERENCE NUMBER	TECHNIQUE	REFERENCE FOR ADDITIONAL INFORMATION
Environmental—Air Pollution		
1-a.1	Emissions Forecasting	*89*
1-a.2	APRAC-1A	*93*
1-a.3	Proportional Model	*90*
1-a.4	Gaussian Diffusion	*86, 95, 101, 105*
1-a.5	Larsen's Model	*90*
1-a.9	Air Quality for Urban and Industrial Planning (AQUIP)	*96*
1-a.10	Michigan Air Pollution Model	*42a*
1-a.13	Environmental Impact of Policies	*80*
Environmental—Water		
1-b.2	Urban Storm Water Runoff Model	*111*
1-b.3	Storm Water Management Model	*114*
Environmental—Noise Pollution		
1-c.1	Noise Nomographs	*109*
1-c.3	Highway Noise Prediction Model	*106*
1-c.4	SAPOLLUT	*83*
1-c.5	Michigan Noise Model	*42b*
Environmental—Energy		
1-d.2	Gasoline Consumption Model	*42c*
1-d.3	Highway Fuel Consumption Computer Model	*119*
1-d.5	Carpooling Energy Submodel	*116*
1-d.6	Energy Submodel—UTCS-1 Network Simulation Model	*118*
1-d.8	Wisconsin Regional Energy Model, Transportation Model	*117*
1-d.9	Fuel Consumption Curves	*121*

Table D-1 (continued)

TABLE[1] REFERENCE NUMBER	TECHNIQUE	REFERENCE FOR ADDITIONAL INFORMATION
Environmental—Natural		
1-e.4	Environmental Sensitivity Computer Mapping	*42d*
1-e.6	Composite Mapping System	*123*
Social		
2-1	Proximity Analysis	*42e*
2-3	Neighborhood Social Interaction Index	*68*
2-4	Housing Displacement Model	*68*
2-5	Social Feasibility Model	*68*
2-6	Mobility Index	*68*
2-7	Social Capacity Indicators	*68*
2-8	Stability Index	*68*
2-9	Statewide Mobility Indicators	*42f*
2-10	Psychological Impact Model	*42f*
Economic		
3-3	Economic Base Analysis	*78*
3-4	Input-Output Analysis	*25*
3-5	Multi-Regional and Multi-Industrial Forecasting Model	*72*
3-6	Economic Impact of BWI Airport on Maryland	*73*
3-7	Economic Impact of Baltimore Port on Maryland	*74*
3-8	Analysis of Transit System Productivity and Equity	*140*
3-9	Railroad Community Impact Analysis	*42h*
3-10	Regional Multiplier Analysis	*71*
Travel		
4-2	Forecasting Coal Transport Demand	*35*
4-3	Diversion Technique for Estimation of Highway Speed Rail Ridership	*46*
4-5	Sub-Area Isolation Technique	*52*
4-6	General Aviation Activity Forecast	*41*
4-7	Air Passenger Distribution Model	*40*
4-8	Forecasting Regional Air Passengers (Macro Approach)	*40*
4-9	Forecasting Regional Air Passengers (Micro Approach)	*40*
4-10	Demand Forecast From Region to Other Cities	*40*
4-12	Highway Needs Evaluation Model	*37*
4-13	General Aviation Assignment Model	*41*
4-14	Freight Network and Distribution Algorithm	*34*
4-15	Transportation Demand Model for Manufactured Goods	*34*
4-16	Transportation Demand Model for Agricultural Goods	*35*
4-18	Passenger Demand and Mode Split Models for Intercity Travel	*38*
4-19	Planning for Elderly and Handicapped	*50*
4-20	Statewide Weekday Travel Model	*53*
4-21	Statewide Weekend Travel Model	*54*
4-22	California Statewide Model	*30*
4-24	Corridor Location Dynamics Model	*42i*
4-25	Fratar Model	*39*
4-26	Direct Demand Model	*29*
4-28	Connecticut Weekend Travel Model	*45*
4-34	Michigan Statewide Model	*42j*
4-35	Effective Speed Model	*42k*
4-36	Level of Service Model	*42l*
4-37	Capacity Adequacy Forecasting Model	*42m*
4-38	Passenger Demand and Modal Split Model—Intercity	*42n*
4-39	Statewide Commodity Flow Matrix	*42o*
4-40	State Trunkline Establishment	*42p*
Development		
5-1	Trend Procedure	*55*
5-3	Statewide Activity Allocation Model	*64*
5-4	Demographic and Economic Modelling System (DEMOS)	*25*
5-5	Bay Area Simulation Study Model (BASS)	*65*
5-6	EMPIRIC	*59*
5-7	Urban Systems Model (USM)	*63*
5-8	Projective Land Use Model	*56*
5-9	Development Pressure Index	*60*
Financial		
6-1	Rail Abandonment and Subsidy Requirements	*35*
6-2	Revenue Cost Analysis of High-Speed Rail Service	*46*

