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FOREWORD

The papers in this Transportation Research Record focus on various aspects of transportation planning ranging from state and regional planning to metropolitan and subcommunity planning.

Hansen and Lockwood review the metropolitan transportation planning process of the 1960s, discuss the shortcomings, and present the elements of a new process that is beginning to emerge through actual planning experience. According to the authors, a major feature of this new process is its flexibility to respond to unanticipated issues and problems, i.e., to salvage variable techniques from the past and relate them with innovative techniques in a new institutional mold.

Schleifer, Zimmerman, and Gendell discuss the community aggregate planning model, which was designed as a sketch- or strategic-planning tool. The model is designed to directly produce easily understood transportation systems performance measures, including information such as a description of the supply alternative being evaluated, its costs, land consumption, residential and business relocations, system operating speeds and costs, air pollution emissions, and energy consumption.

Page, Demetsky, and Morris present a circulation simulation model to be used in a heuristic method of evaluating and selecting from alternative transit designs. The simulator is designed to measure changes in the performance of a trial transit system through variation of the design parameters, including location of transit modes, modal demand and delivery for transit, vehicle capacity and speed, location of routes, and number of vehicles per route. The transit model output includes the system, the route and vehicle performance characteristics, the number of passengers served, and their average in-system travel and wait times.

Sanders and Kowolaski present a conceptual approach to formulate a more comprehensive program for studying and improving trails for park and recreational areas. A review of the growing impact of park and recreational areas is given, and the importance of trails is presented. They also discuss significant trail problems; increase in demand, periodicity, lack of overall planning; and poor design standards.

Kinstlinger discusses the purposes and objectives of the Regional Rail Reorganization Act of 1973 including its planning requirements and the planning efforts of the Pennsylvania Department of Transportation and other states in the Northeast and Midwest. The author points out that federal rail planning is defective because it places undue emphasis on abandonment of excess trackage as the solution to the railroad problem and uses fully allocated system cost rather than avoidable costs for evaluation of branchline viability. The author also points out that federal rail planning has given insufficient consideration to future potential of the rail mode in moving persons and goods and to energy, environmental, and social needs of the communities for continued rail service.

Goldberg and Stander report on the progress being made in developing a regional simulation model that is interactive and linked with employment, population, land use, and transportation components. Particular emphasis has been placed on developing a housing model that forecasts total supply and demand for the region and further allocates these totals to subareas. The model also uses microspatial data to generate successive housing forecasts at the macrolevel.

Wilson discusses experience in Wisconsin as it relates to state-regional transportation planning. He states that, although the Wisconsin experience does not project precise roles for state departments of transportation and multicounty regional planning commissions in cooperative transportation planning, directions are suggested in the paper for state-regional planning coordination.

METROPOLITAN TRANSPORTATION PLANNING: PROCESS REFORM

Walter G. Hansen and Stephen C. Lockwood, Alan M. Voorhees and Associates, Inc.

Shifting public values, increasing competition for public resources, and improved technical capabilities have rendered obsolete certain aspects of the conventional regional transportation planning process. Several recent regional planning reviews and restudies have surfaced a new approach. This paper suggests how philosophy, organization, staffing, and technical approach can be balanced in a new process to incorporate the concern for long-range regional issues with short-range localized issues. The implications of such a restructuring of the planning process will be most dramatically felt in the redefinition of a plan as an open-ended document in response to the current status and future options for a continuing improvement program.

•IN many cities, the transportation plans and programs developed in the 1960s and early 1970s have been questioned or curtailed because of their narrow focus and their inflexibility. They

1. Failed to incorporate environmental, economic, and social concerns;
2. Overconcentrated on long-range capital-intensive solutions at the expense of immediate action, low-cost improvement;
3. Were exclusively devoted to improving supply rather than to dealing with demand modifications as well;
4. Tended to be concerned with a single mode or facility type;
5. Lacked mechanisms for the equitable implementation of plans and excluded meaningful community participation; and
6. Failed to provide easily observable evidence that transportation service was getting better rather than worse.

These shortcomings were extensively discussed in the early 1970s and have led to a variety of reforms: environmental law, joint planning regulations, shifts in capital improvement focus to transit, increasing attention to low-cost operations improvements for both highway and transit, and new concern for system and demand management. The speed at which these changes have taken place has left the conventional planning process behind with its long-range regional focus, its closed-shop style, and its inflexible use of complex planning methodologies (1). However, only recently have the full outlines of a viable new process begun to emerge through actual planning experience as distinct from academic speculation or governmental fiat (2, 3, 4, 5). This new process is derived from recent experience with several regional and urban transportation planning studies, restudies, and reviews whose common elements were large size, complexity, and controversy (6, 7, 8, 9). The process builds on an understanding of the necessary relationships among the philosophy, the organization, and the technical approach required for responsive planning in a changing environment.

A major feature of this new process is its flexibility to respond to unanticipated issues and problems—salvaging valuable techniques from the past but recasting them

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with innovative techniques in a new institutional mold. Although transportation planning will continue to change and respond to specific situations, the basic elements of the approach presented, if exploited, will radically alter the nature and function of regional transportation plans.

PRINCIPLES OF A NEW PLANNING PROCESS

Urban transportation planning is, first, a political decision-making process concerned with trade-offs among the conflicting values of different groups in society and, second, a technical processed concerned with the generation of information on the consequences of alternative courses of action. To ensure that the decision process is fully informed of both the technical facts associated with the choices and the response to these facts by societal groups with differing values, the new planning process must

1. Actively involve the informed participation of all affected groups having conflicting values;
2. Institute a technical analysis directed toward the development of equally detailed levels of information on all potential courses of action rather than toward the recommendation of a preferred solution;
3. Ensure that all technical analyses and findings are provided to all interested groups in an unbiased and easily obtainable manner on a timely basis, i.e., all technical information should be as available to any participant as it is to the decision maker; and
4. Clearly identify how, by whom, and where decisions are to be made and provide an uncomplicated and direct process whereby all interested groups have the opportunity to influence those decisions.

Both one-time studies and continuing technical strategy processes must be made of three interrelated components: organization, staffing, and technical approach. Effectiveness is more related to the balance achieved between these components than to the strength and weakness of any one of them.

ORGANIZATION

All decisions concerning the desirability of a particular transportation facility or service must be understood as policy choices, trading increases in transportation service for community and environmental disruption and dollar costs.

A fully informed decision maker must know not only the technical facts surrounding a particular decision but also the response to these facts by the various interest groups in society for which the planning is being done. This requirement implies more citizen participation than that offered by previous transportation planning and has important implications for the institutional structure of the political and technical organizations involved, the participation of public and local interests, and the nature of the technical assistance for such a process.

Institutional Structure

There is no single formula for organization, but at a minimum, a structure for the new process must

1. Avoid spurious distinctions between technical and community representation since many key issues in the new approach combine technical, qualitative, and value issues;
2. Strike an appropriate balance between political representation of the affected subregions and the regional interest;

3. Establish direct communication between the technical process and the ultimate decision maker;
4. Maintain continuity in an institutional structure established for planning, ongoing implementation, and operation;
5. Permit the representation or direct participation of interest groups representing the complete range of values in the planning process; and
6. Include within the decision-making structure institutions responsible for both regional and local land use planning.

The present hierarchical decision-making structure associated with the transportation planning does not respond well to these needs. Such a structure, consisting of technical and policy committees made up from members of transportation and land use agencies, has a tendency to isolate the decision maker from controversial policy choices during the process. Although membership of these committees could be broadened to include selected representatives of other value positions, e.g., environmental or energy issues, a single-level committee structure is always torn between assisting the decision maker in making an informed choice about the course of action and the overall technical and administrative management of technical studies. A possible structure to resolve this problem is shown in Figure 1. As indicated, two separate committees, not sequential but simultaneous, would be established. The steering committee's function would be to advise the decision maker about the issues surrounding the alternative courses of action and the policy or value position of various segments of the community on these issues. Its membership would be composed of representatives of a wide range of interests, such as business, ecology, and transportation, and of ex officio members from the transportation agencies and local governments. The planning coordinating committee would be involved in the daily administration of the study to ensure that the objectives set forth by the decision maker, advised by the steering committee, are achieved as efficiently as possible and in a technically responsible manner. Its membership would be made up of representatives of organizations that would be involved in either the administering or the financing of the study, i.e., for the most part, state and local transportation and land use agencies in the metropolitan area.

The planning (or study) director would be directly responsible to the decision maker. The chief requirements of this position are the ability to handle, in an unbiased manner, the controversies that emanate from the steering committee and to ensure that each position is given appropriate weight in terms of the allocation of staff resources and the presentation of results. In this type of structure, the decision maker receives input from (a) the director and staff, who provide the technical findings of the various studies conducted; (b) the steering committee, which presents information on the various value positions held by parts of the community and on the community satisfaction or dissatisfaction with the type and nature of technical information supplied by the study staff; and (c) the planning coordinating committee, which evaluates the technical adequacy of the information supplied and the study process itself. This organization can be duplicated in subregional studies that are the focus of the new planning process.

Establishment of Process for Effective Citizen Participation

Citizen participation must become an equal partner with the technical staff in the planning process and cannot be relegated to a passive position in expressing approval or disapproval of technical study results. It must become an integral component of the planning process, sharing responsibility with the technical staff for identifying issues and problems, devising alternative solutions, evaluating solutions, and expressing an informed choice about the course of action desired. So that community participation can assume these responsibilities, near-revolutionary changes are required in the transportation planning process. The decision maker, the planner, and the community must recognize that each has mutually supporting and equally important responsibilities in the study.

The decision maker must be decisive and must clearly specify the issues to be de-

Figure 1. Study organization.

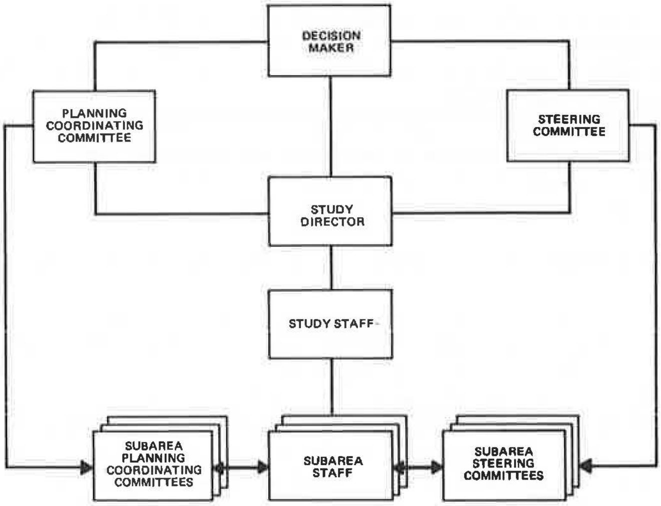
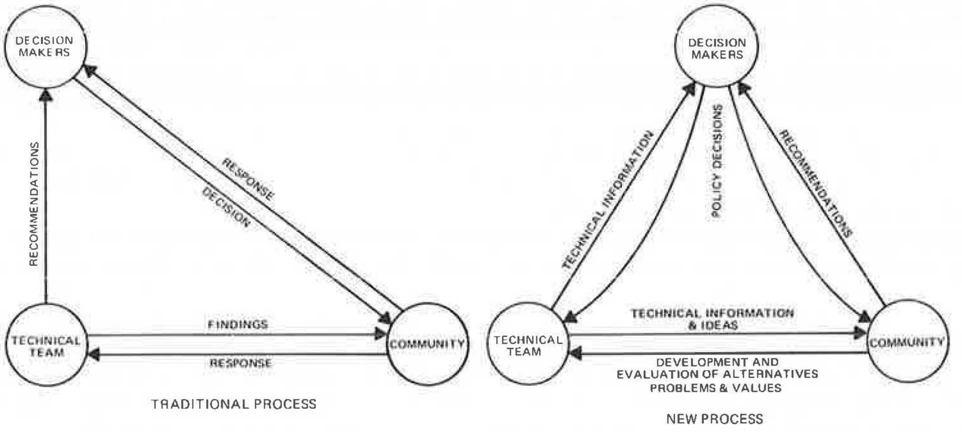


Figure 2. Process comparison.



cided, the time when those decisions will be made, and the manner in which they will be made. Without clear specification by the decision maker, the technical and community participants will not clearly understand what they are to accomplish. The community participants and the technical team jointly participate in the specification of problems, alternative plans, and relevant evaluation issues. The responsibility of the technical team is to provide information on the costs, feasibility, and impacts of these alternatives to both the community participants and the decision maker. The role of the community participants is to develop informative and reasonable arguments for the decision maker regarding the pros and cons of the various alternatives and recommendations for decisions.

Figure 2 shows that the types of information flowing among the various components of the new planning process are dramatically changed from those of traditional planning. The technical team does not make recommendations that involve choosing a value position, and the community participants do not respond to a recommended course of action by the decision maker but propose recommendations for decisions. The achievement of this process requires significant changes in the administration of transportation studies. These changes primarily revolve around the manner and timeliness with which information is provided to other than public agencies and the technical study staff. For the community participants to fulfill their role, they must have access to the same information as the other participants, including direct access to the study's technical staff and files. Administrative processes that require clearance of documents or other information prior to public release are inappropriate and will effectively negate attempts to implement a community participation process.

Techniques that have proved useful in community participation have been the focus of considerable speculation and documentation. The major lesson learned in practice is that a wide range of techniques are appropriate in different contexts. In all cases, however, considerable effort and forethought are necessary on the part of the technical staff to administer and play its role in community-technical interaction (10, 11).

An open and participatory two-way communication process requires considerable nurturing to ensure its maintenance and balance. Community participation may develop previously unforeseen issues; therefore, the total work plan cannot be completely detailed at the beginning. Building responsiveness into the planning process requires a certain degree of creative study management.

Technical Staff

The role of the technical staff is to assist the community in clarifying the issues to determine a course of action that is physically practical and economical and that represents an acceptable distribution of positive and negative impacts. The staff will have several roles: technical advisor to decision makers, agents of the responsible authority, speaker for interests not represented, conflict manager and negotiator, and producer of facts and alternatives. Although several of these roles may be in conflict, experience has shown that a staff can perform all of them under two conditions:

1. It must not be the focus of making recommendations. If it becomes an advocate, the neutrality required to clarify and understand competing interests would be considerably suspect by all participants. It can perform the issue clarification, alternative generation, impact prediction, evaluation, and community interaction functions only if it is free of advocacy.
2. It should be sufficiently free of the client institutions to retain the independence required for even-handed treatment of issues and public credibility. This independence requires that the staff or study director and staff report directly to the decision maker.

TECHNICAL APPROACH

Integration and responsiveness inevitably require a planning process that can incorporate a broad range of interrelated solution approaches to a given set of transportation and transport-related problems. Such a process must be able to incorporate

1. Long- and short-range solutions to both immediate and anticipated problems;
2. An incremental approach to multimodal improvements;
3. A comprehensive regional focus and a facility-specific view;
4. Reliance on operations and controls to allocate existing facilities and services and additions to supply through intensive improvements;
5. Use of demand management and supply management approaches;
6. Close relationships with land use policy as growth management becomes more feasible;
7. Careful evaluation of alternative courses of action;
8. Equal concern for transportation cost, benefits, and external impacts and their distribution; and
9. Recognition of technical, policy, and value uncertainties in planning through sensitivity analysis.

These simultaneous and conflicting demands doom a planning process that focuses exclusively in any one time frame, at any single geographic scale, or on any single solution. The major technical reorientation of planning must, therefore, be on developing a framework where long- and short-range planning are concurrent and interactive for both regional system and subregional facility or service, and these temporal and geographic scales can be bridged by an incremental approach.

Regional and Subregional Planning

Except for air pollution, the major negative impacts associated with transportation improvements are readily visible only at the subregional scale, and experience has shown that only corridor-scale design will produce sufficiently detailed information to respond to the demands of a participatory process. Conversely, ad hoc subregional facility or service studies done without reference to their regional land use and transportation implications are likely to shift transport problems from one area to another, fail to take full advantage of complementary actions in other subregions, or fail to achieve long-term benefits and regional objectives. System and corridor-level planning must be an on-line, interactive process, and each scale of activity should provide a part of the information required to make an informed decision relative to the work and potential implementation of a particular action. Figure 3 shows the planning process implied by these requirements. The implications of such a process are that the regional plan will no longer provide a single basis or justification for a specific facility implementation or an action program but will become one element or component of an evaluation process.

The new approach consists of a series of semi-independent subregional studies responsive to both regional and corridor-scale cost and impact issues. Several of these studies, whether sequential or simultaneous, are related through a continuous and concurrent regional planning activity that functions as an accounting system for system relationships, policy consistency, and issues that overlap subregional boundaries. In such a framework, the regional system activity can be broken into two elements:

1. Formulation of alternative regional approaches in terms of a series of possible functionally consistent systems. Regional systems could simply be based on the results of separate subregional studies, but a regional initiative could shortcut this process with a sufficiently broad range of alternatives.
2. Formulation of alternative land use systems as possible futures. These futures are constructed for testing transportation needs of future activity distributions responding to any set of probable future policy combinations affecting density, type, and locations of activity in space.

Several subregional studies, if concurrent, can be tested against each other for functional interaction within the regional system framework. Often subregions will be highly independent of each other such that subregional improvements of quite different natures can coexist within the same region. In other circumstances, close relationships between subregions revealed that through-system testing will require joint resolution. In this process, regional system testing becomes a continuous on-line evaluation device, i.e., a service element to subregional planning. The subregional transport planning activity consists of the formulation of alternative action plans in type, location, scale, and mix of capital or operational improvements in response to local issues and becomes the focus of plan development and decision making.

Incrementalism

Within a regional or subregional framework, the imperative to deal with both long- and short-range actions can be resolved through incrementalism (12). Incremental development builds into the planning process the concept that transport improvements be implemented in successive stages over time and that each stage be responsive to the highest priority needs at that given point in time. An increment is that component of an overall regional or subregional improvement program that can be expected to be operating within 5 to 10 years and that

1. Defines a stage in a continuing program of improvements within the framework of a generalized long-range plan or plan alternatives;
2. Includes components for the complete range of needs of all market segments in the area consistent with short-term needs and objectives; and
3. Contains short-range improvement projects that are for immediate action and that are oriented to low-cost transportation system management and components of any proposed long-range capital-intensive program.

Incremental development establishes a bridge between long-range plans and the project-level implementation program and alters the role of the long-range plan. In contrast to the traditional master-planning approach, the individual elements of the incremental transportation plan would not be justified by a hypothetical future contingent on completion of a single target regional system in the future. The incremental approach suggests that a single detailed and definitive end state for the transit system is inappropriate. It would encourage the maintenance of flexibility through development of a generalized long-range framework capable of refinement and reinterpretation over time as successive short-range increments are implemented and as uncertainties are reduced. Such flexibility can be achieved by defining the long-range plan at a level of generality consistent with more than one increment for meeting specific short-term need while options are preserved among future increments until they are examined in detail at a project level during the development of each increment.

Within a continuing process, evaluation for specific alternatives for each successive short-term time period should be made based on recent developments and the changes in forecasts for the next period rather than on impact projections and inherent assumptions of the long-range system plan. Incremental plans are less subject to the uncertainties of long-range plans resulting from the shortcomings of forecasting technique, the vagaries of public value shifts, or the introduction of new technologies or institutions. Detailed evaluation can therefore take advantage of the more reliable cost and impact predictions possible for short-term projections. Highly specified service improvements, including a wide range of variations of technologies, locations, and operating policies, can be analyzed.

Evaluation of long-term regional systems should be in general terms, recognizing uncertainties and the fact that most impacts are at the project scale. Focus should be on using the systems level analysis to avoid system incompatibility, to test transport impacts on alternative land development futures (regional-scale diversion), and to develop capital programs. Although detailed facility plans would not be appropriately part of long-range plans under the incremental approach, the long-term implications of an increment would be considered when alternative short-term improvements appear otherwise comparable in the short range.

Incremental transportation program development focuses planning on high-priority problems, such as on shorter range actions related to specific time, place, and group objectives. Concentration on the predictable near-term impacts of immediate and short-run transportation alternatives should stimulate public involvement since implementation actions are chosen based on a short-run cost and impact analysis within the general system framework (or long-range options), and this permits immediate decisions to be consistent with immediate problems.

Finally, incrementalism affords an additional flexibility in relation to long-range planning that permits a locality to avoid the prospect of extremely costly long-term investments (that may later prove to be inappropriate) in exchange for the short-run cost of conducting additional planning and investing in facilities to accommodate the evolution of service levels. Moreover, the flexibility is a safeguard against changing goals and priorities.

Cyclical Approach to Problem Solving

The traditional technical approach to transportation planning does not respond well to the objectives of the new planning process. This approach, characterized by a rational series of sequential steps, is not in itself inappropriate; however, what has led to the ineffectiveness of the approach is that each step is done only once in a study and usually at great expense of time and resources.

In an attempt to respond to the weaknesses emerging from traditional studies, the technical approach used by newer continuing transportation planning has adapted a cyclical approach to problem solving that emphasizes near-term subregional implementation programs rather than long-range plan preparation. This approach attempts to explicitly recognize the following:

1. The issues only fully arise after an evaluation of potential courses of action is exposed, and the process should provide a number of such opportunities before a final decision is required.
2. The purpose of the technical process is to provide information for resolution of policy issues, and the type and accuracy of information vary widely, depending on the complexity of the issues and the range of alternative actions available. Therefore, the preparation of an extensive data base and methodology is likely to be inefficient since either a great deal of effort will be expended to respond to issues never raised or unexpected specific issues will be raised for which information was not prepared.
3. A decision on a particular transport facility or program need only be made in conjunction with other transport programs that it will significantly affect. Not all transport improvement programs are inextricably interrelated. The technical process must be able to define the magnitude of such interrelationships to provide the opportunity for staged, incremental decision making.

Based on the experience of more recent studies, three cycles of technical analysis, each followed by a period of intense policy review, appear to provide the necessary interaction of technology, community, and decision making to accomplish the development of programs to be implemented. Each cycle is composed of periods of problem definition, preparation of alternatives, and evaluation of alternatives and concludes with the rejection of an alternative or its selection for additional analysis and a statement of unresolved issues.

First Cycle

The first cycle of activity focuses on suggesting various alternative improvement programs in response to problems as initially perceived by the community and the decision makers. Technical evaluation material in this cycle is based primarily on the judgment of the professional staff. Reviews by the community and the decision maker focus on the political realities of the proposals, the types of issues, and the information required before a course of action is chosen. The reviews also provide a focus for making the immediate decisions over which no controversy exists.

Second Cycle

The second cycle focuses on the evaluation of the shorter term consequences, such as costs, benefits, impacts of the alternative course of action, and the determination of the interdependence or mutual exclusiveness of one subregional program from another. The evaluation during this cycle is accomplished through the use of more detailed and systematic techniques that can be applied in an unbiased way for all alternatives. Community and policy review is aimed at refining or redefining the issues and alternatives and reducing them to a minimum number for final evaluation.