Table D-1 (continued)

TABLE[1] REFERENCE NUMBER	TECHNIQUE	REFERENCE FOR ADDITIONAL INFORMATION
6-3	Benefit Cost Analysis of High-Speed Rail Service	*46*
6-4	Short-Range Capital Resource Availability Model (SCRAM)	*138*
6-5	Technique for Projecting Transit Deficits	*17*
6-8	Analysis of State Capability to Meet Highway Construction Needs	*18*
6-11	Cost/Benefit Analysis	*136*
6-14	Technique for Assessing Systemwide Tradeoffs Between Design Standards and Costs	*61*
6-15	Highway User Revenue Model	*62*
Administrative		
6-16	Systems Planning Report	*129*
6-17	Problem Definition and Project Proposal Report	*131*
6-18	Railroad Financial Impact Analysis	*42q*
Plan and Program Evaluation		
7-1	Priority Ranking of Branch Lines	*152*
7-2	Time Staging Analysis	*154*
7-3	Transportation Resource Allocation Model (TRANS)	*145*
7-6	Cost/Benefit Analysis	*42r*
7-7	Priority Programming Improvement Methodology	*153*
7-8	Priority Analysis for Ranking Transportation Projects	*142*
7-9	Sufficiency Rating	*155*
7-12	Utah Priority Index	*161*
7-13	Cost Effectiveness Ranking for Airports	*47*
7-14	Sketch Planning Approach to Statewide Transportation Planning	*141*
7-15	Evaluation Matrix	*143*
7-16	Procedures for Rail Planning	*165*
7-17	Highway Needs Evaluation Model	*162*
7-18	Highway Investment Analysis Package	*147*
7-19	Dial-a-Ride City Selection	*42s*
7-20	Objective Priority Programming Procedures	*163*

[1] Tables 1 through 7 are given in Chapter Two.

APPENDIX E

TECHNIQUE EVALUATION CRITERIA

Twenty-one high-priority projects were identified for further evaluation. Sufficient funds are not available to conduct all of these projects in Phase II. Hence, it was necessary to develop some criteria for evaluating these projects in order to determine the highest ranking ones, which can be tested in Phase II. This appendix describes the evaluation criteria that were developed.

EVALUATION CRITERIA

To select a set of projects for testing in Phase II from the twenty-one that were identified, it is necessary to have specific evaluation criteria. These criteria would be the basis for ranking of projects by their relative desirability. Table E-1 gives four basic criteria for evaluation of projects and the factors which influence the rating in each criterion. Based on these criteria, an ideal project would be one that needs research, has a high probability of success leading to results of great utility, and could be accomplished at low cost. The following paragraphs discuss each of the criteria.

Need for Research

The need for research in a project may be defined as:

$$N = G \cdot S \cdot D$$

where:

- N = need for research.
- G = the gap in knowledge in the field to which the project belongs; $0 \leq G \leq 1$
  - $G = 0$ = no gap, perfect understanding
  - $G = 1$ = no understanding at all
- S = the role of the project in improving statewide plan and program evaluation; $0 \leq S \leq 1$
  - $S = 0$ = no importance; peripheral to statewide plan/program evaluation
  - $S = 1$ = critical importance
- D = the level of effort being devoted to research on the project; $0 \leq D \leq 1$
  - $D = 0$ = high current level of effort and thus high likelihood of duplication

Thus, the measure of need is characterized as a variable N $(0 \leq N \leq 1)$. Projects that were duplicative of other ongoing research were eliminated from consideration in the initial screening. In symbolic notation,

$N = 0$ = project is duplicative.
$N = D \cdot G \cdot S$ = project is not duplicative.