Third Cycle

The third cycle focuses on more precisely defining the alternatives, particularly staging programs, and on developing information on the potential longer term consequence of the alternatives in relation to foreclosed and unforeclosed options for future action. The general work process is iterative, and there are repeated cycles of a sequence of basic activities, such as issues and objective analysis, alternative formulation, impact determination, and evaluation in greater detail on successively fewer alternatives.

METHODOLOGY

Three methodological areas support the new process: travel forecasting, alternative land use futures, and plan evaluation. These are critical because the roles of the first and second areas in the new process are significantly different from those in the traditional process, and evaluation is the key component of the new process.

Travel Forecasting

One of the greatest needs for improvement in methodology, in the travel demand models, flow simulation models, network analysis, and evaluation techniques, lies in the general area of system equilibrium. Urban transport systems operate at states of equilibrium where travel demand is appropriately related to the supply at a particular point in time. A better analytical understanding is needed of the performance of transport networks under conditions where limitations in the system capacity, both deliberate and natural, are left to restrain growth in travel demand. Under such conditions, the cost of using the system (in terms of money costs, delays, and inconvenience) rises rapidly as demand approaches capacity so that demand is always limited to a point just below capacity. Neither the impacts on traffic flow patterns, the feedback to demand, nor the secondary effects on land use, environment, and regional economics of this condition are sufficiently well understood.

Alternative Land Use Futures

There are significant uncertainties associated with socioeconomic and behavioral forecasting, particularly at a 20-year time horizon. To overcome these shortcomings, planners are increasingly using a concept of alternative futures designed to either reduce or expose the uncertainties in forecasting and, more importantly, to permit the relationship between transport and land use to be more understood as a subject for public policy related to individual transportation decisions. These alternative futures can be interpreted in terms of magnitude, distribution, and density of population and employment anticipated in the metropolitan area, assumed transport level of service, and other characteristics to which the issues under consideration are sensitive. They can be characterized by the way in which they relate to general social and urban issues, such as balanced employment growth, access to jobs, access to recreation, preservation of open space, and minimum disruption of communities.

Plan Evaluation

The emerging philosophy focuses on evaluation, not forecasting, as the key element in a cyclical, not sequential, process. The technical analyses associated with urban transportation planning must be capable of responding with information to the full range of issues associated with the provision of urban transport. This means that they must be equally concerned with the portrayal of the following:

1. The distribution of costs and benefits among groups as well as aggregate measures of costs and benefits;
2. The short-term effects as well as the achievement of long-term goals;
3. The positive and negative nontransport impacts as well as transportation-related benefits; and
4. The range of uncertainty associated with the information provided as well as the methodology used to generate the information.

Evaluation criteria under the new process must be numerous and complex and of sufficient breadth to permit individuals with widely varying points of view to evaluate alternatives in accordance with their own values. They also should be selected to reveal the real differences in impacts among alternatives to various geographic areas, communities, and groups.

PROTOTYPICAL WORK PROGRAM

The general principles discussed above can be better understood within the context of an example work program. This program can be adapted to a continuing planning process or a specific study focusing on a particular issue agenda. Figure 4 shows the major components and their interrelationship in the prototypical work program. As shown in Figure 4, the new process is composed of a series of intermittent and relatively independent subarea planning studies supported by four continuous streams of regional activity: improvement of planning techniques, monitoring the transportation system, regional system planning, and regional evaluation of subarea alternatives. Figure 4 also indicates that the regional plan and program can be updated or modified based on activities from either the subarea studies or the regional analyses and that these modifications take place intermittently rather than regularly because decisions are made at either of the two levels of activity.

REDEFINITION OF A TRANSPORTATION PLAN

One must recognize at the onset that a process designed in accordance with the concept proposed will dramatically change the nature and function of regional transportation-land development plans. The simultaneous and interactive flow of regional and subregional studies in an incremental context central to this new process alters the concept of the final product and the manner in which it is achieved since it recognizes that subregional studies and incremental planning may require modification in any range of regional plans.

The necessity for subregional planning activity to take place continuously over time in response to local issues indicates that there can be no single, fixed, long-range transportation-land development plan. Such fixed plans are not only unreasonable in relation to uncertainties and policy variation but are also irresponsible, given the technical limitations of forecasting in the rapidly changing technical and social environment.

If transportation planning is defined as a process of guiding (a) staged improvements of the metropolitan transport function, responsive to cost, system, and impact constraints and (b) improvement objectives, subject to variations among the different parts of the region and the different socioeconomic groups in the region, then the product of such a process is open-ended and encompasses the concept that there are equally probable alternative long-range, transportation-land development patterns toward which the region could move. What the region will look like in 20 years will depend on the cumulative effect of future policy choices and the uncertainty about the socioeconomic behavior of future populations. This definition sharply contrasts with the traditional process whose product was expected to be a single comprehensive regional transportation system for one possible long-range future. This does not imply that there can be no long-range direction to the future of the metropolitan area, but rather that such

Figure 3. System and corridor-level planning.

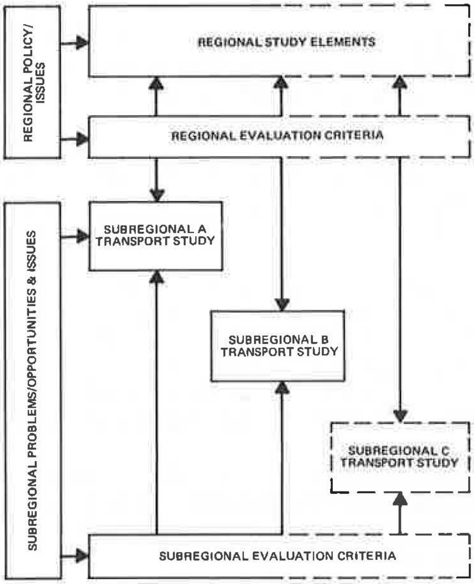
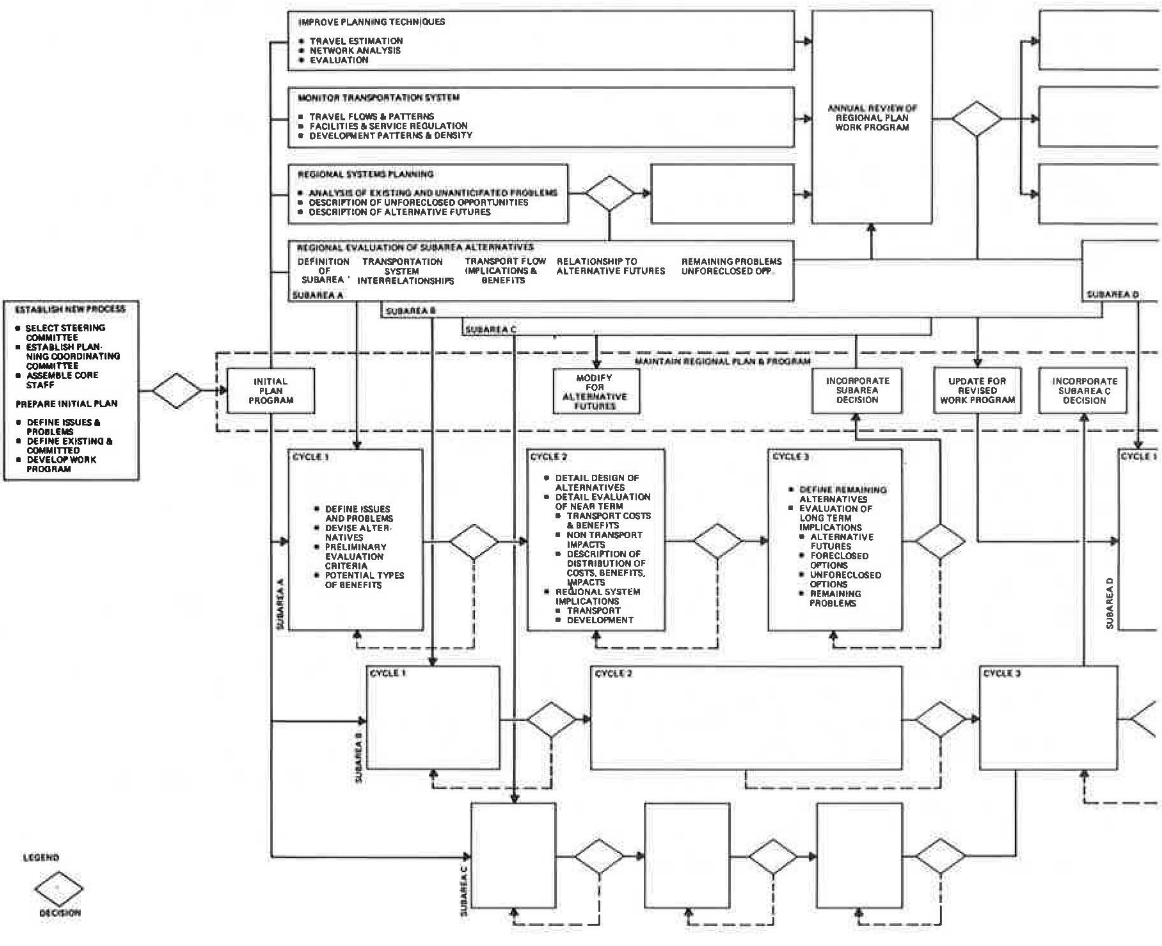


Figure 4. Prototypical work program.



direction is the result of a sequence of decisions and the response to those decisions over time, not the existence of a long-range plan.

Given that the plan is no longer a picture of an end state, the components of the new on-going process are as follows:

1. The existing transport system not only portrays the physical facilities that constitute the transport network but also describes the types and levels of service currently available and current transport policies relating to the operation and regulation of the system.
2. The committed transportation improvement program describes those actions for which there is a firm implementing program, i.e., an allocation of resources, and should display not only the allocation of funds for capital and service improvements but also any policy actions to be implemented. Further, this portion of the plan should fully describe the allocation of technical study resources; e.g., preparation of final designs for a particular facility, undertaking of a subarea study, or preparation of a new regional land use forecast.
3. Unresolved transportation problems include the existing and anticipated transport and transportation-related problems that will not be resolved by the committed transportation improvement program and both near and anticipated long-term problems by type, geographic area, and time.
4. Unforeclosed transportation opportunities are those alternative possible transportation actions that have been suggested to resolve the unresolved problems or to exploit an opportunity for social or economic improvement about which no decisions have yet been made. In addition, this part of the process would describe alternative long-range future metropolitan development patterns toward which the region could be directed, depending on the nature and timing of future decisions relative to transportation policy.

Although a document with the above components will be less than satisfying to those looking for a clear and stable objective for urban areas, it should provide a more realistic basis for decisions about transportation in metropolitan areas. It would provide basic information to everyone concerning where metropolitan transportation planning is today, where it might be in the future, and what is currently being done to direct the development of our metropolitan areas.

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THE COMMUNITY AGGREGATE PLANNING MODEL

Harry Schleifer, John Hamburg and Associates, Inc.;
Samuel L. Zimmerman, Urban Mass Transportation Administration; and
David S. Gendell, Federal Highway Administration, U.S. Department of Transportation

As urban transportation studies have begun to reevaluate existing system plans, planners have seen a need for more rapid and efficient tools for system evaluation. This need has been accentuated by increased public awareness of environmental and social consequences of transportation policy-related decisions and by the demand for increased citizen participation in the planning process. The community aggregate planning model attempts to fill this need by operating at the community level, by using easily obtained inputs, and by directly producing usable evaluation criteria. The model requires only simple inputs. System capacity is given by the freeway and surface-arterial lane miles (kilometers) in each community. Connectivity is assumed to be ubiquitous for arterials and is simply represented for freeways and expressways; there is no need to code extensive conventional networks. The only required demand measure is the number of vehicle trip ends in each community; this reflects externally derived transit-automobile modal-demand analysis. The model also combines, in one efficient computer package, modules that, with one pass, generate a regional system-sensitive vehicular travel demand, distribute the demand to the arterial and freeway systems in each community, and compute a full range of useful evaluation measures describing the direct and indirect consequences of the test alternative for each unit-community analysis. The output measures are comprehensible to planners, citizens, and decision makers and do not need intermediate summarization or interpretation. In addition, the model is designed to output performance measures for two alternatives simultaneously and thereby facilitates the comparative analysis of base and future alternatives.

•AS urban transportation studies have begun to reevaluate existing system plans, planners have seen a need for more rapid and efficient system evaluation tools. The community aggregate planning model (CAPM) fills the need for quick and easily used tools to assess the economic, social, environmental, and transportation system performance consequences of varied transportation system implementation and operating policies.

The role of planners has always been to provide information to decision makers about the consequences of their decisions; this has not changed. However, as citizens have become more directly involved in the planning process, the absolute number and variety of decision makers have vastly increased. Where at one time, the planner only had to provide information to a select group of knowledgeable public officials, he or she must now address the often broader concerns of a much larger and diverse group of citizens.

The recent emphasis on citizen participation in contemporary planning and on the concern given to broad quality-of-life and environmental issues provides a major challenge to transportation planners. Planners have found that it is no longer sufficient to analyze different transport alternatives on a purely engineering or economic basis and, therefore, have accounted for environmental and social impacts as well.

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However, the increase in the number of people involved and the concurrent broadening of the criteria by which transportation plans and policies are judged and the range of transportation options being considered have cast some doubt on the effectiveness of existing urban transportation planning tools. In many cases, although answers can be obtained through exercising traditional planning procedures, they cannot be obtained within the budget or time constraints under which the study is operating. There is a need for improved tools that are designed specifically to provide a first-cut evaluation of transportation proposals. There are three basic requirements for these sketch-planning tools. The first requirement is ease of input preparation. Because the standard mesolevel tools must necessarily produce detailed information, their inputs must also be detailed. This results in the provision of information describing physical facilities or operating policies that may be superfluous to the issues being addressed or the needed scale of the analysis. Another related problem with using current mesolevel tools in long-range system planning is that there must be a great deal of system detailing by planners and technicians before a proposed alternative can be defined for analysis. Because an alternative may be sensitive to these details, the planner may inadvertently bias the outcome of the analysis.

An additional characteristic of contemporary planning that supports the need for ease of input data preparation is the large number of alternative systems that must be considered. The large number of alternatives arising from increased citizen participation is also partly the reason for the second requirement of long-range system planning tools, ease of computer operation. Not only must a large number of alternatives be examined, but each one should also be evaluated relative to the varied future state. At the regional systems level, new facilities will have a profound effect on land use patterns and vice versa. It is, therefore, desirable to test each transportation alternative in conjunction with a variety of future land use configurations. Unless the evaluation tools are efficient in terms of setup time-cost and actual runtime-cost, the expense of making a large number of land use-transport alternative tests would be prohibitive.

The last requirement for sketch-planning tools is that their outputs be easy to understand and relevant to the evaluation task at hand. Because conventional mesolevel models were originally intended to directly produce only network link flow volumes, much planner interpretation is required to obtain information useful to the alternative system selection process. The time and cost of this interpretation, combined with the excesses of the other analysis steps, limit the number of alternatives that can be studied. This long interpretation time can also mean that results will not be available soon enough to allow meaningful input to or feedback from the actual decision process.

CAPM was designed as a sketch- or strategic-planning tool. As such, CAPM was developed specifically to eliminate the drawbacks and to conform to the criteria described above. CAPM represents an outgrowth of the transportation resource allocation study (TRANS) (1, 2, 3, 4, 5). TRANS is a national policy planning model designed to produce quick-response, multicriterion evaluation of transportation options. CAPM departs from TRANS in several respects; mainly it is designed to produce results meaningful for an individual urbanized area and communities within the area. As such, it is similar in concept to the work of Koppelman (6, 7) for the tri-state regional transportation study.

In CAPM, ease of input preparation, computer setup and operation, and output interpretation result in the ability to address the following kinds of issues at a community level:

1. Decisions about the location, magnitude, and function of urban transportation investments;
2. Formulation of highway operating strategies useful in obtaining environmental and system performance objectives, such as pollution abatement and fuel conservation; and
3. Examination of the transportation implications of future land development policies.

A major strong point of CAPM is that it can approach these issues with no need to code up extensive networks for computer manipulation. Highway capacity is input as the number of lane miles (kilometers) of arterials with freeway supply in each community represented by using route number to indicate lane miles (kilometers). This representation coupled with knowledge of the community in which various freeways intersect is used to describe high-level system connectivity.

Commensurate with this simple supply representation is the input measure of travel demand, i.e., community vehicle trip ends. These can be estimated directly from population and employment by using readily available factors or can emerge from a more rigorous multimodal demand analysis. In current CAPM development, land use and transit alternatives are evaluated through changing the vehicular trip ends input to the model. This enables the analyst not only to determine the highway requirements compatible with the particular option being evaluated but also to study changes in highway performance, costs, and impacts resulting from changes in land use activity or transit use.

As stated previously, CAPM is designed to directly produce easily understood transportation system performance measures. These include information such as description of the supply alternative being evaluated, including its cost, land consumption, residential and business relocations, system operating speeds and costs, air pollution emissions, and energy consumption. Based on development of these measures for a range of future alternatives and for the existing situation, within a limited time and with only limited expenditure of funds, CAPM should provide information useful to transportation decision making.

COMMUNITY AGGREGATE PLANNING MODEL SYSTEM

As shown in Figure 1, CAPM is composed of three basic modules: travel generation, travel distribution, and performance evaluation. In the travel generation module, a system-sensitive estimate of total regional vehicular travel is obtained. The travel distributor takes this regional total and allocates it to the arterial and freeway system in each community. Given the vehicular travel on, and capacity of, the highway system, the performance module computes a full range of community-level performance measures.

To gain a fuller understanding of this process, we should examine the basic assumptions and component modules of CAPM in more detail. Special attention will be paid to inputs from a user preparation point of view and outputs from the perspective of analysis utility.

Basic Relationships

CAPM represents a significant departure from conventional transportation planning procedures in that computerized networks are not used. This approach required the development of two basic relationships not present in the standard processes. The first of these deals with the direct determination of average speeds by facility type at a subarea level. It is generally agreed that the speed on a highway facility of a particular type and capacity is a function of the volume of traffic using the facility (8):

$$S_i = F\left(\frac{VMT_i}{CMS_i}\right) \tag{1}$$

where

S_i = average highway travel speed on link i,
VMT_i = vehicle miles (kilometers) of travel on link i, and
CMS_i = capacity miles (kilometers) of supply for link i.

The weighted space-mean speed S can be found by weighting the speeds on individual links by the vehicle hours of travel on the links or by

$$S = \frac{\Sigma (S_i \cdot VHT_i)}{\Sigma VHT_i} \tag{2}$$

where VHT_i equals vehicle hours of travel on link i. However, Zahavi (9) and others have shown that, for a small area, S can be directly computed as a function of the total capacity of all links in the area and the total volume on those links by

$$S = F\left(\frac{\Sigma VMT_i}{\Sigma CMS_i}\right) \tag{3}$$

Zahavi (9) made no attempt to distinguish between freeways and surface arterials. For the purposes of CAPM, this differentiation has been made, and separate functional relationships were developed for each. Figure 2 shows the forms these functions take. The horizontal axis is labeled demand-capacity rather than the traditional volume-capacity. This does not imply any computational change from accepted practice where volumes greater than capacity are often computed. Its use only reflects the idea that the actual volume of travel does not exceed the capacity but rather that more vehicles wish to use the system in a given amount of time than can be accommodated. For such situations, the speed estimates reflect the excessive demand. The freeway curve shown is for a speed limit of 60 mph (96 km/h). To compute the curve for any speed limit, the equation used is as follows:

$$S = \frac{3,600}{K_1 e^{K_2(d/c)} + \frac{3,600}{S_o}} \tag{4}$$

where

S = average speed in miles (kilometers) per hour;
S_o = speed limit (free-flow speed) in miles (kilometers) per hour;
K_1 = constant, i.e., 0.4; and
K_2 = constant chosen so that the curve passes through 25 mph (40 km/h) at capacity [for 60 mph (96 km/h), K_2 = 5.35].

The surface arterial curves shown are for a speed limit of 35 mph (56 km/h). The approach used in CAPM to estimate these curves is a slight modification of one that was developed for TRANS (10).

The second basic relationship used in CAPM deals with the direct estimation of vehicle miles (kilometers) traveled (VMT) by facility type for a subarea. To make such an estimate possible, a process was developed (11) that circumvented the need for network coding by making use of certain properties of highway systems and some assumptions about travel behavior. Basically, the processes suggest that

1. Because the surface arterial system is ubiquitous, travel from any point to any other point in the region is made possible.
2. In the absence of freeways, drivers will use the shortest distance route to make their trips.
3. If there are freeways, drivers will divert from the shortest distance path to the

Figure 1. Community aggregate planning model system.

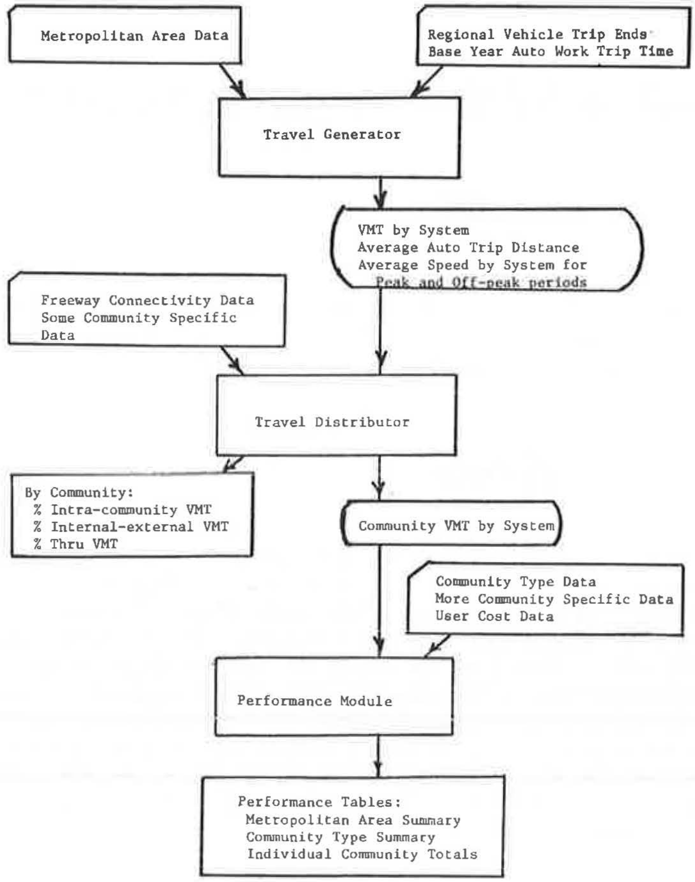
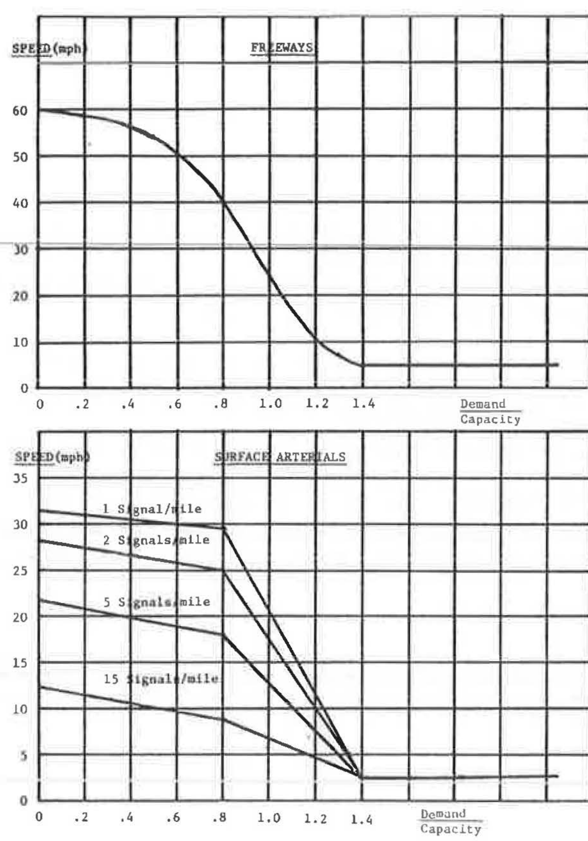


Figure 2. Speed versus demand.



extent that they perceive a time savings that is reflected in a time ratio diversion curve.

4. Availability of a freeway for a given trip can be ascertained if its position relative to the origin and destination of the trip is known; information about any intermediate points is not needed.

These ideas form the basis of the travel distributor.

Process

VMT Generator Module

The first module in the CAPM system (Figure 1) is a modified version of the DAM III analytic assignment model (12). Given highway system supply [miles (kilometers) of freeways, surface arterials, and locals], total vehicle trips, and average trip distance, DAM III enables one to compute the amount of travel on each highway facility type, commensurate equilibrium speeds, and average trip time. The total regional vehicular travel is fixed since both the number of trips and average trip distance are fixed. For CAPM, DAM III was modified to compute an average trip distance for the region sensitive to system speed. To accomplish this, the model is iterated on trip distance, assuming that, for the region, average over-the-road trip time for work trips remains constant regardless of long-term changes in the urban activity pattern or transportation system.

The nationwide personal transportation study tends to support the assumption of constancy in regional work-trip time (13). It shows that, for a sample of workers, more than one-half experienced no change in work-trip time over a 5-year period and that the number with increased trip time was essentially balanced by those with decreased trip time.

The average work-trip distance is computed by multiplying average highway speed at equilibrium by the assumed constant input average work-trip time. Finally, the average trip distance for nonwork trips is estimated by using the relationship shown in Figure 3, which was developed from transportation study data from 15 metropolitan areas. The two trip distances are then weighted to produce a regional average trip distance. Multiplying this value by the total number of trips generates a total VMT that is sensitive to system speeds. The areawide functional split of travel among freeways, surface arterials, and locals and regional system speeds is also estimated, though not used explicitly.

Travel Distributor Module

The travel distributor, which determines how much travel is on the respective systems in each community, is discussed below. The description explains the basic components of the process and how they fit together and does not completely present the details of the analysis, which can be found elsewhere (11).

Most basic to the whole approach is the exponential trip distance probability assumption, which states that trips distribute themselves over a region such that

$$P_i = e^{-x/\bar{x}_i} \qquad (5)$$

where

P_i = probability of traveling a distance x or greater given the trip end is in community i, and
$\bar{x}_i$ = average trip distance of trip ends in community i.

This relationship directly or indirectly uses a value of $\bar{x}_i$ developed from the travel generator estimate of regional average trip distance and the position of community i relative to all trip ends in the region to estimate the probabilities discussed below.

The analysis is conducted by dividing the travel with respect to a community into its three components: internal, internal-external, and through. Internal and internal-external (with respect to each community) travel is estimated by using the trip ends associated with that community. The probability of a trip being wholly within the community is calculated by using the above distribution and the area of the community. This probability is multiplied by one-half the total community trip ends (a trip has two ends) and then is multiplied by the estimated average trip distance for intracommunity trips to yield the intracommunity VMT. The probability of a trip being internal-external is equal to 1.0 minus the probability of a trip being intracommunity. This probability is multiplied by the total community trip ends, and the resultant number of trips (internal-external trips have only one end in the community) is multiplied by the computed average distance for the portion of the internal-external trips within the community to yield the internal-external VMT for the community.

The remaining type of trip associated with a community is the through trip, that is, a trip with neither end in the community. To estimate these trips, the concepts of shadow area and freeway connectivity are introduced. The concept of a shadow area is shown in Figure 4. Assuming straight-line travel, any trip leaving community X and destined for area S_{xy} must pass through community Y. Thus, S_{xy} is the shadow area for the community pair X and Y. By estimating the probability of a trip going from X to S_{xy}, one can estimate the number of trips through Y that emanate from X. However, if there are freeways in the communities neighboring Y, some trips might better be diverted from their straight-line paths and use the higher type of facility. The number of such trips is estimated by using the freeway connectivity of communities. By noting the presence of a given freeway route in two communities, one can determine the extent of such diversions and hence estimate freeway use and through travel. For example, if communities X and Y in Figure 4 were on the same freeway route, we could assume that there would be no loss of through trips to neighboring communities. There would, however, be an estimate, based on a time-ratio diversion curve, of how many trips would use the freeway versus the arterial street system. If the freeway were in a neighboring community of Y, but not in Y, then those trips that used the freeway to go from X to shadow area S_{xy} would become through trips to the neighbor of Y and not go through Y itself. By looking at all community pairs, one can estimate the through travel and functional split of that travel for a given community and the functional split of the internal-external travel discussed above. Through trips are multiplied by the estimated average trip distance for through trips taking place in the community in question to yield through travel.

By summing these three travel components, we have an estimate of a community's total travel and the split of that travel between freeways and surface arterials. Only one step remains, normalizing to ensure that the total areawide travel distributed to all communities equals the areawide total travel produced by the generator. This step is necessary even though the average trip distance output of the generator is a parameter of the distributor probability function because the trip distances used in the distributor are based solely on community area and do not include system sensitivity.

Performance Module

In the performance module, the direct and indirect impacts of an alternative are computed. Computation of the indirect impacts is based on the daily travel forecast by highway system and community passed from the travel distributor, but the estimation of direct impacts is based on information on new highway system capacity.

Direct costs include things such as construction and maintenance costs, vehicle operating cost, and residential and business relocations. In the calculation of construction costs, the base year system is compared with a future alternative to determine, for each community, how many lane miles (kilometers) of new freeways and surface arterials are to be constructed. These values are used in conjunction with rates of cost per lane mile (kilometer) for the relevant system additions to compute costs. Major reconstruction and basic maintenance costs are computed in a similar manner.

For an estimation of residential and employment relocations, the area taken for new right-of-way is computed based on the miles (kilometers) of new-system and average right-of-way width. Next, the community's net residential and employment densities are computed. Finally, based on the proportion of each freeway's right-of-way occurring in each of the two land use types, relocations are computed. This procedure is similar to that recommended by Klein (14).

The remaining direct cost, vehicle operating cost, and important indirect impacts, such as energy consumption and air pollution emissions, depend on operating speed. As was indicated previously, knowledge of the amount of travel and capacity, by system and community, allows computation of space-mean speeds. These speeds are, however, only useful for the estimation of impacts when they are representative of the speeds in a given community. To improve the likelihood of this situation, the CAPM performance module takes the daily travel forecasts from the distributor and breaks them down by time of day and direction of travel in a similar fashion to that used by TRANS (1). This temporal and directional disaggregation is accomplished by using factors input for each type of community. When the VMT by community, system, time, and direction are known, the respective demand-capacity ratios can be computed, and the speed relationships entered.

Given the speeds by system type, time period, and direction of travel for each community, performance curves are used, impacts obtained, and daily totals computed. The relationships used to estimate vehicle operating costs, fuel consumption, and pollution emissions have been developed for the base year and future year conditions for automobiles and trucks. They assume average highway and traffic characteristics normally found in large urban areas, such as highway grades and curvature, speed change cycles, stops, and vehicle age distributions. As such, they represent default or average value inputs that are taken from the results of national transportation needs and research studies. They can, however, be easily replaced if a user wishes to supply what is thought to be better information. Thus, the model system is fully operational for quick application and is readily adaptable to local situations that may differ from national averages.

Input

Because of some assumptions made in the travel distributor, the analysis seems to work best for areas of about 10 $miles^2$ (26 km^2). Communities are defined to be areas of about that size, although a range of 8 to 30 $miles^2$ (20 to 78 km^2) is tolerable. Effort should be made to have regular community shapes, i.e., approximately equal length and width.

To use the full CAPM system, one must supply the following data items for the base and future (analysis) year:

1. Description of the community,
2. Trip ends for each community,
3. Regional average work-trip time assumed constant over time,
4. Surface-arterial lane miles (kilometers) for each community, and
5. Description of the freeway-expressway system for each community.

Community Description

A short description for each community includes input specifying name and number, type (central business district, central city, suburb, rural), area, population, and employment.

Trip Ends by Community

Trip ends can be input in either of two forms: internal vehicle trip ends or total person trip ends. If total person trip ends are used, then transit trip ends and average automobile occupancy must also be input. For the analysis year, a transit person trip end estimate commensurate with the policies to be tested would be skimmed off this total person trip end estimate, and the result would be divided by an average vehicle occupancy. This average vehicle occupancy would also be a function of the policies under analysis. Truck trips are accounted for by inputting the percentage of VMT that is the truck VMT.

Base-Year Regional Average Work-Trip Time

As was discussed previously, regional average work-trip time is assumed to remain constant over time. If a value were not available for the base year, one could be approximated and the model run until the VMT estimate for the base year corresponded to the one that was known (e.g., from a highway-transportation needs study or traffic-counting program).

Surface-Arterial Lane Miles (Kilometers) by Community

For the base year, surface-arterial lane miles (kilometers) of system capacity could be measured manually by using a functional classification map that is skimmed from a computerized network or that is computed on a mileage density basis. This latter technique, appropriate when an analysis must be done in a hurry and no data exist, amounts to the measurement of the lane-mile (kilometer) density for selected areas within the given region and the application of these density factors to the areas of the various communities. For the best accuracy, a number of density measurements would be made for each major land use type (e.g., rural, suburban-residential), an average computed, and the appropriate factor applied to each community based on the predominant character of its development. For the future year, surface-arterial capacity would be equal to the base-year estimate plus the new capacity corresponding to the implementation-operation policy to be tested.

Freeway System Representation

For each freeway passing through or having an end in the community, the following information must be known:

1. Route number of the freeway;
2. State of freeway, existing or proposed;
3. Average number of lanes;
4. Length of the facility within the community; and
5. Land use along the freeway route.

Route numbers for a proposed facility being tested could be determined the same way as Interstate or state route numbers; i.e., a relatively straight route with no doglegs or abrupt turns would be assigned a single route number. For existing freeway facilities, the route numbers may remain whatever they actually are. In case of a beltway or other circumferential freeway, for a more accurate analysis, the length should be divided into sections. If the beltway is a continuous ring, then division would be into three sections; if it is not continuous, then division can only be into two sections. Each section should be assigned a different route number. The average number of lanes and the length of the particular facility for the base and future year are self-explanatory.

The land use along the freeway route specifies the percentage of residential or employment use for calculation of dislocations.

Other Data

For other data items, average value inputs, obtained from summaries of the various transportation studies, are available. These data items are input to CAPM by community type for groups of communities, rather than for individual communities, with similar characteristics. Data of this nature include construction costs, freeway ramp spacing, capacities, speed limits (free-flow speeds), temporal splits, and directional flow. The model is completely flexible on community type of aggregations, but most of the average value items have a CBD, non-CBD central city, suburb, and rural breakdown. Though these average value items allow CAPM to operate with little information preparation by the local agency, a more accurate use of the model would entail the local derivation of as many average value data items as possible. (CAPM data input formats are available from the Urban Planning Division, Federal Highway Administration.)

Output

The evaluation measures produced by CAPM are displayed in three tables based on geographical aggregations by individual community, community type (e.g., CBD, central city, suburb, and rural), and metropolitan area totals. Each table is divided into five categories as given in Table 1. Evaluation measures for the base year appear directly above these for the proposed alternative in the computer output and thus facilitate direct comparison.

APPLICATIONS AND RESULTS

CAPM currently exists as a computerized model, written in FORTRAN IV, that requires less than 190 K bytes of core and about 6 CPU min for execution on an IBM 360/65 computer to process an alternative for 100 communities. Pilot applications of the process are taking place in St. Louis, Missouri; Phoenix, Arizona; Baltimore, Maryland; and Cincinnati, Ohio. Currently, CAPM directly produces only highway impacts. The evaluation alternatives in these four cities will, however, include proposals encompassing various public transit schemes. To analyze such multimodal systems, one must externally estimate transit ridership in each community and then make the appropriate adjustment to the total community vehicular trip ends. Thus, the input to the model remains highway trip ends, but the highway impact implications of a proposed transit alternative can be evaluated. One possible means of estimating transit use at a level of aggregation commensurate with CAPM is the Urban Mass Transportation Administration macro manual transit sketch-planning tool (15).

Table 1 gives the CAPM model outputs; as stated earlier, these appear for the region as a whole, for community types, and for the individual communities themselves. Table 2 gives selected results for a metropolitan area; the base condition is compared to two proposed alternatives. Two things should be realized when Table 2 values are looked at: (a) The change in the number of trips is an input rather than an output of the model, and (b) the drastic drop in pollution between the base and either alternative is primarily caused by the assumption that legislated pollution emission standards for automobiles will, in fact, become a reality. As can be seen, alternative 2 results in speeds that are slightly better than those in the base year but that are significantly better than those expected from alternative 1. Thus, if system performance is the major concern, the second alternative seems clearly superior. Alternative 2 also shows lower amounts of pollution, fuel consumption, and annual fatalities than alternative 1. However, for 20 to 25 percent higher speeds and 2 to 6 percent less pollution and fuel use, 80 percent

Figure 3. Average automobile non-work-trip distance versus average automobile work-trip distance.

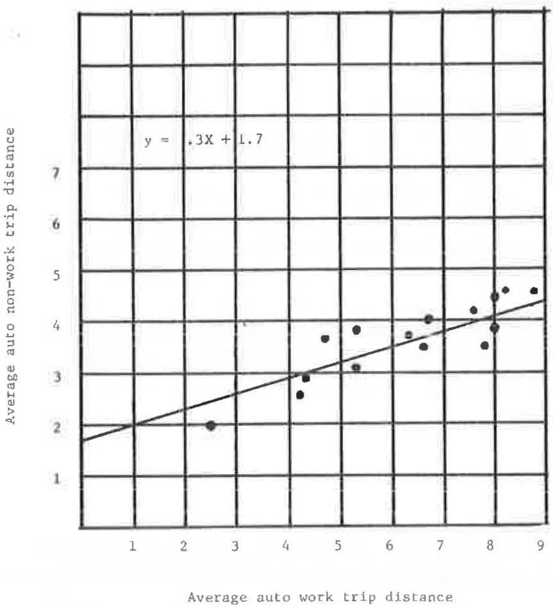


Figure 4. Shadow area concept.

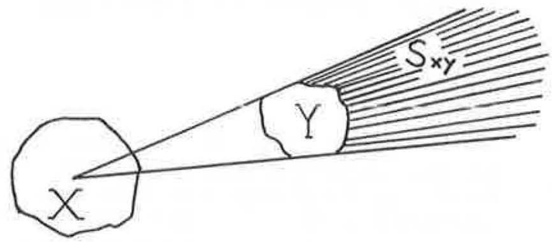


Table 1. Model evaluation measures.

Socioeconomic Data	Demand Data	Supply Data	Cost Data	Performance Data
Population	Automobile driver trips	Freeway lane miles	New freeway construction cost	Daily average arterial volume-capacity
Land area	Daily freeway VMT	Percentage of total capacity on freeways	New surface arterial construction cost	Weighted average daily freeway speed
Employment	Daily surface-arterial VMT	Surface-arterial lane miles	Freeway reconstruction cost	Weighted average daily surface-arterial speed
Automobile ownership	Daily local VMT	Daily bus-miles	Surface-arterial reconstruction cost	Weighted average daily local speed
	Peak total VMT	Daily car rail miles	Freeway maintenance cost	Weighted average daily total speed
			Surface-arterial maintenance cost	Peak-hour average freeway speed
			Total daily vehicle operating cost	Peak-hour average surface-arterial speed
			Daily accidents	Peak-hour average total speed
			Number of jobs displaced	Daily total vehicle hours of travel
			Number of residents displaced	Daily average trip time
			Land consumed by new freeways	
			Total annual fatalities	
			Daily pounds of CO pollution	
			Daily pounds of HC pollution	
			Daily pounds of NO_x pollution	
			Daily gallons of gasoline consumed	

Note: 1 mile = 1.6 km. 1 lb = 0.45 kg. 1 gal = 3.8 l.

Table 2. Selected model outputs for metropolitan area.

Output Measure	Base Condition	Alternative 1	Alternative 2
Total daily automobile trips	3,138,200	5,406,800	5,050,800
Total freeway lane miles	576.3	1,189.0	1,588.5
Total surface-arterial lane miles	3,351.2	3,662.6	4,250.3
Total daily freeway VMT	4,716,400	10,751,400	11,479,700
Total daily surface-arterial VMT	12,967,400	19,839,900	18,835,100
Total daily local VMT	1,065,100	2,237,100	1,901,800
Daily average trip speed, mph	27.0	23.3	28.3
Peak-hour average trip speed, mph	22.8	16.8	23.4
Daily CO pollution, lb	2,020,574	818,110	767,219
Daily HC pollution, lb	334,114	98,806	93,871
Daily NO_x pollution, lb	233,960	106,884	106,402
Daily gasoline consumed, gal	1,702,601	2,950,939	2,893,815
Total annual fatalities	220	374	363
Total new construction cost, dollars	-	1,038,496,000	1,865,749,000
Jobs relocated	-	3,001	9,114
Residents relocated	-	12,380	17,660

Note: 1 mile = 1.6 km. 1 lb = 0.45 kg. 1 gal = 3.8 l.

Figure 5. Model ADT versus ground counts for Phoenix.

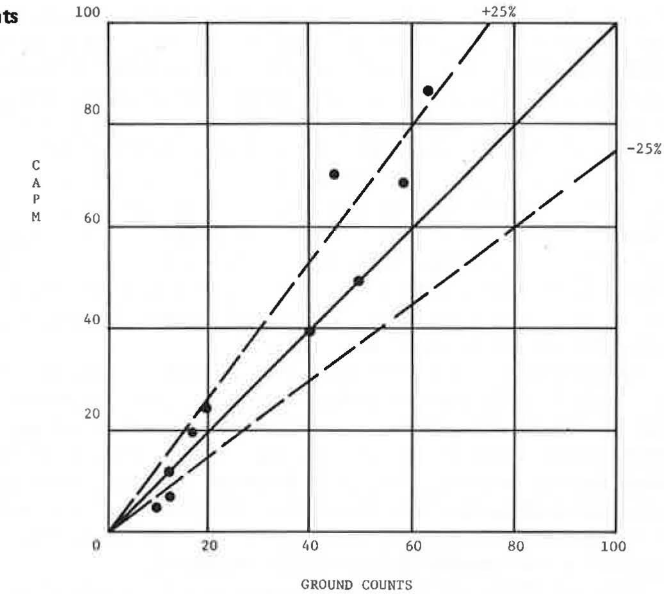
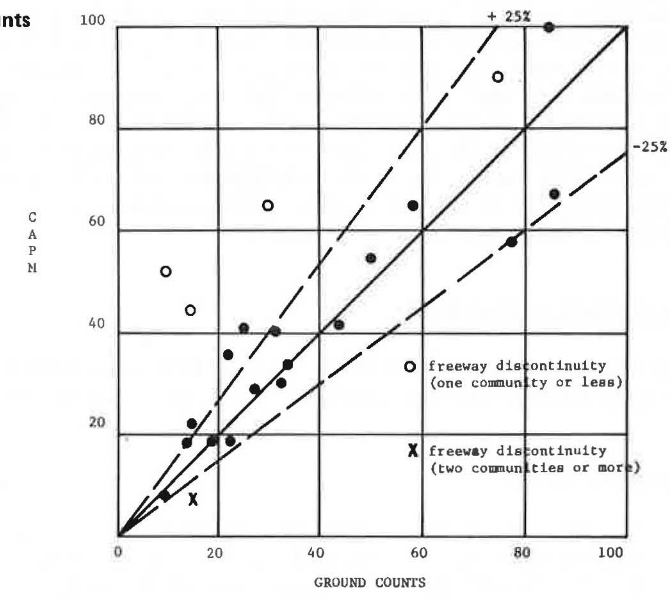


Figure 6. Model ADT versus ground counts for St. Louis.



more money is required to build roads, and a considerably greater number of jobs and people must be relocated. Although the above considerations are for the region as a whole, the same information is output for each community so that localized impacts may be examined.

Such simple comparisons make CAPM useful. The model does not make any decisions; these are reserved for the appropriate decision maker. What it does provide is reasonable and easy to understand information on which to base these decisions. Currently, only preliminary indications of the model's accuracy are available; however, data for base years have been analyzed in Phoenix and St. Louis. Phoenix has a very regular network layout, is basically contiguous, and showed excellent results. Data from ground counts and assignment indicated about 13 million regional VMT (21 million vehicle km), of which 1.25 million VMT (2 million vehicle km) were on freeways. CAPM, using the average work-trip time as reported and no adjustment (slight changes in average work-trip time), estimated less than 14 million regional VMT (22 million vehicle km), of which about 1.3 million VMT (2.1 million vehicle km) were on freeways. St. Louis, with the Mississippi River as a natural barrier, had a data base that did not exactly match the CAPM base system, but the results were quite pleasing. Regionally, CAPM showed 18.9 million VMT (30 million vehicle km) total, of which less than 4 million VMT (6.4 million vehicle km) were on freeways. Data indicated 19.7 million total VMT (32 million vehicle km) of which 3.7 million VMT (6 million vehicle km) were on freeways. Here, however, reported work-trip time was shifted (by about 5 percent) to bring the regional VMT into line.

Community-level VMT data are difficult to obtain. However, Figures 5 and 6 show how well CAPM replicated base-year volumes along segments of the freeways in Phoenix and St. Louis respectively. For Phoenix only 1 out of 10 points falls outside the 27 percent range. For St. Louis, the plot shows that, ignoring points where the freeway network has discontinuities, only 3 out of 17 points fall outside the 25 percent range. Considering that both cities were run with exactly the same model, calibration consisting of no more than inputting average work-trip time, the results are quite pleasing and suggest a reasonable theoretical foundation.