TABLE E-1

CRITERIA FOR SELECTION OF RESEARCH PROJECTS

CRITERIA		INFLUENCE FACTORS
1. Need for research (N)	increases with	• Gap in knowledge
	increases with	• Importance of area relative to state level plan/program evaluation
	decreases with	• Amount of research underway or projected in area
2. Utility of results (U)	increases with	• "Sketch Planning" nature of candidate project
	increases with	• Contribution to providing information for state-level decision making
	increases with	• Potential for immediate application
3. Probability of success (P)	decreases with	• Technical difficulty of achieving project (0 if it can't be done in Phase II)
	increases with	• Potential for achieving useful partial results
	increases with	• Availability of background knowledge
	increases with	• Capability and willingness of state to sponsor project
4. Costs (C)	increase with	• Manpower requirements
	vary with	• Skills requirements
	increase with	• Equipment and facilities requirements
	increase with	• Extent and complexity of state
	increase with	• Input data requirements of methods

Utility of Results

The utility of results, U, of a project would be 1 for immediate usefulness of results. Results of no value would be rated 0. It may be postulated that N and U will be directly related. If there is a great need for the research project, then there will be utility in the successful results. However, because of the nature of the Phase II effort and the project panel's direction, research projects of a "sketch planning" (SP) nature that were likely to provide critical information (CI) for statewide decision making and that had potential for quick (Q) application were judged to be very significant. In the evaluation conducted here, U was estimated as:

$$U = SP \cdot CI \cdot Q$$

Probability of Success

In this study, the probability that the project will be successful, p ($0 \leq p \leq 1$), was estimated giving consideration to technical difficulty, potential for achieving useful results, availability of background knowledge, and the capability and willingness of the sponsoring state. The last factor was judged most important in determining the likely success of the project. If no potential sponsor was envisioned, the project was given a value of zero.

Effectiveness

The factors U and P in this expression provide an estimate of the expected value of the research results,

$$\bar{U} = U \cdot P$$

In the more general approach described above,

$$\bar{U} = U^{**},$$

where:

$$P(U^{**}) = 0.5$$

that is, U^{**} is the mean of the distribution of utility, P (U).

Within a context of limited resources to be utilized on research, it is desirable to pick the projects of greatest relative value. The measures of expected utility, $\bar{U} = U \cdot P$, refers to the utility of the project in reference to other projects. The measure of need (N), however, refers to a field to which the research is directed. The overall effectiveness of a project is then measured as:

$$E = N \cdot U \cdot P$$

which is an estimate of the relative expected utility of the project. Then it may be said that a project (i) is of greater value than another project (j) if $E_i > E_j$. If $E_i = E_j$, the projects are of equal merit relative to effectiveness.

Measure of Cost

The measure of cost, C, in this analysis is simply a direct estimate of the level of technical effort required in professional person-years. This estimate approximates manpower requirements, skill requirements, equipment and facilities, extent and complexity of the pilot state, and input data requirements of the techniques.

Cost Effectiveness

The Phase II work program was developed recognizing the budget constraints available for the next phase of work. However, other lower ranking projects are desirable and they are recommended for conduct by other researchers or states. The best or more preferred project is that which has the highest value of the ratio of effectiveness to cost, E/C. This criterion can be applied satisfactorily so long as the various research projects under consideration meet the conditions that:

1. Selection of any one project does not preclude selection of others.
2. Implementation of any particular project does not influence the costs or effects of any other projects.

This ratio (E/C) can be computed for each project, and projects can be ranked in order of decreasing values. Allocation of funds would start with the first project in the list and proceed downward until all projects are implemented. However, with the budgetary limitations on Phase II, only a small number of projects can be implemented.

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