The CAPM process is an attempt to fill a critical void in transportation planning methodology, namely, the need for a first-cut tool to quickly sort through the many alternatives that must necessarily be examined for current planning. The key word is quickly; response to questions must come when they are asked, not 6 to 12 months later. The approach presented here is compact in that outputs appear in a simple and ready-to-use form, and there is no need to run multiple computer programs. Comparisons with field data indicate that the procedure is sufficiently accurate to deal with the broad policy questions that are of interest. One problem, however, is the back-door approach to transit, in which the transit analysis is done outside the program. Work is currently under way to remedy this by making the CAPM process multimodal and by including a set of transit outputs in the performance module. When this is accomplished, CAPM will be an even more useful tool.

ACKNOWLEDGMENTS

We would like to express our sincerest thanks to Paul J. Linden of the Federal Highway Administration for his assistance in the preparation of this report.

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TRANSIT SYSTEM CIRCULATION SIMULATOR: A PRACTICAL DESIGN TOOL

John H. Page, Virginia Department of Highways and Transportation; and
Michael J. Demetsky and David Morris,
University of Virginia and Virginia Highway and Transportation Research Council

This paper presents a transit circulation simulation model to be used heuristically for evaluating and choosing from alternative designs. The simulator measures changes in the performance of a trial transit system that result from variations in the design parameters. These include location of transit nodes, demand flows, vehicle capacity and speed, location of routes, and number of vehicles per route. The model output includes system, route, and vehicle performance characteristics, number of passengers served, and their average in-system travel and wait times. A monitoring capacity provides information, at any time interval, for the number and location of passengers waiting for service, delivered, or en route. The time interval scanning technique is also used to trace the movement of vehicles through the transit system and to provide insight for the next trial scheme. The simulator is demonstrated through the analysis of a new transit system for a university activity center.

•THE contemporary transit system planner faces unprecedented concerns when formulating new or improved public transportation services. In spite of significant advances in transportation planning theory and the computing capability to process large, comprehensive data sets, the growing awareness of social and environmental impacts of transportation systems has made the problem more complex and challenging. The advent of interdisciplinary planning groups, including lay representation, is increasing the need for multiple alternative investigations and a more open style of decision making. A means to quickly trace the effects of a particular change in transit routing, vehicular selection, or other expenditure-related elements is desirable. Test plans that accommodate certain interests or social objectives can be examined in terms of resource allocation and, when compared with other schemes, an equivalent cost for granting these benefits can be illustrated. The analysis components include a model, the electronic means of mapping the physical trial plan and of processing the data, and the planning group that provides the data. What is apparently lacking is a practical algorithm to test the various proposed transit systems. This is sometimes referred to as the black box, which is an unfortunate description when the confidence of a multidiscipline group is sought. Regardless of name or method, however, it seems desirable to work with a means that is simple, direct in principle, and capable of being understood by most users.

Currently, major transit routes are established through the use of techniques originally developed for planning urban highway systems (1). The methodology consists of a sequence of models, commonly referred to as the model system of the transportation planning process, which has recently been modified by the Urban Mass Transportation Administration to include a minimum-path transit algorithm. A number of more specialized transit models have also been developed, but their application has been

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limited. A review of these transit-oriented models is helpful to establish the requirements of a generalized transit planning tool sensitive to operational policy. These models can be classified as the theoretical flow models (2, 3, 4), the socioeconomic model (5), the problem-oriented linear cost-based methods (6, 7, 8), and the route cost relative to level-of-service methods (1, 9). The major limitations of the theoretical models are their many qualifying constraints and assumptions that often require that the actual problem be modified to fit the analytical format. The solutions are correspondingly questionable. The problem-oriented models are directed toward specific situations, and their general use is limited because of narrow goals and the inadequate attention given to factors that directly affect use. These latter considerations include individual waiting time, total time spent in the system, and accessibility of the transit system. In addition, most problem-oriented methods of transit analysis are concerned with the performance of the total system and do not indicate individual travel time or the performance of system components such as specific routes and vehicles.

The available transit planning procedures are also incapable of incorporating and testing the full range of operational policy strategies relative to how they affect alternatives within a major transit plan. Thus a means for evaluating the effects of short-term improvements in existing systems, such as route structures, schedules, and vehicle allocation, is needed along with a means for planning new systems based on the complete range of available technological and operational procedures. Such a tool may be applied subsequent to the modal-choice phase of the urban transportation planning process so that the performance of the transit system can be simulated in a more detailed fashion than a conventional transit assignment currently gives.

MODEL SCOPE

The proposed transit system circulation simulator (TSCS) is designed as an analytical tool to be used in a heuristic approach to area-scale transit planning problems. It is intended to be a practical means of examining, through an iterative process, the governing parameters of various vehicular designs, route configurations, and operating policies for a given travel demand in a service area. The basic objective of its use can be to (a) minimize the required system's physical components, (b) minimize average individual travel time, or (c) establish an acceptable trade-off between the travel time and required system components.

A simulator model is not an optimum-seeking technique in itself, and an exact solution algorithm capable of dealing with large-scale dynamic transportation problems is beyond the present state of the art. However, the heuristic procedure used must be rigorous and exhaustive if it is to provide a probable and practical optimal solution. The model must be flexible in its ability to cope with the large number of constraints present in some situations; on the other hand, it must be capable of incorporating a considerable number of design variables. Ideally, it should be as free of built-in bias as possible, and it should rely on information supplied by each user.

Inputs

TSCS requires two types of input information: demand variables and system variables. These variables are then processed to establish measures of the system, route, and vehicle effectiveness. A basic flow diagram of TSCS is shown in Figure 1. The number and location of the system nodes (trip origin and destination points) are initially specified by dividing the service area into geographical points, each having a demand function (trips per unit time) and a distance component [miles (kilometers)] to all other nodes. These demand variables are given for all modal pairs and can be entered as either a uniform or a random distribution. When the latter approach is more realistic, it can be accomplished with Monte Carlo techniques.

The system variables characterize the transit service in terms of vehicle parameters and network factors. Those system measures associated with the vehicle describe its technology in terms of capacity and speed and specify the number of vehicles on each route or in the entire system. The network parameters are associated with the selection of the nodes that specify the location and number of routes in the network. Finally, loading and off-loading rules are established to select which passengers access or egress a vehicle at each node relative to the direction of travel.

Outputs

TSCS output consists of measures of performance of the entire system, each route, and every vehicle. Figures 1 and 2 show and Table 1 gives some of the performance characteristics that the model provides. During time interval t, the number of passengers waiting for service and the number of passengers who have reached their final destination are designated. The location of every vehicle, its future travel pattern (nodes and arrival times), the number of passengers on the vehicle, and the origins and final destinations are also specified. These summary performance characteristics are used to evaluate the system design relative to designated policy objectives. For example, the operator may desire that the system deliver a maximum number of passengers within a specified time period or that the time the average passenger spends in the transit system be less than some predetermined standard.

TRANSIT SIMULATOR

TSCS uses the time interval method for controlling the scanning process. At the end of each scanning period, time measures that describe all passengers in the system, those waiting for service and those aboard vehicles, are updated. Operationally, TSCS translates the given demand and system variables into performance characteristics and consists of three primary stages:

1. The information synthesizer collects and stores the demand and system variables, computes the transit system schedule, and gives the transit demand for each scanning interval;
2. The load and off-load procedure uses the system schedule, loading and off-loading instructions, and nodal demand to simulate the accessing and egressing of passengers as transit vehicles travel through the network; and
3. The performance characteristics collector calculates and catalogs the various measures of effectiveness for the transit system, routes, and vehicles.

Information Synthesizer

The information synthesizer, shown in Figure 3, integrates the system variables with the demand variables to produce the temporal distribution of demand, the node-to-node traveling and walking times, and the transit system schedule. The locations of the transit nodes determine the distance between all nodes in the transit network. Given this distance, the average system speed, walking times, and system travel times are determined for all nodal pairs. These nodal-pair walking times are later compared to the average system times to determine the true mode (transit or walking) for that nodal demand. The walking time is measured along the straight-line distance between nodal pairs, and the system time is measured along the transit links between nodes and includes the time at each node spent loading and off-loading passengers. When the transit routes and the number of vehicles per route are specified and the node-to-node travel times are produced, the transit system schedule is developed. A typical portion of this transit system schedule is given in Table 2 in matrix form. The rows represent the time interval t, and the columns represent the vehicles m. If the vehicle is at a transit node, element $P(t, m)$ will be equal to that node's number. If the vehicle is not at a node, a zero will fill element $P(t, m)$. For example, if vehicle 10 is at node 6 at

Figure 1. Flow diagram of transit system circulation simulator.

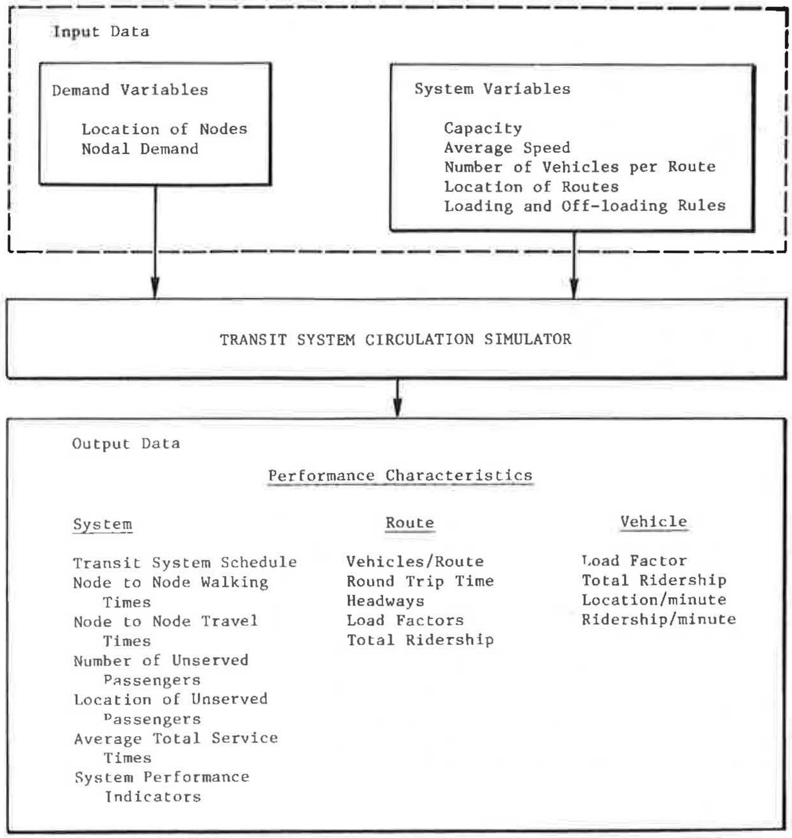

Figure 2. Transit system at time t.

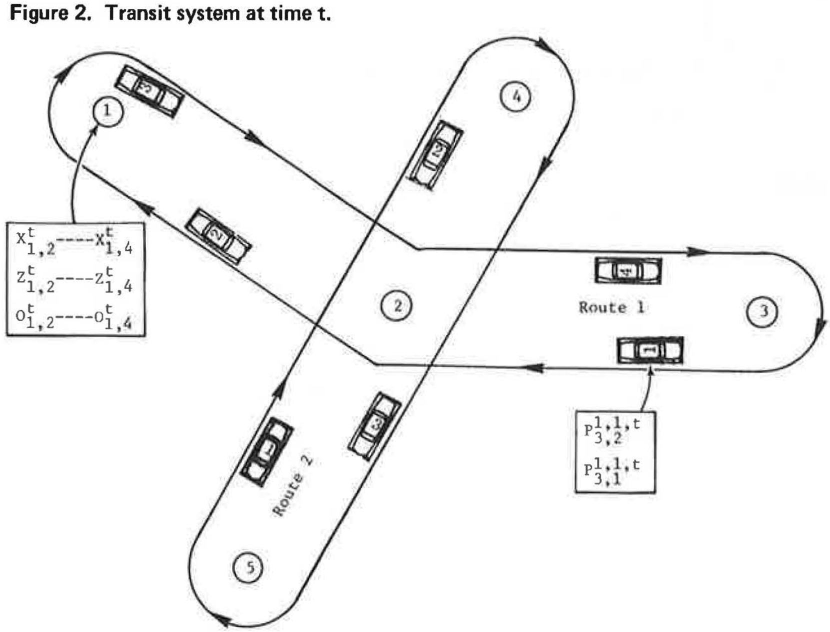

Table 1. System performance characteristics.

Characteristic	Description	Notation[a]
Passengers-in-system matrix	Number of passengers waiting at nodes i whose final destination is j	$X^t_{i,j}$
Delivery matrix	Number of passengers delivered at node j that enter system at node i	$Z^t_{i,j}$
Overflow matrix	Number of passengers at node i going to node j that could not board vehicle because their numbers exceeded capacity of vehicle	$O^t_{i,j}$
System time matrix	Average time spent by passengers (waiting and traveling) from node i to node j	
Average system time	Sum of travel time per passenger in minutes divided by total number of passengers	
Passenger en-route matrix	Number of passengers on vehicle p, on route q with origin i and destination j	$P^{p,q,t}_{i,j}$
Performance matrix	Total number of passengers waiting, delivered, and en route and time values for waiting and delivered passengers	$\Sigma X^t_{i,j} + \Sigma Z^t_{i,j} + \Sigma P^{p,q,t}_{i,j}$

[a]For any system of nodes, vehicles, and routes and any scanning period.

Figure 3. Information synthesizer.

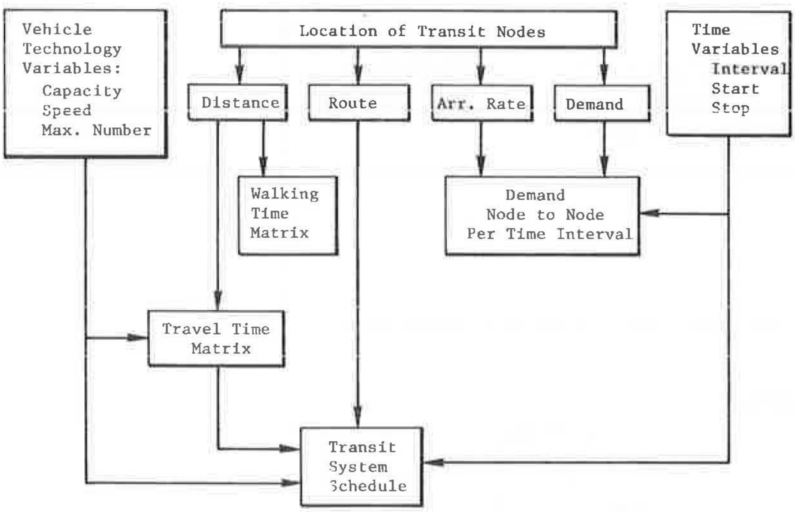

Table 2. Transit system schedule.

Time Interval	Vehicle Number 1	2	3	4	5	6	7	8	9	10
100	2	0	0	0	0	0	9	0	0	7
101	0	0	0	0	0	0	0	2	0	0
102	0	0	7	3	1	7	0	0	3	0
103	0	9	0	0	0	0	8	0	0	6
104	1	0	0	0	0	0	0	9	0	0
105	0	0	8	6	2	6	0	0	2	0
106	0	2	0	0	0	0	7	0	0	3
107	2	0	0	0	0	0	0	8	0	0
108	0	0	0	7	3	3	0	0	9	0
109	0	0	9	0	0	0	6	0	0	2
110	3	1	0	0	0	0	0	7	0	0

t = 103, then P(103, 10) = 6 as given in Table 2. If vehicle 9 is traveling between nodes at t = 100, then P(100, 9) = 0. Thus the transit system schedule represents the position of each vehicle for every time interval in the study period.

Load and Off-Load Procedures

The load and off-load procedures, shown in Figure 4, use a time-interval scanning procedure to update the demand for transit and to access and egress passengers on the vehicles that circulate on the routes. During each time interval, the position of each vehicle is monitored to determine if the vehicle is at a transit node, i.e., $P(t, m) > 0$, and if this is so, passengers are off-loaded and loaded.

There are two possible off-loading procedures: final delivery and transfer of passengers. The number of passengers who have reached their final destination and their corresponding travel times (passenger minutes) are added to the delivery matrix. If the passengers are to be transferred, the sums of all transfer passengers and their passenger minutes are added to the temporal demand matrix. After the off-load procedure is completed, the load subroutine is activated. The load subroutine is designed to load passengers from the temporal demand matrix to the vehicle matrices.

There are two types of loading conditions: (a) All passengers that are waiting for transit can board the vehicle without exceeding the vehicle's capacity or (b) the number of passengers waiting would exceed the maximum capacity of the vehicle. In the first case, the loading instructions are used to load the passengers and their time values into the vehicle matrix. In the second case, when the total number of passengers waiting for transit is greater than the number the vehicle can accommodate, a loading assumption governs. This assumption states that passengers are selected to board the vehicle in the same proportion as the individual nodal demand is to the total nodal demand. For example, if the maximum number of passengers to be loaded at node A, without exceeding the capacity of the vehicle, is 30, the demand would be $X_{a,b} = 40$, $X_{a,c} = 20$, and $X_{a,d} = 0$, and the number of passengers loaded would be $P_{a,b} = 20$, $P_{a,c} = 10$, and $P_{a,d} = 0$. The remaining passengers that are not loaded are added to an overflow matrix. The boarded passengers and their time values are then added to the vehicle matrix. The temporal demand matrix is subsequently reduced to indicate that passengers are loaded on the vehicles or added to the overflow matrix. These load and off-load subroutines are repeated for all vehicles located at a node during the time interval.

Performance Characteristics

As TSCS moves vehicles through the network, the effectiveness of the system's design must be measured. This final stage of the TSCS process determines, catalogs, and stores certain performance characteristics for the total system, individual routes, and each vehicle.

System Performance

The description of system performance characteristics is given in Table 1 as mentioned previously. In addition, the overflow matrix is a principal indicator of the system's performance since it shows which nodes and routes need more vehicles or shorter headways. This matrix also shows removal of passengers not initially served by the transit system and serves to prevent passenger queues at the nodes from becoming too large. The removal of the passengers not served by the first available vehicle is assumed to give a realistic representation of a working system. It is hypothesized that, if a potential passenger is forced to wait for a transit vehicle while full vehicles are passing the stop, the passenger will find another mode of transportation for the trip.

The system time matrix and average system time are measures of the system's performance from the user's point of view; thus, the time values in the matrix and the total average travel time give the planner an indication of the system's effectiveness as measured by the passenger.

Route Performance

The route performance characteristics are used to describe each route and the way in which each affects the performance of the system. These characteristics include number of vehicles per route, round-trip time per route, route headways, and route load factors. The route load factor is an average of the vehicle load factors on that route and is an indicator of the route's ability to meet the travel demand.

Vehicle Performance

The vehicle performance characteristics are similar to the route performance characteristics and are used to determine some of the route characteristics. The vehicle load factor indicates the average number of passengers on the vehicle. This value is also expressed as a percentage of the seated capacity. The total number of passengers carried, the number of passengers on each vehicle, and the position of each vehicle are determined. This information identifies which vehicles can be removed and determines which routes are overloaded or underloaded.

The following application of the transit simulator will clarify and further explain the operational qualities of the model and will define the demand measures and system variables that serve as the initial model inputs. It will also exhibit some typical performance characteristics that can be produced.

APPLICATION

An application of TSCS is demonstrated by an analysis of alternative rubber-tired transit system designs for the University of Virginia. This system will function as a line-haul system (morning and afternoon peak periods) and a circulation system. The following design constraints prevailed in this application of the model:

1. The maximum demand of first trip passengers during the 8 a.m. to 10 a.m. peak period will be met.
2. The transit system will provide service to all areas of the university grounds as well as nearby residential areas.
3. The transit simulator will test the designs during the 7 a.m. to 11 a.m. time period; the peak demand for service is included within this time period.
4. The time the average passenger spends in the transit system, waiting and traveling, during a trip from origin to destination will be less than 10 min.
5. Location of routes will make maximum use of the existing roadways.
6. All nodes will be located at areas of maximum potential ridership, i.e., parking lots, dormitories, residences, and other locations.
7. The system will be designed for a 40-passenger bus; maximum number of vehicles available to the transit system will be 25 buses.
8. The system will average 20 mph (32 km/h) between transit nodes; loading and off-loading times are not included.

Specification of Demand

Nine transit nodes are selected, and their locations are shown in Figure 5. The demand data for the interchanges among the nine nodes are given in Table 3. The distances [miles (kilometers)] between all nodal pairs are given in Table 4.

The arrival rate for transit service is assumed to be uniform for each of the nine

Figure 4. Load and off-load procedures.

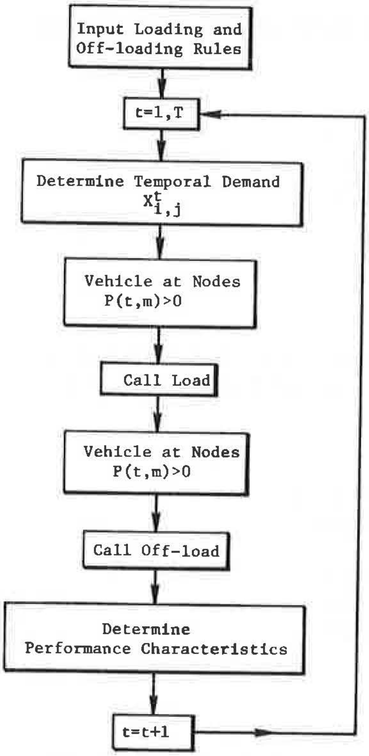

Figure 5. Transit nodes.

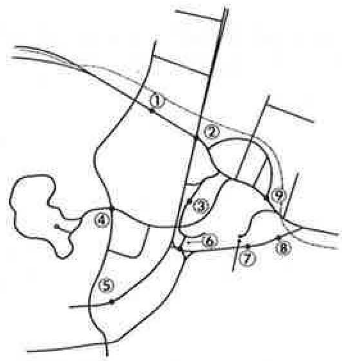

Table 3. Total demand for first trip.

	Destination Node								
Origin Node	1	2	3	4	5	6	7	8	9
1. University Hall	0	190	450	120	0	1,320	970	400	10
2. Fine Arts	40	0	360	100	0	1,060	780	310	10
3. Newcomb	10	50	0	30	0	580	270	110	0
4. Alderman	80	250	530	0	0	1,560	1,080	480	10
5. Stadium	40	140	240	70	0	750	570	230	10
6. Grounds	20	70	140	500	0	0	3,300	1,400	0
7. Brandon	10	40	30	30	0	240	0	80	10
8. Medical	10	50	120	40	0	370	270	0	0
9. Elliewood	40	200	430	130	0	1,220	830	360	0

Note: Values are in miles. 1 mile = 1.6 km.

Table 4. Distance node to node.

	Destination Node								
Origin Node	1	2	3	4	5	6	7	8	9
1. University Hall	0.0	0.70	1.20	1.00	1.70	1.50	1.75	2.10	1.00
2. Fine Arts	0.70	0.0	0.50	1.10	1.20	0.80	1.05	0.85	0.30
3. Newcomb	1.20	0.50	0.0	0.60	0.70	0.30	0.55	0.90	1.45
4. Alderman	1.00	1.10	0.60	0.0	0.70	0.50	0.75	1.10	1.45
5. Stadium	1.70	1.20	0.70	0.70	0.0	0.50	0.75	1.10	1.45
6. Grounds	1.50	0.80	0.30	0.50	0.50	0.0	0.25	0.60	1.15
7. Brandon	2.10	0.85	0.90	1.10	1.10	0.60	0.35	0.0	0.55
9. Elliewood	1.00	0.30	1.45	1.45	1.45	1.15	0.90	0.55	0.0

Note: Values are in miles. 1 mile = 1.6 km.

transit nodes in the system. The arrival rate is divided into two components:

1. The hourly load factors, as given below, represent the percentage of the total number of trips made during the hour.

Hour	Load Factor (percent)	Hour	Load Factor (percent)
7 to 8 a.m.	20	9 to 10 a.m.	30
8 to 9 a.m.	30	10 to 11 a.m.	20

2. The arrival ratios of the passengers, as given below, are centered around the change of classes within the hour time periods. The hour is divided into six 10-min intervals.

Time (min)	Arrival Ratio	Time (min)	Arrival Ratio
0 to 10	0.25	30 to 40	0.15
10 to 20	0.10	40 to 50	0.15
20 to 30	0.10	50 to 60	0.25

System Variables

The alternatives evaluated are shown in Figures 6 and 7. Each network is evaluated with the number of vehicles per route varied, but the route network and all other design constraints are held constant. Each change in the number of vehicles per route is referred to as a transit plan; these transit plans are given in Table 5 for networks A and B.

Evaluation Criteria

After the design constraints were reviewed, the following evaluation criteria were used to determine the best alternative transit plan:

1. System performance criteria include delivery of maximum number of passengers, in-system time (waiting and traveling time) less than 10 min, and average vehicle load factor greater than 10 passengers/vehicle/min.
2. Route performance criteria include headways less than 10 min and route load factors greater than 10 passengers/vehicle/min.

The results of these evaluations are given in Table 6. Based on the evaluation criteria, plan A-4 would be selected. It meets all of the route and system criteria and delivers the maximum numbers of passengers. Plan A-6 delivers more passengers but does not meet the route load factor criterion of maintaining a minimum of 10 passengers/vehicle/min. The evaluation criteria given in this application are not intended to limit the simulator but are only examples of the many possible evaluation criteria. TSCS output can be included within a cost-benefit analysis or combined with nonuser impacts to provide for a comprehensive evaluation of transit system designs.

Figure 6. Network A.

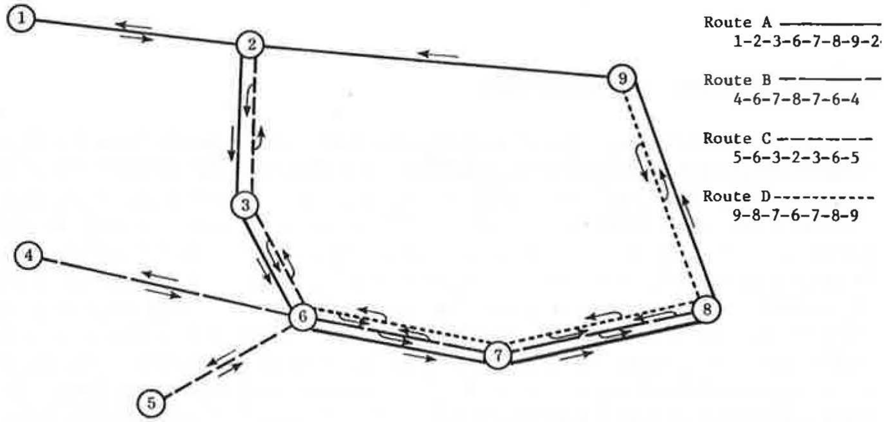

Figure 7. Network B.

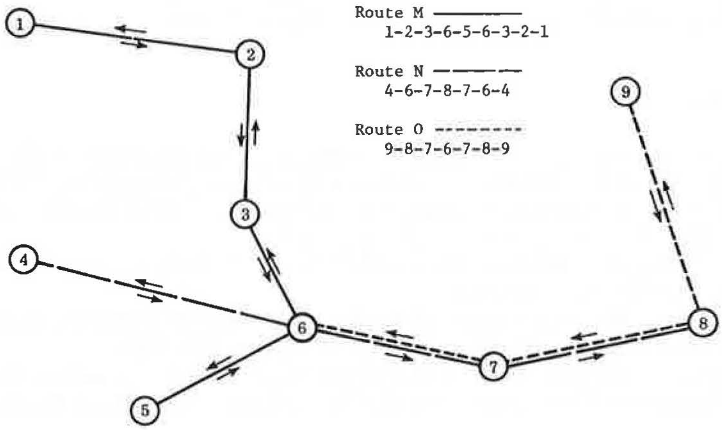

Table 5. Number of buses per route.

	Network A Routes				Network B Routes		
Plan	A	B	C	D	M	N	O
A-1	4	4	4	4			
A-2	6	4	4	4			
A-3	8	6	4	4			
A-4	10	7	5	3			
A-5	12	6	3	4			
A-6	10	7	4	4			
B-1					3	3	3
B-2					5	5	5
B-3					7	6	6
B-4					8	7	7
B-5					10	7	7

Table 6. Evaluation matrix of alternative transit plans.

Plan	Number of Passengers Delivered	In-System Time (min)	Average Load Factor	Headways (min)	Route Load Factor
Network A[a]					
A-1	11,843	8.6	15	7, 5, 6, 6	20, 16, 11, 14
A-2	12,473	8.5	14	5, 5, 5, 6	17, 16, 11, 14
A-3	13,313	8.3	13	4, 4, 5, 6	15, 17, 8, 12
A-4	14,191	8.1	12	3, 3, 4, 7	14, 10, 10, 12
A-5	14,031	8.3	11	3, 4, 7, 6	14, 9, 9, 11
A-6	14,250	8.1	11	3, 3, 5, 6	14, 9, 9, 11
Network B[b]					
B-1	8,829	9.7	22	9, 7, 7	26, 18, 22
B-2	11,134	8.7	17	6, 5, 5	21, 15, 16
B-3	12,632	8.5	16	4, 4, 4	19, 13, 16
B-4	13,485	8.2	14	4, 3, 3	15, 13, 12
B-5	13,798	8.1	14	3, 3, 3	15, 13, 12

[a]Routes A, B, C, D in Figure 6.
[b]Routes M, N, O in Figure 7.

SUMMARY AND CONCLUSIONS

The TSCS model uses a person-computer interaction procedure for testing alternative transit systems and operating policies. By showing the sensitivity of various system components, this analytical tool aids in selection of optimal circulation routes, vehicular designs, and transfer points. TSCS needs only readily available data as inputs (demand and system variables), and the output information (performance characteristics) is designed to indicate the effectiveness of the system in a relatively simple manner. The number of transit nodes and the size and number of the time intervals are limited only by the storage capacity of the computer. The present stage of development of TSCS limits the average in-system-time values to approximations based on groups of passengers and not on an average of each individual passenger trip. A method for inventorying individual trips would improve the accuracy of the simulator. An additional improvement would be to key the arrival rate of the vehicles to the arrival of passengers at pickup points. An interactive computerized format using data displays and light-screen mapping can also be developed to greatly improve the synthesis process.

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TRAVEL BY TRAILS IN PARK AREAS

David B. Sanders and Jon M. Kowolaski, De Leuw, Cather and Company

This paper is essentially an early conceptual approach to formulate a more comprehensive program for studying and improving trails for park and recreational areas. A review of the growing impact of park and recreation areas is given, and the importance of trails is presented. Recent recreation studies and their theoretical approaches are evaluated, and significant trail problems, such as increase in demand, periodicity, lack of overall planning, and poor design standards, are discussed. The paper also addresses user characteristics, costs, signing, and accidents. Examples of minor administrative and engineering improvements are given that might make for more efficient park use. The paper concludes that many principles applicable in urban transportation planning can be applied to park and recreational trail planning.

•TRAVEL by foot is the oldest means of transportation. Pedestrian movement is a vital part of any urban or rural transportation system because any trip involves a pedestrian movement at the origin or destination or at both. Generally, the pedestrian movement is not the sole purpose of the trip. There is, however, a class of trips where the pedestrian movement itself is the purpose. These trips include walking and hiking and mainly involve recreational pursuits.

This paper will address hiking along trails. Hiking is defined as that activity involving a long walk especially for pleasure or exercise. We will use data supplied mainly by the National Park Service (NPS) and the National Forest Service (NFS) to review, in a macro manner, the state of the art and to make recommendations to improve trail planning. The focus is on low-density foot trails although the principles apply to other types of trails.

PROBLEM

Today people are going to and using parks and other outdoor recreation areas in increasing numbers. NFS of the U.S. Department of Agriculture administers 124 national forests containing about 286,000 miles^2 (740 737 km^2), about 20,000 miles^2 (51 800 km^2) larger than Texas. In 1973, these areas attracted about 188 million visitor days of use (a visitor day is defined as one visitor spending 12 hours of consecutive time in the national forest).

NPS of the U.S. Department of the Interior is the administering agent for about 298 unique geographic areas totaling 47,000 miles^2 (121 730 km^2), about the same size as Mississippi. These areas include a system of 38 national parks, 82 monuments, and 178 other historic and recreational areas. In 1973, these areas attracted nearly 216 million visitors. Table 1 gives previous and projected levels of use for 29 selected national parks and monuments classified by 6 regional areas. Each park region, between 1960 and 1973, shows significant absolute and percentage increases (Table 2). By 1985 and 2000, these parks are expected to attract an average of about 243 and 300 percent more visitors than they did in 1960.

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Table 1. Existing and projected use of selected National Park Service areas.

Location[a]	Area (miles^2)	Existing Use 1960	1965	1970	1971	1972	1973	Projected Use[b] 1985	2000
Northwest									
Glacier Bay NM, Alaska	4,381	900	1,800	29,700	25,700	24,700	36,000	61,000	76,000
Mt. Rainier NP, Washington	378	1,538,700	1,643,100	1,925,100	1,742,600	1,682,400	1,528,200	1,971,000	2,420,000
Crater Lake NP, Oregon	250	397,700	480,500	535,000	557,900	594,300	539,500	698,000	857,000
Craters of the Moon NM, Idaho	84	134,300	183,900	223,500	274,600	205,900	190,900	327,000	368,000
Olympic NP, Washington	1,401	1,160,400	2,058,000	2,283,100	1,859,700	3,031,700	2,817,000	4,360,000	5,354,000
Subtotal	6,494	3,232,000	4,367,300	4,996,400	4,460,500	5,539,000	5,111,600	7,417,000	9,075,000
West									
Hawaii Volcanoes NP, Hawaii	468	709,100	573,900	822,300	980,700	1,389,100	1,260,500	1,966,000	2,579,000
Yosemite NP, California	1,190	1,150,400	1,635,400	2,277,200	2,416,400	2,666,600	2,339,400	2,874,000	4,150,000
Death Valley NM, California	2,981	355,900	453,000	580,500	559,500	568,300	606,500	768,000	1,008,000
Sequoia NP, California	604	610,800	877,300	875,700	882,000	869,600	846,300	1,017,000	1,334,000
Pinnacles NP, California	23	72,000	118,000	166,200	169,200	168,900	155,500	226,000	297,000
Subtotal	5,266	2,898,200	3,657,600	4,721,900	5,007,800	5,662,500	5,208,200	6,851,000	9,368,000
Midwest									
Rocky Mountain NP, Colorado	410	1,532,500	1,619,800	2,357,900	2,457,300	2,519,600	2,522,000	3,149,000	4,024,000
Grand Teton NP, Wyoming	485	1,429,900	2,507,000	3,352,500	3,284,500	3,002,200	3,083,300	4,072,000	4,577,000
Pipestone NM, Minnesota	1	155,500	92,100	157,500	156,800	169,700	143,600	293,000	350,000
Yellowstone NP, Wyoming, Montana, Idaho	3,472	1,443,300	2,062,500	2,297,300	2,126,300	2,251,700	2,066,200	2,337,000	2,627,000
Glacier NP, Montana	1,585	724,500	847,100	1,241,600	1,303,100	1,392,200	1,399,000	1,874,000	2,106,000
Subtotal	5,953	5,285,700	7,128,500	9,406,800	9,328,000	9,335,400	9,214,100	11,725,000	13,684,000
Northeast									
Acadia NP, Maine	65	1,638,200	1,733,600	2,776,300	2,455,700	2,645,400	2,776,600	3,555,000	4,351,000
Isle Royale NP, Michigan	843	6,400	9,500	14,400	15,900	16,100	15,700	25,000	30,000
Statue of Liberty NM, New York	1	769,000	1,064,500	1,104,900	1,078,500	1,091,100	1,125,900	1,200,000	1,474,000
Fort McHenry NM, Maryland	1	511,500	628,800	569,100	515,000	504,800	506,800	548,000	673,000
Subtotal	910	2,925,100	3,436,400	4,464,700	4,065,100	4,257,400	4,425,000	5,328,000	6,528,000
Southwest									
Big Bend NP, Texas	1,107	75,900	174,600	172,600	247,400	290,200	341,300	445,000	543,000
Canyonlands NP, Utah	527	—	19,400	33,400	55,400	60,800	62,600	108,000	138,000
Carlsbad Caverns NP, New Mexico	73	537,000	591,000	712,700	791,000	850,100	840,100	1,102,000	1,485,000
Bryce Canyon NP, Utah	56	272,000	366,800	345,900	379,500	426,200	431,000	636,000	813,000
Natural Bridge NM, Utah	12	6,500	19,300	39,900	49,100	58,500	42,700	78,000	100,000
Subtotal	1,775	891,400	1,171,100	1,304,500	1,523,000	1,691,800	1,717,700	2,429,000	3,079,000
Southeast									
Great Smoky Mountains NP, Tennessee	807	4,528,600	5,954,900	6,778,500	7,179,000	8,040,600	9,774,100	13,304,000	16,337,000
Everglades NP, Florida	2,188	579,200	977,600	1,273,500	1,293,500	1,773,300	1,790,700	2,637,000	3,499,000
Shenandoah NP, Virginia	302	1,780,100	2,289,400	2,411,500	2,406,500	2,304,100	2,574,300	2,825,000	3,470,000
Mammoth Cave NP, Kentucky	80	519,100	872,200	1,726,500	1,745,000	1,872,900	1,927,500	2,254,000	2,739,000
Virgin Islands NP, Virgin Islands	23	27,200	57,400	126,600	256,600	281,600	293,600	407,000	540,000
Subtotal	3,400	7,434,200	10,151,500	12,316,600	12,880,600	14,272,500	16,360,200	21,427,000	26,585,000
Total	23,798	22,666,600	29,912,400	37,210,900	37,265,000	40,756,600	42,036,800	55,177,000	68,319,000

Note: 1 mile = 2.6 km^2. Use values are given in total number of visits per park.

[a]NM = national monument; NP = national park. [b]Does not account for possible fuel shortages that might impact use.

Table 2. Percentages of use higher than 1960 level for selected National Park Service areas.

Location	Existing Use 1965	1970	1971	1972	1973	Projected Use[a] 1985	2000
Northwest	135.1	154.6	138.0	171.4	158.2	229.5	208.8
West	126.2	162.9	172.8	195.4	179.7	236.4	323.2
Midwest	134.9	178.0	176.5	176.6	174.3	221.8	258.9
Northeast	117.5	152.6	139.0	145.5	151.3	182.1	223.1
Southwest	131.4	146.3	170.9	189.8	192.7	272.5	345.4
Southeast	136.6	165.7	173.3	192.0	220.1	228.2	357.6
Total	132.0	164.2	164.4	179.8	185.5	243.4	301.4

[a]Does not account for possible fuel shortages that might impact use.

These increases, along with the assumption of approximately fixed natural resources, will present new and serious problems for persons interested in the pursuit of recreation in a low-density environment. There are limits to the amount of use these areas can withstand.

Thedore Roosevelt, in 1912, summarized his views on conservation and the environment aptly with the following remarks:

> In utilizing and conserving the natural resources of the Nation, the one characteristic more essential than any other is foresight. Unfortunately, foresight is not usually characteristic of a young and vigorous people, and it is obviously not a marked characteristic of us in the United States. Yet assuredly it should be the growing nation with a future which takes the long look ahead.

NPS, partially as a result of vehicle access studies, has suggested and implemented significant changes in the way people have historically been enjoying their parks and recreation areas. For example, buses are now used rather than private vehicles to take visitors into most of Yosemite National Park's major activity centers (namely, the valley), and public transport systems are also under study for Yellowstone, the Everglades, and Mount McKinley National Parks. The buses now used in Yosemite were mandated because of concern about the growing incompatibility between vehicles and pedestrians and air and noise pollution levels. Parks, however, are seeking to minimize all forms of environmental-ecological damage, and this concern will result in changes in how all of us use these areas in the future.

REASON FOR TRAILS

Trails have historically played an important part in America's development. Today their function is not just for historical purposes but for low-density recreation as well. They have served to open remote areas by allowing mail and commerce to be interchanged. They permit persons to view and obtain access to desert, seashore, marsh, and forest areas close up without damaging existing ecological relationships. Many existing highways and railroad rights-of-way follow previously existing trails formed by the American Indian or by wagons during America's westward push in the 1700s.

Many activities occur on trails, such as hunting, fishing, bicycling, horseback riding, picnicking, sightseeing, nature study, and hiking. As the popularity of recreation areas has generally increased the use of components of these areas has concomitantly increased. NFS data show that trail use has been increasing (1969 to 1973) at an average annual rate of about 6.1 percent; trail use as a percentage of total forest use ranges from about 3.4 to 4.3 percent during this same period. There are about 96,000 miles (154 500 km) of trails in the NFS; however, although classified and used as trails, 67,000 miles (107 826 km) are actually all-purpose roads, 9,000 miles (14 484 km) are walking trails, 15,000 miles (24 140 km) are fire roads, and 5,000 miles (8047 km) are limited-purpose-access roads.

Data from the NPS indicate that trail use is increasing at about 25 percent per year. The specific numbers of people using trails are not available, but a figure of 32,000,000 per year is estimated. Table 3 gives some recent trends in overnight and backcountry use that are probably highly correlated with trail use. Table 4 gives the total supply and type of trails for the United States. NPS has about 9,750 miles (15 691 km) of trails; over 80 percent are more than 25 years old, and another 10 percent are over 10 years old.

One of the few comprehensive transportation system studies made concerning recreational areas was previously described in another publication (4). Trip generation, distribution, modal split, and assignment were forecast from models calibrated from a series of national forest travel surveys. Like other studies (2, 9), however, data were collected primarily from interviews and observations along the major road network leading to the forest. Few studies (3) have been devoted to the analysis of low-density origins and destinations such as those that occur along trails in remote sections of parks and other recreation areas. In addition, these studies were primarily concerned with the private automobile, and the fact is that most parks are still oriented toward serving people close to their vehicles.

Lately, the U.S. Department of the Interior has recognized the seriousness of increasing park use for all its activities and is engaged in an active program to study this and methods of managing existing demand. This has generally been addressed by researching new methods of data collection (10) and by attempting to determine park use motivational characteristics (1, 5, 11). These new statistics, when they are available, should prove useful.

Existing procedures for managing demand along trails in some parks now include

1. Establishing camping duration limits along with campground capacities,
2. Requiring permits for some trails,
3. Restricting trail users such as in Sequoia National Park, and
4. Encouraging reservations for designated camping areas (some parks have tried a computerized reservation system).

TRAIL PLANNING AND DESIGN

Unlike the typical urban transportation planning process that designs transport facilities around criteria of maximum density and volume under constraints of safety and travel time, the objectives of trail planning are quite different, depending on the attributes of its users. Trail planning should recognize explicitly the purpose of the trail and integrate the user with the environment in such a way that this is achieved.

Problems

Major problems currently confronting trail specialists include

1. Methods of determining trail-user characteristics;
2. Facilities required to support trail use;
3. Determination of trail capacity;
4. Ecological and environmental impact of trail use on water, plant, and animal systems;
5. Methods of setting maintenance and staffing standards;
6. Provision of trails for the handicapped; and
7. Methods of calculating trail demand.

Trail-User Characteristics

Trail specialists have already taken interim steps to control the demand for trails; they have done so with little or no information on specific user characteristics, such as age, education, trip length, length of stay, facilities used or desired, origin and destination, and frequency of use. The design of trails should be related to the users; Table 5 (13) gives a summary of one of the few user studies made in a low-density park area. The way an individual reacts on a trail is a function of friction and gravity and other factors. Trails could be improved if more were known about how people walk as a function of grade and surface. Trails, in general, have too long been designed by rules of thumb that, when examined, are unrelated to today's user. Few if any studies have been made correlating the hiker's sense of comfort with the type of trail. Design criteria are needed as well as research concerning the following:

1. Frequency of providing level rest areas on steep trails;
2. Cause of trail accidents such as slippage due to fatigue, weather, and surface;
3. Maximum acceptable grade and trail surface for users;
4. Suggested grades to control erosion;
5. Visual and noise criteria; and
6. Physical layout of trails such as spacing, connectivity, length, width, grade, and surface.

The amount of time hikers spend on trails is important for planning purposes. Walking speeds depend on many factors, as suggested in the table below (1 mile = 1.6 km):

Type of Terrain	Average Time To Cover 1 Mile (min)	Speed (mph)
Along road	15	4.0
Open field, gentle upgrade	25	2.4
Wooded area, gentle upgrade	30	2.0
Mountain area, steep upgrade	40	1.5

Table 3. Type of use of selected National Park Service areas.

Location[a]	Area (mile²)	Overnight Use[b] 1971	Overnight Use[b] 1972	Overnight Use[b] 1973	Backcountry Use[c] 1972	Backcountry Use[c] 1973	Total Trail Length (miles)	Hiking Trails	Camping Sites on Trails	Shelters on Trails
Northwest										
Glacier Bay NM, Alaska	4,381	13,100	17,100	18,600	700	1,100	8	3	0	0
Mt. Rainier NP, Washington	378	144,400	141,200	205,100	18,200	24,900	300	75	21	13
Crater Lake NP, Oregon	250	65,300	81,200	92,000	600	1,100	79	14	0	1
Craters of the Moon, NM, Idaho	84	19,000	18,700	17,800	0	0	20	6	0	0
Olympic NP, Washington	1,401	402,500	553,000	566,400	175,200	185,900	586	94	99	76
Subtotal	6,494	644,300	811,200	899,900	194,700	213,000	993	192	120	90
West										
Hawaii Volcanoes NP, Hawaii	468	88,700	93,500	93,600	2,500	2,500	156	22	5	4
Yosemite NP, California	1,190	1,596,300	1,609,400	1,754,300	220,800	318,100	766	141	—[d]	—[d]
Death Valley NP, California	2,981	279,900	255,200	257,900	1,400	—[d]	21	6	0	0
Sequoia NP, California	604	212,100	221,100	235,800	69,100	58,800	809	105	0	0
Pinnacles NP, California	23	47,000	46,200	47,700	—[d]	—[d]	19	7	0	0
Subtotal	5,266	2,224,000	2,225,400	2,369,300	293,800	379,400	1,771	281	5	4
Midwest										
Rocky Mountain NP, Colorado	410	275,600	281,100	301,400	36,100	37,200	320	92	99	0
Grand Teton NP, Wyoming	485	593,200	618,600	559,600	30,400	31,400	200	33	22	0
Pipestone NM, Minnesota	1	—[e]	—[e]	—[e]	—[e]	—[e]	1	1	0	0
Yellowstone NP, Wyoming, Montana, Idaho	3,472	1,345,600	1,464,600	1,141,200	24,900	36,800	990	108	99	0
Glacier NP, Montana	1,583	360,500	357,500	368,700	14,500	27,500	936	177	82	6
Subtotal	5,951	2,574,900	2,721,800	2,370,900	105,900	132,900	2,447	411	302	6
Northeast										
Acadia NP, Maine	65	239,400	224,500	233,500	400	—[d]	123	102	0	0
Isle Royal NP, Michigan	843	75,100	67,700	66,700	8,400	8,200	167	20	99	73
Subtotal	908	314,500	292,200	300,200	8,800	8,200	290	122	99	73
Southwest										
Big Bend NP, Texas	1,107	192,000	215,300	215,100	11,500	13,000	68	31	0	20
Canyonlands NP, Utah	527	25,200	29,600	33,000	11,500	13,400	22	13	0	0
Carlsbad Caverns NP, New Mexico	73	1,400	0	0	0	0	61	11	0	0
Bryce Canyon NP, Utah	56	108,300	119,400	123,800	600	700	62	26	0	0
Natural Bridge NM, Utah	12	6,600	7,700	7,200	—[e]	—[d]	5	8	0	0
Subtotal	1,775	333,500	372,000	379,100	23,600	27,100	218	89	0	20
Southeast										
Great Smoky Mountains NP, Tennessee	807	559,800	626,100	537,900	68,800	82,500	697	186	62	22
Everglades NP, Florida	2,188	131,400	166,600	227,900	8,700	22,800	179	23	20	0
Shenandoah NP, Virginia	302	450,500	446,200	600,500	75,900	120,500	465	171	21	21
Mammoth Cave NP, Kentucky	80	160,500	166,700	186,100	400	700	12	8	0	0
Virgin Islands NP, Virgin Islands	23	90,000	110,600	92,900	—[d]	—[d]	24	22	0	0
Subtotal	3,400	1,392,200	1,516,200	1,645,300	153,800	226,500	1,377	410	103	43
Total	23,794	7,483,400	7,938,800	7,984,100	780,600	987,100	7,096	1,505	629	236

Note: 1 mile² = 2.6 km². 1 mile = 1.6 km.

[a]NM = national monument; NP = national park.
[b]Passing of 1 night per person.
[c]Use of area at least 0.5 mile (0.8 km) from a paved road and 0.25 mile (0.4 km) from improved facilities.
[d]Not applicable.
[e]No overnight use.

Table 4. U.S. supply trails by type.

Location	Total Trail Length[a]	Trail Type: Hiking	Horseback	Bicycle	Motor	Nature	Handicapped
Northwest	55,646	4,438	3,337	215	2,964	402	37
West	23,122	3,657	2,236	731	466	243	17
Midwest	12,709	3,791	2,507	1,513	5,986	1,418	52
Northeast	16,478	7,844	2,186	1,445	3,555	1,110	54
Southwest	16,823	2,827	1,716	431	816	394	10
Southeast	9,981	3,690	1,694	660	997	1,316	37
Total	134,759	26,247	13,676	4,995	14,784	4,883	207

Note: All values are given in miles. 1 mile = 1.6 km.

[a]Does not equal total type of trails because many that are classified as trails are used for roads, emergency fire lanes, and so on.

Table 5. Results of study on area use of low-density area of Rocky Mountain National Park.

Item	Response (percent)	Item	Response (percent)
State of residence		Family income, dollars	
Colorado	31	<3,000	9
Illinois	8	3,000 to 5,999	8
Michigan	6	6,000 to 8,999	10
Texas	5	9,000 to 11,999	13
Other	50	12,000 to 14,999	13
Age, years		15,000 to 17,999	11
11 to 19	24	18,000 to 29,999	17
20 to 29	50	>30,000	13
30 to 39	11	No response	6
40 to 49	9	Backcountry experience, years	
50 to 59	4		
60 to 69	1	0 to 1	33
Other	1	1 to 2	24
Level of education		2 to 3	10
Less than high school	9	3 to 4	7
High school	30	4 to 5	4
2-year college	12	5 to 10	10
4-year college	26	Over 10	12
Postgraduate	23	Previous visits to Rocky Mountain National Park	
Occupation			
Student	45	0 to 1	49
Professional	25	2 to 4	24
Technician	6	5 or more	27
Other	24		

Travel times for hikers in various situations, based on the table above, can be computed according to the following table:

Situation	Change in Travel Time Increase	Decrease	Percent
Backpacking on trail	X		25
Running on trail		X	50
Walking on gentle downgrade		X	10
Walking on steep downgrade		X	25

Figure 1 shows the duration characteristics of those hikers using trails in national parks; the average trip length is about 2.15 hours.

Design of Trails

The identification and provision of trails are important for recreational use; trail planning and design should be part of a master plan. The steps in planning and laying out trails are similar to the general transportation process: reconnaissance, inventory, plan formulation, alternative development, analysis, and evaluation. Trails designed today should

1. Be long enough for a user to reach some satisfaction level consistent with their speed,
2. Avoid motor crossings,
3. Not use frequent bends or loops because they can create an element of surprise and produce a feeling of remoteness,
4. Use local materials,
5. Use landscaping to separate different trail uses, and
6. Be part of a master plan.

DEMAND FOR TRAILS

Determining the aggregate demand for parks and recreation areas and the specific demand for trails is important. Demand calculation can provide a basis for fiscal and personnel allocation and better management procedures. The tables in this paper have only shown consumption relationships; demand in economic terms is the relationship between price and quantity. Most existing demand methods for trail planning attempt to count the numbers of existing users and extrapolate them according to local population projections and adjust for minor irregularities. The demand for trails, however, may depend on the following internal and external attributes:

1. Condition and capacity of campgrounds,
2. Type of trail,
3. Climate and aesthetic factors,
4. Population of urban area,
5. Distance traveled,
6. Income,
7. Leisure, and
8. Competing trail opportunities.

Normally, field surveys are taken to establish user origins, mode of travel, length of stay, and demographic characteristics so that demand can be calculated. Historically, they have been vehicle and park oriented rather than activity oriented and are expensive and time-consuming. Low-cost methods of determining trail demand are necessary. Figures 2, 3, 4, 5, and 6 are scatter diagrams that attempt to show correlation with other easier to obtain variables. Backcountry use was used as a proxy variable for actual trail use. Regression analysis failed to show any statistically significant relationships.

If the demand for park and recreational use were evenly spread throughout the year, there probably would not be the crowding problem that presently exists in some areas. Unfortunately, visits to most park facilities are concentrated in the summer months of June, July, and August, and 61 percent of activities occur between May and September (Figure 7). Naturally, each park has its own particular characteristics that affect use, such as prevailing weather, proximity to major urban centers, and internal scenic attributes. Long holiday weekends may also generate a great deal of park use.

COST OF TRAILS

Hiking trails are currently estimated to cost between \$2,000/mile (\$1243/km) in typical forest areas and \$6,000/mile (\$3728/km) in steep, rocky terrain. Trails in very rough terrain have cost more than \$10,000/mile (\$6214/km), and others have cost \$200 or \$300/mile (\$124 or \$186/km). Costs depend on many factors, such as the number and type of bridges, culverts, signs, hand or guard rails, and material and on location and specific labor requirements. Maintenance varies a great deal, depending mainly on how and to what intensity the trail is used and on erosional effects. During 1972 NFS averaged \$55/trail mile (\$34/km). Of the initial cost per year, 1 to 3 percent can be used as a rough guide (12).

SIGNING

The proper and uniform signing of trails is extremely important. The head of a trail should be identified with a symbol and name (perhaps color coded), mileage for the section indicated, probable walking time, and the level of difficulty (e.g., leisurely, moderate, difficult, and for experienced hikers only). Additional information such as facilities available along the trail would also be beneficial. Along the trail, simple but clearly identified symbols and markers can be used to indicate trail name and important distances. Signing, however, should be standardized at least in recreational areas of similar types.

ACCIDENTS

Visitor accidents in park and recreation areas have generally been increasing. At this time, detailed accident statistics along trails cannot be presented. Most parks, however, report that accidents, particularly falls, occur as a result of hikers leaving the designated trail and getting into terrain that is too steep. Many other accidents, however, occur on trails that are not, or are seldom, maintained. The statistics do show that it is the under-25 age group that is most affected. Most accidents occur in the peak season.

TRAIL DEVELOPMENT

The U.S. Congress, acting in response to new demands on park areas, has passed a number of legislative acts that have set policy for the park and other recreational operating agencies. Passage of the National Trails Systems Act of 1968 recognized the value of trails as a significant form of recreation. It established two types of trails: national scenic trails (NST) and national recreation trails (NRT). NST are

Figure 1. Estimated trip length distribution.

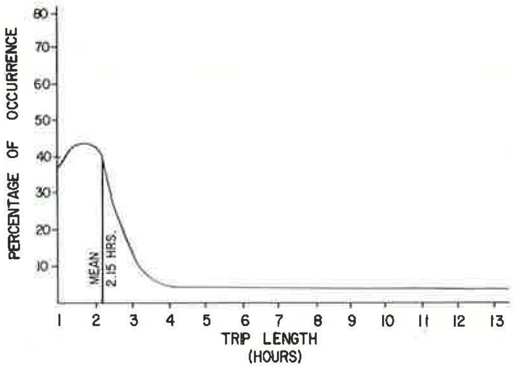


Figure 2. Backcountry versus park use.

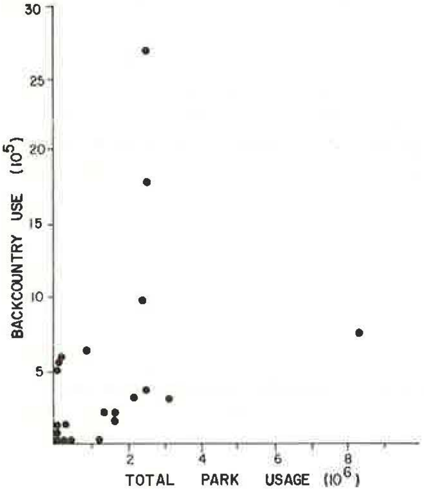


Figure 3. Backcountry use versus park area.

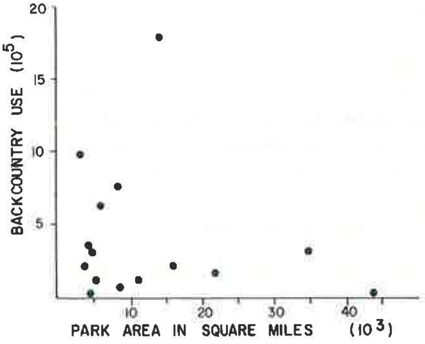


Figure 4. Backcountry use versus trail density.

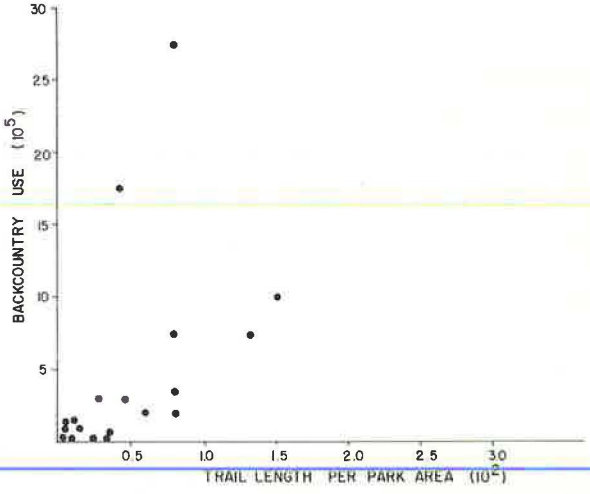


Figure 5. Backcountry use versus overnight use.

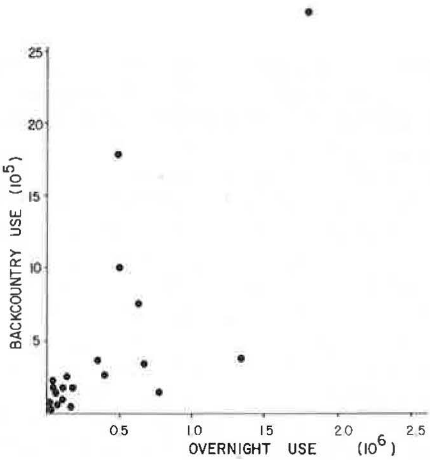


Figure 6. Backcountry use versus trail length.

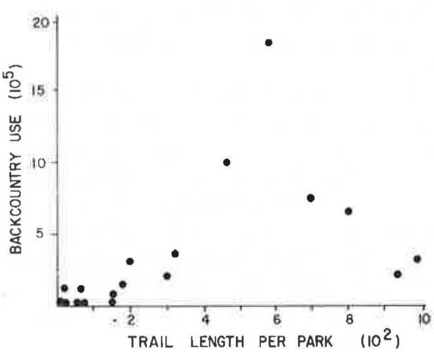


Figure 7. Park use by month, 1972.

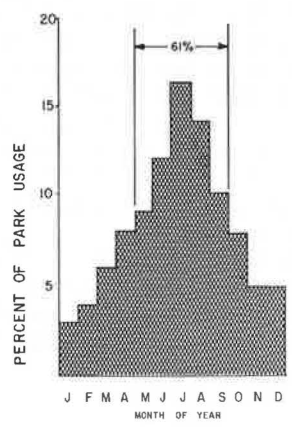
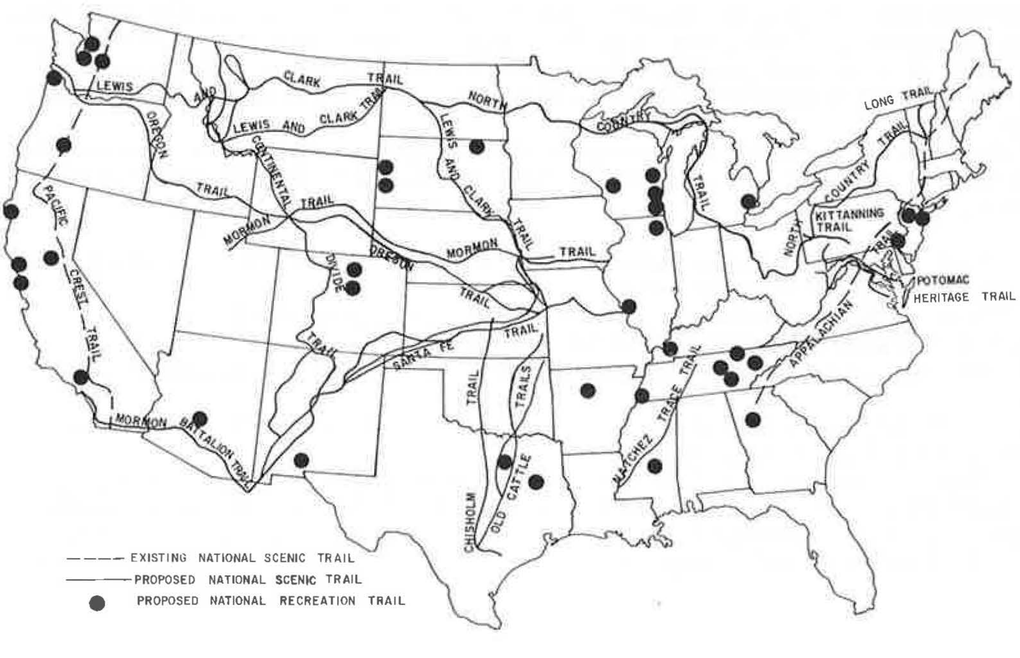


Figure 8. Proposed and existing hiking trails.



nonmotorized trails whose major function is to provide hiking access to noteworthy scenic, historic, national, or cultural features. Representative of this type are the Appalachian and the Pacific Crest Trails (Figure 8); the others are still under study. Both of these are continuous trails, about 2,000 and 2,350 miles (3219 and 3782 km) respectively. NRT can be designated by the Department of the Interior or the Department of Agriculture (without legislative approval but with the consent of the local jurisdictions) to serve any one of several purposes: nature-interpretative tours, walking, horse-mule riding, four-wheel-drive vehicles or snowmobiles, or personal car. These trails are specifically legislated to be located near urban centers.

Other trails under consideration for addition to the NST include the Continental Divide Trail [3,100 miles (4989 km)]; Potomac Heritage Trail [825 miles (1327 km)]; Old Cattle Trails [800 miles (1287 km)]; Lewis and Clark Trail [2,000 miles (3219 km)]; Natchez-Trace Trail [600 miles (966 km)]; North Country Trail [3,200 miles (5150 km)]; Kittanning Trail [200 miles (322 km)]; Oregon Trail [2,000 miles (3219 km)]; Santa Fe Trail [800 miles (1287 km)]; and Mormon Trail [800 miles (1287 km)]. Others are being investigated.

Congressional legislation also provides for financial assistance to states for trail planning. As a result, many states are in the process of establishing systems of scenic trails. In addition, the Federal Highway Administration has authorized the use of federal funds for trails in urban areas as long as they are part of the Interstate or primary road system and in the highway right-of-way.

Most trail planning now done on the federal level is directed by the National Forest and National Park Services, and some is being done by the U.S. Corps of Engineers; no centralized agency, however, deals with trails, and states are only now entering this area actively. Little initiative is taken by the U.S. government, and it does not usually address specific problems until private interest groups place enough pressure on it. Although there are two primary sources of funds for trails, the Highway Trust Fund and the Land and Water Conservation Fund, these must compete with other projects sponsored from these monies. Other significant legislation affecting trails also includes the National Environmental Policy Act of 1969, the Water Quality Act of 1965, the Wilderness Act of 1964, and the Historic Preservation Act of 1935.

CONCLUSIONS

Many of the principles applicable in urban transportation planning can be applied to park and recreational trail planning. As in any plan, goals and objectives need to be established and clearly stated, and the plan must be analyzed and evaluated with meaningful measures of effectiveness. New data collection techniques are currently available, such as aerial photography, to decrease overall costs, but the field survey will probably continue to generate the most useful data, especially in light of disaggregate behavioral trends.

Trail planning and design can be expensive, but improvements can be made simply by applying minor administrative and low-cost engineering techniques including the following:

1. Better and more uniform signing, especially at the head of a trail or along roads, may distribute hikers more efficiently.
2. Dead-end trails should be connected with other trails to form loops.
3. Use of one-way trails should be encouraged.
4. Park managers should try to separate users by type and trip purpose on certain trails.
5. Trails without an adequate and safe surface or grade should be improved and maintained or closed to the public.
6. Maps and descriptions of hiking trails should be prepared and be more readily available; maps showing trails and other facilities should be frequently updated with suitable map scales [preferably 1 in. = 2,000 ft (1 cm = 610 m)] so that they can be followed without frequently placed signs or indications; and information including trail

description, mileages, and trail cross sections or profiles, suggested hiking season, and other pertinent local information should be easily obtained.

7. Trails should be planned, designed, and constructed as part of an overall master plan.

8. Trails can be constructed in highway, railroad, canal, and river rights-of-way as well as on land fills. This often negates land-purchasing costs.

Various techniques can be used to allocate or physically assign trail users to obtain more efficient use. These techniques include pricing (time of year or by facility type), metering (permit use only or licensing for certain park facilities), general information system (advisement and diversion), and new construction (shelters, additional trails, and the improvement of trails).

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RAIL PLANNING: A STATE VIEWPOINT

Jack Kinstlinger, Pennsylvania Department of Transportation

The purposes and objectives of the Regional Rail Reorganization Act of 1973; its planning requirements; and the planning efforts of the Pennsylvania Department of Transportation, other northeastern and midwestern states, and various federal agencies in response to that legislation are described. Also included are a description and criticism of the report of February 1, 1974, by the U.S. Department of Transportation in response to the rail reorganization act. Attention is focused on the 17-state Conference of States on Regional Rail Reorganization, its formation and purposes, and its adopted resolutions and positions on rail reorganization planning by the U.S. Railway Association. This paper concludes that federal rail planning is defective because it places undue emphasis on abandonment of excess trackage as the solution to the railroad problem and uses fully allocated system cost rather than avoidable costs for evaluation of branch-line viability. The paper points out that federal rail planning has given insufficient consideration to future potential of the rail mode in moving persons and goods and to energy, environmental, and social needs of communities for continued rail service. Attention is focused on the harmful effects on competition and efficiency that may arise if federal rail reorganization efforts lead to one large single reorganized entity serving the entire northeast-midwest region.

•STATE and local planners have taken on rail planning, and railroading will never again be the same. In this paper, I will describe statewide railroad planning by the Pennsylvania Department of Transportation, by other states in the Northeast and Midwest, and by various federal agencies. This planning is being performed primarily in response to the Regional Rail Reorganization Act of 1973 and, therefore, is most relevant to states in the Northeast and Midwest; however, the rail problems and potential solutions in that region will increasingly apply throughout the remainder of the United States.

My observations are influenced by my perspective as a state government official with a commitment to having transportation decisions made through open public debate on the basis of rigorous analytic investigations of feasible alternatives and their impacts on the economic and social factors in the community. Given this vantage point, this paper finds much that is useful and promising in the planning by the states, but it is less optimistic about the efforts that have been undertaken so far by the federal agencies.

Major influences on rail freight transportation in the United States in recent years have been the bankruptcy of eight railroads in the Northeast and Midwest, near bankruptcy and generally low return on investment by many other railroads in other parts of the nation, and passage of the rail reorganization act by the Congress on January 2, 1974. These developments have brought much railroad decision making into the public sector, which, in policy and methodology, treats railroading substantially different from the way it had been considered previously by the railroad companies themselves. These company decisions were made primarily to maximize return on investment. Recently, this has primarily meant cost cutting rather than attempting to generate new revenues.

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The states, and to a lesser degree the federal agencies, involved in rail planning view railroad transportation as one element of a complex network of sometimes competing and sometimes mutually supporting transportation modes that should be used, as a matter of public policy, to provide safe, efficient, and low-cost mobility of goods and persons necessary to support the economic, social, and environmental objectives of the communities, the states, and the nation. Most states would prefer seeing these objectives met through a private enterprise rail system with, perhaps, some government assistance through judicious adjustment to freight rates and regulations, more rational funding policies for various transportation modes to allow each to compete more effectively with the other, appropriate tax reforms, and loan guarantees and similar mechanisms to allow the railroads to generate needed capital. Although more direct financial participation and public ownership are not generally an objective of the states, these would be acceptable to the extent necessary to provide adequate rail services. Essentially, the states see the solution as provision of higher levels of rail service, better use of facilities and equipment, and extensive use of new equipment and rehabilitation of run-down plants. Federal planners appear to be torn between what appears to them to be two conflicting goals: profitability and maximum service.

REGIONAL RAIL REORGANIZATION ACT OF 1973

In response to the serious threat that the eight bankrupt railroads (Penn Central Transportation Company, Reading Company, Lehigh Valley Railroad Company, Central Railroad Company of New Jersey, Ann Arbor Railroad Company, Boston and Main Corporation, Erie-Lackawanna Railway Corporations, and Lehigh and Hudson River Railroad Company) in the Northeast and Midwest might actually cease all operations and create an economic chaos, the Congress enacted the Regional Rail Reorganization Act of 1973. According to the act, its purposes are as follows:

1. To identify an adequate rail service system in the Midwest and the Northeast to meet needs and service requirements,
2. To provide an economically viable system that has adequate and efficient service,
3. To financially assist the continuation of local rail service, and
4. To federally finance the system at the lowest cost for the taxpayer.

Objectives of the act are to create a rail system that

1. Is financially self-sustaining,
2. Meets regional rail transportation needs,
3. Provides for high-speed rail passenger service over the northeast corridor,
4. Has access to fossil fuels,
5. Preserves and promotes competition,
6. Achieves and maintains environmental standards,
7. Maintains and improves efficient and safe movement of freight and people, and
8. Minimizes job losses.

To implement these purposes and achieve these objectives, the act created the U.S. Railway Association (USRA), a nonprofit government corporation. This association was charged with preparing and implementing a reorganization plan that would transfer rail properties of the bankrupt carriers to a new entity called the Consolidated Rail Corporation (ConRail). Courts have since determined that the Erie-Lackawanna and the Boston and Maine can be reorganized under standard bankruptcy procedures, so the reorganization act now only applies to the remaining six. The act also established a Rail Services Planning Office (RSPO) within the Interstate Commerce Commission to conduct public hearings and evaluate U.S. Department of Transportation reports, described further on, and preliminary and final system plans prepared by USRA. The association is also authorized to permit the discontinuances and abandonments of lines pending the reorganization and to issue $1.5 billion in loans to ConRail, Amtrak, and other railroads and to state, local, and regional authorities.

The Federal Railroad Administration (FRA) is required to prepare a report on rail service in the midwest and northeast regions, and to provide, within the planning period, $150 million for the rehabilitation and acquisition of equipment and facilities to be included within ConRail, up to $85 million in emergency grants during the planning period, and $180 million to state and regional authorities for service continuation subsidies and rehabilitation loans for branch lines left off the final system plan for 2 years following issuance of that plan. The states to qualify for service-continuation subsidies and rehabilitation loans must prepare a state rail plan acceptable to FRA.

The Congress is empowered to either approve or reject the final system plan. Despite several lower court reverses, the U.S. Supreme Court on December 16, 1974, dismissed various claims and found the rail reorganization act to be constitutional.

As a result of a recent congressional action extending the deadline dates of the act, the new schedule calls for USRA to complete the preliminary system plan by February 26, 1975; the final system plan is to be completed by June 26 and submitted to Congress by July 26. Congress has 60 days after it receives the final plan to either accept or reject it.

In the views of Pennsylvania DOT, the rail reorganization act has two major defects. First, it appears, at least through the federal interpretation, to place undue emphasis on consolidation and reduction of railroad trackage as a primary means of achieving an economically viable system. This has led to a disproportionate federal emphasis on branch-line abandonments and main-line downgrading to the substantial neglect of other key issues such as regional revenue divisions, government regulatory and promotional policies, work rules, poorly maintained infrastructure, inefficient yard operation, need for rail and motor carrier rate structures that more closely reflect relative costs, greater freedom in intermodal competitive rate making with elimination of noncompensatory rail rates, promotion of containerization, and improvement of freight car use.

Second, the act is substantially underfunded in light of the needs, and much of the funding available would not be used to essentially rehabilitate the railroads but rather to bail out the bankers, other creditors, and stockholders of the bankrupt railroads. The act provides $1.5 billion in federally backed guarantees of which only $500 million is specifically earmarked for upgrading ConRail trackage. Recent federal studies show that rehabilitation costs for Penn Central trackage alone may amount to $4 billion or $5 billion, of which only $2 billion to $2.5 billion can be generated by revenues. Justice Douglas, writing for the minority, in the recent Supreme Court approval of the act, claimed that, before the creditors get through suing the government under the Tucker Act for insufficient compensation for their holdings, it would cost the taxpayers $10 billion to $12 billion simply for transfer of rights to dilapidated rail properties.

A counter proposal by Governor Shapp of Pennsylvania is the Rail Trust Fund, similar to the one established in 1956 for the Interstate Highway System. Under this fund, $12.9 billion would become available over a 6-year period for all railroads in the nation, on an equitable basis, by the sale of federally backed bonds. The program would be financed by removing the present 10 percent ICC surcharge and replacing it with a 5 percent surcharge on all shippers that would be used to retire the bonds guaranteed by the fund. The program would meet the primary problem facing railroads today, capital starvation. When facilities were rehabilitated, costs would decrease and revenue would increase. Improved productivity through plan rehabilitation could adequately retire the bonds and eliminate most current railroad losses. Essentially the trust fund idea permits a private enterprise solution, except for the fund itself.

The Surface Transportation Act of 1974 currently wending its way through Congress, although not as innovative as Governor Shapp's proposal, could similarly provide for a free enterprise solution to the rail poverty problem through the mechanism of massive government loan guarantees.

PENNSYLVANIA RAIL PLANNING EFFORT

Pennsylvania DOT began to mobilize its statewide rail planning effort before the Regional Rail Reorganization Act of 1973 was passed but has subsequently modified the work program to make it directly responsive to the requirements of that act and planning requirements of FRA.

According to FRA guidelines (1), such planning by the states must be based on a comprehensive, coordinated, and continuing planning process designed to meet economic, environmental, and energy needs and to provide for the development of a coordinated and balanced transportation system. The plan, furthermore, is to be developed with opportunity for participation by public and private agencies and interested individuals. The plan must consider

1. Existing rail facilities and their use;
2. Economic and operational analysis of present and future rail services needs for both freight and passengers;
3. Potential for moving rail traffic by alternative modes;
4. Relative economic, social, and environmental costs and benefits involved in the use of alternative modes;
5. Evaluation of the condition of track roadbed and structures for which the state and its regions will apply for assistance;
6. Classifications of rail systems into lines to be included in the final system plan;
7. Lines of railroads in reorganization that are to be continued in operation;
8. Lines of railroads in reorganization that are not included in the final system plan; and
9. Lines for which the state wants to receive assistance for subsidy or acquisition in order of priority of importance.

The Pennsylvania study is being conducted by the Pennsylvania DOT Office of Planning and is receiving significant consultant assistance from R. L. Banks and Associates, Inc., and Creighton, Hamburg Associates, Inc. The study is being coordinated with efforts by the Governor's Office of State Planning and Development and the Pennsylvania Public Utilities Commission. It is designed to involve the public and affected interests through the formation of nine regional rail advisory committees working through a statewide rail advisory committee that consists of well over 100 members. The membership is drawn from representatives of state agencies, universities, Pennsylvania legislature, federal government, regional planning agencies, local government, rail industry, rail trade unions, rail-user organizations, environmental associations, business interests, and lay citizens. Regional and statewide committees meet bimonthly or more often as required and have engaged in discussions concerning issues, problems, and solutions. They have also proved useful in obtaining information and verifying or refuting data received from federal and other sources.

The objectives of the Pennsylvania DOT Railroad Planning Study are to collect data, undertake analyses, present all evaluated alternatives that can be used to formulate a comprehensive rail plan, and develop policies and positions useful in responding to federal proposals on rail reorganization. The study considers both freight and passenger traffic and includes

1. Analysis of present conditions, facilities, and use;
2. Estimation of demand for future rail transportation based on the State Investment Plan and socioeconomic targets to 1980, with special emphasis on coal transportation;
3. Analysis of branch-line and trunk-line needs and facilities;
4. Impacts on communities and regions from alternative branch-line and trunk-line configurations;
5. Financial implications of alternative solutions; and
6. Development of a strategy and methodology for plan implementation (e.g., rail passenger planning), monitoring, and reevaluation.

A major obstacle to the preparation of the rail plan is the absence of readily available data on physical facilities, use, and, particularly, origin and destination flows of rail freight. Some information is being provided by the bankrupt carriers themselves and by USRA. However, similar information for nonbankrupt carriers and all origin and destination flow information are lacking, partly because of unavailability and partly because of the unwillingness or inability of USRA to effectively process and disseminate this information to the states.

A major source of information for branch-line analysis is a statewide rail shipper-receiver survey of firms on branch lines considered by USRA as candidates for abandonment. This survey solicited information concerning type of business; patterns of shipments and receipts both by rail and competing modes; possible impact on costs, production, and employment from branch-line discontinuance; possible impact from improved or downgraded rail service; and estimates of rail use to 1980.

CONFERENCE OF STATES ON REGIONAL RAIL REORGANIZATION

One of the more exciting developments resulting from the rail reorganization effort has been the formation and activities of the 17-state Conference of States on Regional Rail Reorganization. In forming the organization, the states pledged themselves to meet regularly to formulate broadly supported positions on key issues including methodology, federal-state relationships, main-line planning, branch-line service planning, passenger service, public participation, policy formulation, data collection availability, and data dissemination. Its formative meeting was held in Columbus, Ohio, in May of 1974, and subsequent meetings were held in Buffalo, New York, in June; in Boston, Massachusetts, in August; in Oak Brook, Illinois, in September; and in Newport, Rhode Island, in November. Other meetings were held in Lansing, Michigan, in January 1975 and in Pennsylvania in March. The executive committee of the organization has been meeting regularly with USRA and other federal agencies to exchange ideas and information. Meetings of the organization have generated discussions among the states and federal representatives and have resulted in the adoption of formal resolves that are undoubtedly shaping the states' planning efforts and challenging the various efforts and assumptions on the part of the federal agencies. It represents the most intensely cooperative transportation planning effort among the states that I have been witness to in my 20-year career.

The conference of states has formulated a consensus on various key policy and planning efforts including positions on lack of public participation in USRA decision making, evaluation of a USRA analysis of branch-line viability, evaluation of main-line strategic options of USRA, positions on the U.S. DOT report, positions on expenditure of financial assistance by FRA during the planning process, and a resolution supporting federal legislation to provide funds to the states for essential railroad planning. An early request from the states insisted on a cooperative, comprehensive, coordinated planning process and a role for the states in development of preliminary and final system plans analogous to their leadership roles in federally mandated highway, aviation, and urban transit planning. So far, this request has not been granted.

The states in the Northeast and Midwest have been polled recently on their rail planning efforts in connection with the findings of both the conference of states and another meeting (2). Results of this poll, as of January 1, 1975, reveal that nearly all states in the region have legal authority to prepare a rail transportation plan and that the majority currently possess statutory authority to qualify for federal rail subsidy or loan assistance. Of the 17 states polled, 15 are now actively planning for branch-line service, 13 for freight trunk-line service, and 12 for rail passenger service. Sixteen expect to make rail planning a continuing state activity. Nearly all states have conducted branch-line shipper surveys and are evaluating the economics and community impacts of branch-line abandonments. About half the states have conducted surveys of shippers on trunk lines as well.

A sample questionnaire is shown in Figure 1, and the survey results are given in Table 1 for questions 1, 2, 3, and 4 and in Table 2 for question 5. Only four states submitted lists of computer programs or new methods in response to question 6 on the questionnaire: New York, Maryland, Massachusetts, and Illinois.

Figure 1. State rail planning questionnaire.

STATE __________

NAME OF RESPONDENT __________

TITLE __________

TELEPHONE __________

1. Does your state have legal authority to prepare a multi-mode transportation plan?
   ________YES ________NO

2. Does your state have the necessary statutory authority to comply with the requirements of Title IV of the Regional Rail Reorganization Act for receipt of rail service continuation subsidies? ________YES ________NO

   (a) If so, what agency has been designated as the state rail planning agency?

   ____ State Highway Department
   ____ State Department of Transportation
   ____ State Planning Agency
   ____ Public Utility Commission
   ____ Other (Identify ________________)

   (b) As the state rail implementation agency?

   ____ State Highway Department
   ____ State Department of Transportation
   ____ Other (Identify ________________)

3. Is your state now actively engaged in (a) planning for rail branch lines (local rail services)? ________YES ________NO; (b) planning for rail freight trunk lines? ________YES ________NO; (c) planning for rail passenger service? ____YES ____NO

4. (a) How many professionals do you currently have engaged, full time, on railroad planning?
   ____

   (b) How many professionals do you plan to have engaged, full time, on rail planning in mid-1975? ________

   (c) Do you plan to make rail planning a continuing part of your agency's work? ____YES ____NO

5. In what phases of rail planning is your state now actively engaged?
   (please check)

	PHASE	FOR Potentially Excess Branch Lines	FOR Trunk Lines	FOR Passenger Service
1.	Study of Financial Revenues			
2.	Establishing Citizen Committees			
3.	Establishing Committee to Coordinate with Railroads			
4.	Freight Demand Forecasting			//////////////
5.	Goal Setting			
6.	Shipper Survey			//////////////
7.	Network Survey (physical system, service density)			
8.	Alternative Improvement Plans (facilities, services)			
9.	Estimating Future Usage (computer or hand assignment)			
10.	Community Impact of Branch Line Closing(s)		//////	//////////////
11.	Branch Line Evaluation (carrier economics)		//////	//////////////
12.	Strategic Pattern of Railroad Property Ownership			//////////////
13.	Evaluation of Alternatives			

6. Please list any substantial computer programs or other new methods to facilitate the foregoing work items.

Table 1. Responses to state rail planning questionnaire for questions 1, 2, 3, and 4.

Question	Conn.	Del.	Ill.	Maine	Md.	Mass.	Mich.	N.H.	N.J.	N.Y.	Ohio	Penn.	S.D.	Vt.	Va.	W.V.	Wisc.	Total
1	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes-15 No-2
2	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	No	Yes	—[a]	Yes	No	—[a]	Yes	Yes-11 No-4 —[a] -2
2(a)	SDOT	SDOT	SDOT	SDOT	SDOT		SHD	PUC	SDOT	SDOT	SDOT	SDOT		PUC	SPA	O	SDOT	SHD-1 SDOT-10 SPA-1 PUC-2 O-1
2(b)	SDOT	SDOT	SDOT	SDOT	SDOT		SHD	O	O	SDOT	SDOT	SDOT		O			SDOT	SHD-1 SDOT-10 O-3
3(a)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Yes-15 No-2
3(b)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No	Yes	No	No	Yes	Yes-13 No-4
3(c)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No	No	No	No	Yes	Yes-12 No-5
4(a)	6	1	9	1	5	3	4	1	0	—[a]	0	21	1	1	0	0	3	
4(b)	6	1	9	1	7	5	4	5	2	—[a]	—[a]	7	2	1	—[a]	—[a]	4	
4(c)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes-16 No-1

Note: SHD = state highway department, SDOT = state department of transportation, SPA = state planning agency, PUC = public utility commission, O = other.

[a]Not applicable.

Table 2. Number of responses to state rail questionnaire for question 5.

Phase	Branch	Trunk	Passenger	Phase	Branch	Trunk	Passenger
1	14	10	8	8	8	7	5
2	11	8	5	9	11	9	7
3	6	5	5	10	14	—	—
4	12	8	—	11	11	—	—
5	11	8	8	12	5	6	—
6	14	9	—	13	11	9	6
7	14	12	8				

BRINEGAR REPORT

On February 1, 1974, Claude S. Brinegar, secretary of transportation, issued his now notorious report that was mandated by section 204 of the Regional Rail Reorganization Act of 1973 (3). The purpose of the report, as stated in the act, was to launch the planning process for reorganizing the region's rail system, describe the existing system, analyze capital and operating problems and possible improvements that might be realized, and provide recommendations on restructuring and consolidation. The report was not designed to develop detailed solutions but to recommend geographic zones between which rail service should be provided and the criteria for subsequent more detailed analyses. It identified over 15,000 miles (24 140 km) of rail routes, or 25 percent of the region's total, as potentially excess. It also recommended that Interstate main lines be consolidated into a high-volume upgraded network shared by ConRail and other carriers by eliminating or downgrading of unnecessary main lines, that rail competition be maintained only over Interstate networks from traffic centers that generate a minimum of eight daily trains traveling more than 200 miles (322 km) in the same direction, that local rail service requirements be provided generally by a single carrier in a given geographic area, and that rail facilities not financially self-sustaining be abandoned unless subsidized by state or local transportation agencies.

The public outcry resulting from the recommendation for massive rail abandonments was unprecedented and has made the public suspicious of federal rail agencies; this feeling has yet to subside. The main outlet for public opposition was a series of public hearings held throughout the region by RSPO. The public response is well documented in two RSPO publications (4, 5).

The Brinegar report suffered, in the view of RSPO and state and local officials, from defects both in data and logic. The data analyses were based on 1972 rail traffic volumes that, in Pennsylvania and elsewhere, were critically influenced by Hurricane Agnes and that reflected the worst of possible conditions: bankruptcy, the kind of management that has led railroads to bankruptcy, lack of capital, poor service, lack of incentive, and poor morale. No consideration was given to future energy, economic, or management conditions that would lead to more favorable traffic volumes and revenue. The data in many cases identified a billing station, not an actual origin or destination point, and did not consider through traffic data, and some of the lines designated as potentially excess were already abandoned although some were clearly economically viable in terms of carloads.

Determination of potentially excess lines was based on economic viability rather than on public need. Much of the public has argued, quite correctly in my opinion, that the abandonment of almost any rail branch line will have devastating effect on shippers and jobs but little impact on railroad profitability. The latter is much more influenced by revenue divisions, freight rates, poor state of repair of equipment and facilities, insufficient car supply, work rules, and poor management.

William E. Loftus of the FRA Office of Policies and Plans has claimed that the report has been widely misinterpreted: that it was not intended as a recommendation for abandonment but rather as an identification of those areas where duplication existed. Whatever its original intent, it has led federal rail planners to rail abandonment as the prime solution and has forced many shippers and industrial developers to hold expansion plans in abeyance.

In Pennsylvania, the abandonment proposals in the Brinegar report were seen not only as an abandonment of rail lines but also as an abandonment of shippers and employees whose jobs depend on these lines. According to our studies, thousands of small businesses and perhaps as many as 25,000 employees would be affected by cutbacks as specified in the secretary's report.

According to the conference of states, disproportionate attention has been focused on branch lines. The states point out that the law mandates that the system as a whole, not each individual segment, be profitable. The states call for a refocusing of organizational planning efforts onto other significant issues including terminal coordination, end-to-end regional and transcontinental mergers, extension of profitable railroads, consolidation and coordination of main-line yard and terminal operation, adequate competition, capital generation, rehabilitation and modernization needs, interline revenue division, rate making and per diems, continued improvements in labor productivity, and involvement of labor in the planning process.

Subsequent to Brinegar's report, USRA came up with still more candidates for branch-line abandonment, again using questionable data and analytic techniques. In Pennsylvania alone the number of rail sections considered as potentially excess has increased from the 87 sections in Brinegar's report (3) consisting of 1,450 miles (2334 km) to the current total of 233 sections covering 2,331 miles (3751 km). Despite urgent pleas by the states, USRA has failed to remove the threat of abandonment from even those lines about which USRA and state staffs generally agree that traffic density adequately satisfies any reasonable criteria.

USRA, with a staff of 180 and a total authorized budget during the planning period of some $40 million, remains hard at work with its own planning efforts. It has some 18 consultant research studies under way on subjects such as property appraisals, environmental assessments, rail facility inventories, community impact from branch-line abandonments, regional and national economics, rail passenger service, rail competition economics, and equipment use. However, although USRA meets periodically with staffs of states and other interests, the discussions are not entirely satisfactory and are limited primarily to a review of USRA consultant efforts. The meetings are not open to the public; opportunity for outsiders to present testimony at these meetings is very limited; and opportunity by the states and others to review, participate in the preparation of, and respond to position papers before they are submitted to USRA for final action has been denied.

One of the chief problems is that USRA staff has not adequately provided the board with states' views and will not release findings, reports, and calculations to the states and other outsiders until they are approved by the board. Such a policy makes public participation impossible. USRA has finally agreed to allow the states to review calculations on the economics of branch lines, but so far few, if any, such calculations have been delivered. Rail carload data have not been disseminated to the states even though they are in USRA possession. Generally the staff seems to work in secrecy, giving their own comfort and security higher priority than the obligation to make decisions in public. One recent concession has been a policy to make summaries of board meeting minutes available to the states.

The states have, on several occasions, argued that a tax supported agency must keep the public informed as a matter of policy and that such a practice serves to make analyses more valid and proposals more achievable. Such pleas have generally not been acknowledged. Most USRA officials come from the business world where competition no doubt compels a measure of secrecy. Unfortunately, these officials do not appear to have made a complete transition to the public sector nor do they appear to fully comprehend the responsibilities of public service.

I must compare this situation with the much more open and constructive relationship that the states have had and continue to have with the Federal Highway Administration, Federal Aviation Administration, Urban Mass Transportation Administration, and staff of the Office of the Secretary of Transportation.

BRANCH-LINE VIABILITY

One of the key elements in the planning process is the USRA evaluation of branch-line viability in the design of the final system plan and in the determination, by the states, of the use of limited financial-assistance funds for service continuation.

From the state viewpoint, there are a number of deficient aspects in the USRA methodology. The USRA analysis evaluates each individual branch-line section, but the act prescribes that the whole system as opposed to each individual segment be profitable, if possible. The analysis

1. Considers only revenue loss or gain to the carrier on ConRail, not the national system;
2. Uses fully allocated system costs rather than avoidable off-branch costs, as specified in the act;
3. Ignores the abandonment cost of dismantling highway and stream structures and the additional cost of circuitry for overhead traffic;
4. Uses an unrealistically short economic life for amortizing rehabilitation costs and an interest rate greater than ConRail's capital cost; and
5. May require abandonment of a branch line because of need for rehabilitation even where profit levels in the past would, under good management practices, have been sufficient to permit adequate maintenance.

A main conclusion from these viability analyses is that most branch lines will generate sufficient revenue to cover normal operating and maintenance costs but not the necessary cost of rehabilitation. This suggests that, instead of massive branch-line abandonments, what is needed is a one-time major capital investment in the rail plant that now exists in the Northeast and Midwest, and, with some exception, elsewhere in the nation. This again argues strongly in favor of Governor Shapp's Rail Trust Fund or similar capital formation arrangements.

U.S. RAIL ASSOCIATION ANNUAL REPORT

In October 1974, the Congress passed Senate Joint Resolution 250 amending the Regional Rail Reorganization Act of 1973 by extending planning deadlines by 120 days. As a result, the preliminary system plan due October 29 was not issued, and, instead, USRA issued its annual report (6). The publication reported on the progress of planning analyses conducted by the USRA through October 1974 and included a financial report. Unfortunately, there is little in the USRA annual report to define the direction of USRA thinking on the preliminary system plan. The report is still preoccupied with profitability tests, allocated costs, and branch-line abandonments. USRA is still saying that every single mile (kilometer) of branch-line traffic must make a profit or it will be presented to the state for a 2-year subsidy program that is neither adequate nor long enough. The report is now talking of 10,000 miles (16 093 km) of potentially excess trackage out of the 24,000 miles (38 624 km) of bankrupt rail trackage in the region. This is even more drastic than Brinegar's report (3) that discussed 15,000 miles (24 140 km) of potentially excess lines out of a combined bankrupt and solvent system of 62,000 miles (99 780 km). There is still little evidence that USRA considers such factors as future profitability of branches; present and future economic, energy, and social needs of the communities; or even the relationship of the federal rail transportation planning effort to other federal efforts such as that considered in the Federal Energy Administration's Project Independence, which will require substantially increased production of coal if any attempt is made to meet the nation's energy needs. Given an increase in demand for coal, it follows that coal shipments by rail will also increase and thereby justify the retention of many branch lines now considered potentially excess by USRA.

A key aspect of the USRA plan for reorganization of bankrupt railroads (6) is the design of the new ConRail. The USRA options are as follows:

1. Properties of the bankrupt lines would be consolidated into one system called ConRail. This appears to be the basic plan Congress had in mind when it enacted the

legislation. According to USRA, ConRail 1 has the best opportunity to reduce duplication and therefore the best chance for profitability. According to the states, however, ConRail 1 will exert a dominant monopolistic influence over the entire region, weakening existing solvent railroads and displaying the typical characteristics of monopoly: lack of incentive and poor service to shippers. Furthermore, this option would result in unmanageable size, and there would be greater risks of massive future collapse, and nationalization of railroads would result in the region or in the entire United States.

2. ConRail would be established, but the New York-Newark, Philadelphia, and Allentown areas would be served through small neutral terminal companies to provide access to those markets through other carriers than those in the ConRail system. According to the states, terminal companies traditionally have shown no motivation to provide good service, and there is no reason to think that the situation will be different under this option. The viability of the terminal operation is considered to be exceedingly questionable; therefore, subsidy requirements will be placed either on the federal treasury or on the states or communities in which the terminals are located. Terminal companies are also considered incapable of providing good north-south traffic service, particularly passenger service in the northeast corridor.

3. ConRail would be established essentially as a large terminal company, north of Washington, D.C., and Norfolk, Virginia, and east of Harrisburg, Pennsylvania, and Albany, New York. To the west of this terminal company, a presumably profitable Penn Central entity would be reorganized. Again, however, ConRail east would be monopolistic, and the problems of ConRail and neutral terminals would be combined. Furthermore, Penn Central west may not be able to become an economical system.

4. Structure and operation before the merger of the Pennsylvania and New York Central Railroads would be resumed, and the smaller bankrupt railroads would be merged into either of the two systems. USRA says that this alternative could prevent another Penn Central situation, in which the collapse of one firm undermined the rail system of the entire region.

5. Government would own some or all lines in a consolidated facilities corporation through which ConRail would lease facilities and over which it and other carriers would operate rail service.

The position of the Conference of States on Regional Rail Reorganization is that the finally adopted option must provide major cities in the region with direct competitive main-line service by more than one carrier and that it must ensure the financial viability of the solvent carriers and those being reorganized under standard procedures. The states found ConRail to be unacceptable because of its monopolistic position, diseconomy of size, and inflexibility. The conference voted unanimously that the unmerging of the Penn Central appears to be potentially the most desired of the options because it best meets its objectives. The states further stated that no reorganization is feasible without adequate financial support. It urged USRA to fully explore the financial needs and limitations of the act and seek additional funding options, if necessary, including the Rail Trust Fund proposed by Governor Shapp.

In Pennsylvania also we favor the unmerging of the Penn Central and provision of additional competition by the formation of a Mid-Atlantic Rail Corporation consisting of the Reading Company, Lehigh Valley, Central of New Jersey, and Lehigh and Hudson River Railroads.

In closing, I would like to repeat what I perceive to be the commitment of the states in the region: retention of all necessary existing rail service and expansion and improvement of the rail network to the maximum extent possible because rail is the most economical, energy saving, and environmentally protective of all modes for person and goods movement under certain conditions. Our economy and our communities demand nothing less.

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ANALYSIS OF OUTPUT AND POLICY APPLICATIONS OF AN URBAN SIMULATION MODEL

Michael A. Goldberg, University of British Columbia; and
Jeffrey M. Stander, Oregon State University

This paper reports the progress made in developing a regional simulation model. It is essentially a case study of a model-building process. The model is interactive and linked with employment, population, land use, and transportation components. The models have undergone considerable refinement, calibration, and elaboration during this period. In particular, emphasis has been placed on developing a housing model that not only forecasts total supply and demand for the region (i.e., a macrospatial model) and allocates these totals to subareas (i.e., a microspatial model) but also uses these microspatial data to generate successive housing forecasts at the macrolevel. The failure of earlier work to identify such micro-macro gaps and develop suitable linkages is one of the significant shortcomings of simulation modeling, and this paper discusses approaches that have been taken to develop such linkages. The response of the output variables to the inclusion of such links is compared with the output of the model without these links. Some observations about programming and debugging procedures are made. Output under various scenarios is presented, and a few general conclusions are drawn from this output.

•THIS paper presents the results of and approaches to the continued development and refinement of a regional simulation begun nearly 5 years ago. The details of this work are discussed in Goldberg (4, 5) and Goldberg and Davis (7); reviews of other work can be found in Brown et al. (3) and Sweet (13). Similarly, earlier works describing the present model can also be referred to for discussions of model-building strategy and philosophy. It is our intent to focus on the progress made in debugging the model and making it more useful for policy application. This is an ongoing process, and the current model can only be refined through continued use and modification. Of particular interest is the interaction between microspatial magnitudes, such as housing and land use in small areas, and macrospatial phenomena, such as regional migration and economic and employment growth.

MODEL-BUILDING STRUCTURE AND STRATEGY

The module structure is shown in Figure 1 and includes three principal component models: population, economic-employment, and land use. Figure 1 is an idealization because it shows all of the components connected by two links; although this is our ultimate goal, it does not describe our present level of achievement. Figure 2 shows the linkages between the module and the transportation model. The transportation-land use interaction is similar to that described in Wendt and Goldberg (15). Currently, the transportation model is being developed independently and in parallel with the three-component module, and the generation and distribution elements are operational. A modal-split model is being developed. Figure 3 shows both the present state of our ef-

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Figure 1. Module.

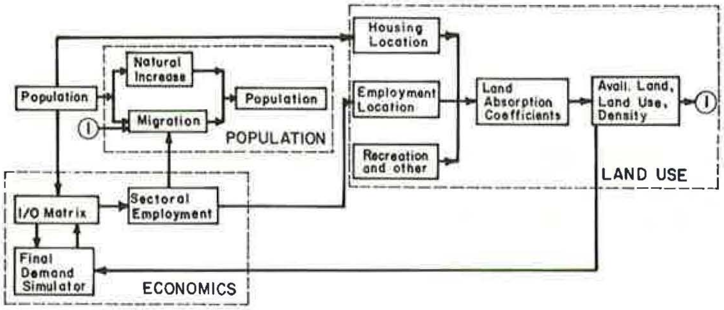


Figure 2. Transportation and the module.

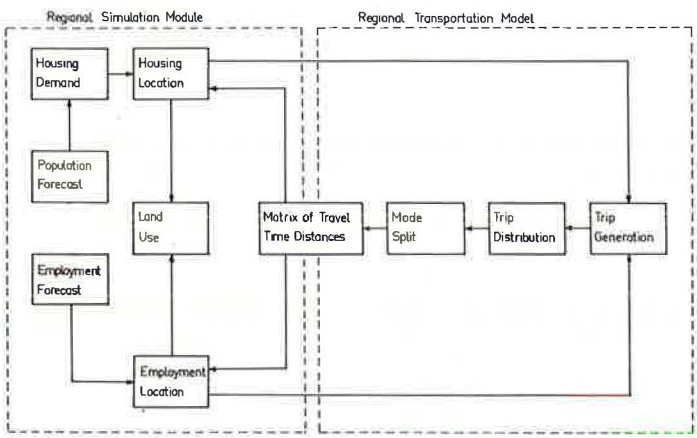
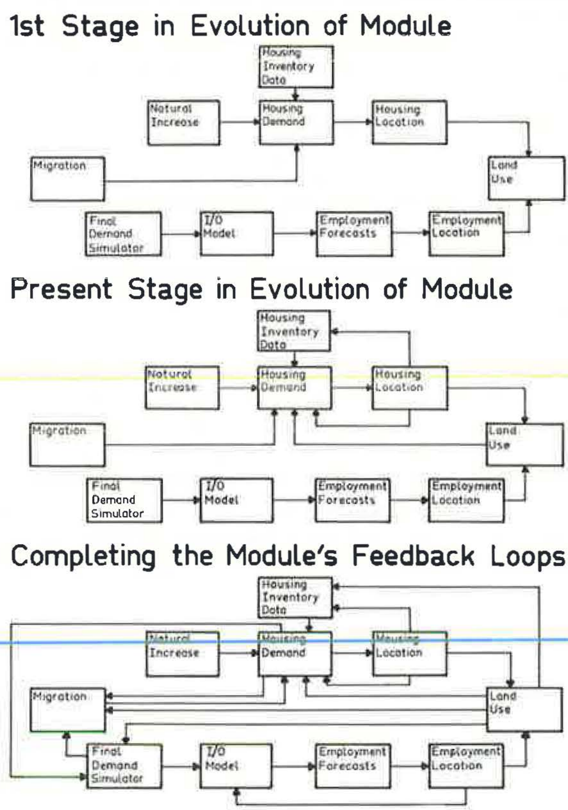


Figure 3. Module evolution.



forts and the strategy we are following in developing each of these models and the module simultaneously.

Our basic approach is that the models shown be flexible and that they evolve as our understanding of their behavior and of the world they simulate improves with continued research. Each of the models is carefully documented so that the model building remains process-oriented and we avoid, at any cost, creating a black box. Our emphasis on process instead of product helps by keeping us mindful that it is the usefulness and actual use of our models that will prove their worth. To be used they must be accessible, understandable, and subject to careful scrutiny, criticism, and most importantly, change. By viewing model building as an evolutionary process, we avoid creating a black box and, what is worse and quite common, justifying it. We are not interested in developing a product and then selling it, but rather in the continual evolution of our system of models and their continual documentation and criticism by users and others. This paper is therefore seen as part of that process. An integral part of that process is the linkage with the transportation planning process. Housing and employment location forecasts are key inputs to forecasting travel demand. The land use models set out below are intended to provide better inputs to transportation models. Figure 3 shows the development strategy being followed here and in our subsequent work.

The land use component of the module is important in allocating jobs and houses spatially. There are 27 economic sectors that have been aggregated into four groups for location purposes: 10 kinds of manufacturing in one group, retail trade in another location group, six sectors in the office-commercial group, and six sectors in the personal and business services group. Construction and three primary sectors are not allocated to subareas in these models.

The land use models are shown in Figure 4 in their simplest detail. The right side of the figure represents various supply elements, and the left side represents the principal demand element of land for jobs and houses. The conceptual structure is simple in these models, in that activities (jobs and houses) are allocated to each of the 82 subareas in the Vancouver region by using a number of algorithms (one algorithm associated with each activity). These allocations are then converted to land use by using a land absorption coefficient that represents the amount of land a unit of each activity requires. If there is sufficient land for the activity, then it is considered to be allocated to that zone, and the land use, employment, housing, and population files are all updated for that zone. If there is insufficient supply, the excesses are cumulated across all subareas and relocated, by using the initial algorithms, to subareas with excess capacity. When all jobs and households are allocated to subareas, for year t, a new set of forecasts from the population and economic models are read in for t+1 and allocated as above until the module reaches the terminal year for its forecasting horizon.

The housing model shown in Figure 5 represents its initial stage of development. The present stage of evolution is essentially identical, with the exception of a simple feedback mechanism that relates the microspatial allocation functions and land availability to the macrospatial supply-demand housing model.

Step 1

Initially, for computational convenience, it was assumed that supply equalled demand for the region as a whole. However, it was not assumed that supply and demand had to be equal in any of the 82 subareas, nor did we even constrain regional totals for demand by structure type (single-family and high-rise) or by value class (four value classes) to be equal to the equivalent regional totals for supply. All we assumed was that the total number of units demanded equalled the total number of units supplied each period. Regional demand by structure type and value class is a function of information on family size and age distribution of household heads (from the population model) and of the income distribution (from the economic model) for each annual forecast increment. In addition, demand derives from households whose housing units have been demolished during the previous period. Finally, the initial model kept track of households that were forced into units other than those they desired, and these dissatisfied households also entered into the calculation of demand. Given these regional totals for demand by value

Figure 4. Land use models.

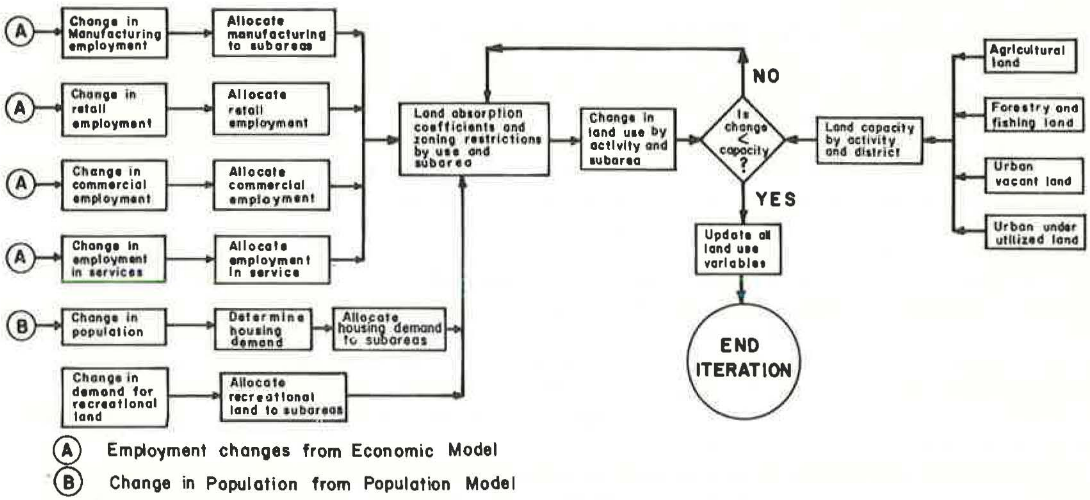
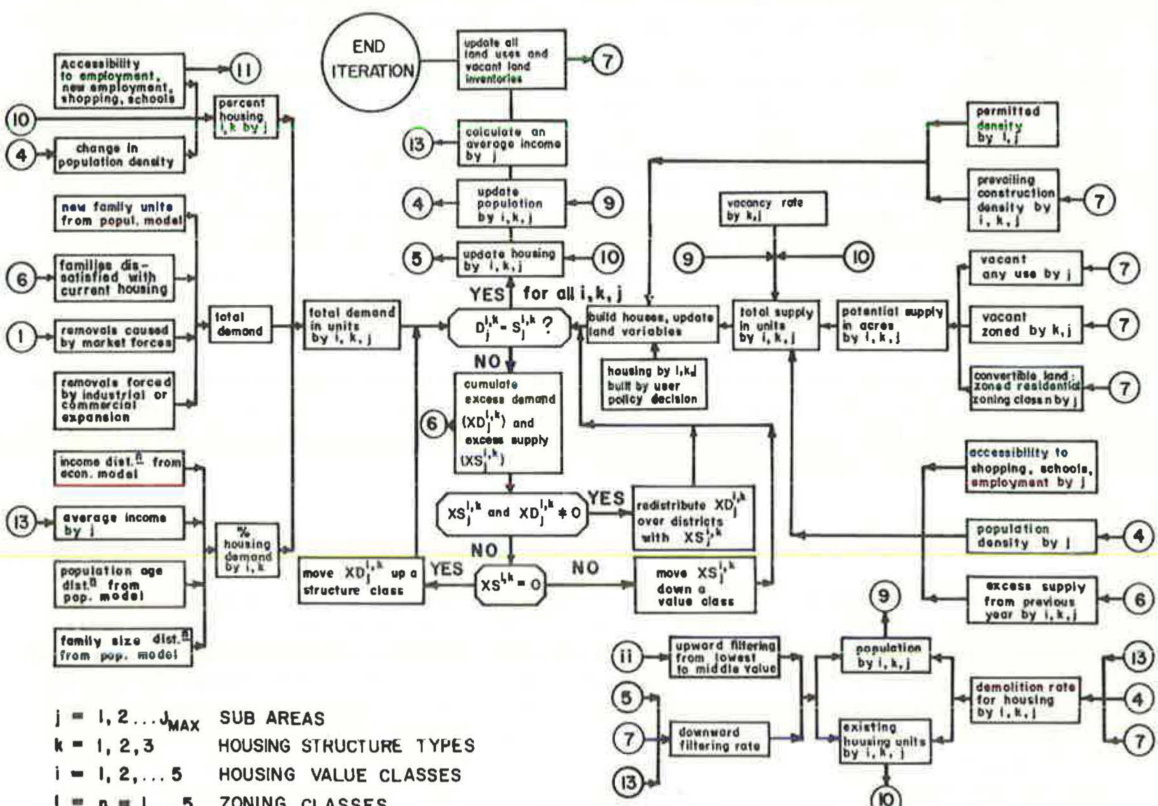


Figure 5. Housing model.



class and structure type, the microspatial model then allocated demand to each of the 82 subareas, again by value class and structural type. The resulting demand $D_j^{i,k}$ is demand in subarea j, for housing type k, and value class i. Prices are not included in either the demand or the supply equations. This was a conscious decision derived from the great difficulty involved in forecasting subsequent period prices that would be needed if prices played a significant role in the model. It was also felt that the presence of prices created an illusion of precision that simulation does not warrant, and this could lead to misuse and misunderstanding of the models.

Since supply was constrained to equal demand in this initial phase, the supply model took the number of units demanded for the region as its starting point. Thus, the supply model proceeded, from the total regional supply in number of units, to disaggregate this supply into structure types, value classes, and subareas. The principal data inputs to this disaggregation procedure are actual and allowable densities; available land; accessibility; and excess supply by value class, structure type, and subarea from the previous iteration of the model. The result is supply $S_j^{i,k}$ by subarea j, structure type k, and value class i.

Differences between supply and demand by structure type and value class for each subarea are reconciled by cumulating excess demand and redistributing it to areas with excess supply until there is no excess demand or excess supply in any subarea, structure type, or value class of housing. Excess demand is allocated first to other subareas with similar housing (by type and class). If no similar housing is available, demand is allocated to those areas that have housing of the same value class but any structure type. If there is no such housing available, the excess is allocated to subareas with the originally desired structure type but the next lower value class. Such housing is then reclassified and raised one value class. The model generates a kind of upward filtering of houses and neighborhoods in this way. This process continues until all excess demands are allocated. If, on the other hand, there are excess supplies in certain subareas, the excess housing is assigned to the next lower value class. In this way excess supply moves down through value classes; this is what happens in practice where high vacancy rates lead to price cutting. Excess demand, however, moves across structure types within the same value class, unless no housing exists in any subarea in the desired value class. In this case, demand moves down one value class and then across the structure types again if necessary. This phenomenon has been observed in Vancouver (<u>14</u>) and in such renewal schemes as Society Hill in Philadelphia, Cobble and Boerum Hills in Brooklyn, Russian Hill and Jackson Heights in San Francisco, and Capitol Hill in Seattle.

Excess demand and excess supply are both kept in memory for one period: the former to measure dissatisfaction, the latter to introduce a dynamic lag into the supply determination process.

<u>Step 2</u>

In step 2 the assumption was dropped that demand and supply had to be equal for the region as a whole. Accordingly, we adopted a very simple multiplier-accelerator type of model from macroeconomics. Demand in this step was merely set equal to forecast population divided by the number of persons per household PPH to yield an estimate of the number of households forecast for each time period. New supply, on the other hand, was assumed equal to this change in the number of households TNHH plus a demand for vacancies DV to allow for equilibration of short-term disturbances (i.e., some inventories for short-run adjustments) minus the housing supply TH. Equation 1 sets out the supply relationship as follows:

$$NS_t = TNHH_t - TH_t + VACRAT_t \cdot TNHH_t \qquad (1)$$

The demand for vacancies in turn was assumed to be a function of vacancy rates in the preceding 3 years [there is 3-year planning horizon for developers in our region (<u>9</u>)].

If NS_t is negative, then a small number of units are still built; this reflects the fact that construction does not cease even when there are high excess housing stocks.

$$VACRAT_t = (VAC_t) \Big/ \left[\left(\sum_{i=1}^{3} VAC_{t-i} \right) \Big/ 3 \right] \qquad (2)$$

The demand for vacancies is now to be equal to the ratio between last year's vacancy rate and the average over the last 3 years. Demand $TNHH_t$ and new supply NS_t are then disaggregated by structure type, value class, and subarea as before.

Step 3

Step 3 is the stage at which we are currently running the model. This step builds on step 2 and continues to assume that regional demand for units and regional supply are not necessarily equal. Supply is again calculated as in step 2. Demand, however, is now calculated by using feedback from the housing location (microspatial) submodel. This is accomplished by using an index of available land in each subarea weighted by the amount of development already existing in that subarea. Thus, demand is now calculated as follows:

$$D_t = TNNH_t \cdot \frac{CINDEX_t}{CINDEX_o} \qquad (3)$$

where $TNHH_t$ is demand as calculated previously, and $CINDEX_t$ is the weighted capacity or land-availability index from the housing location (microspatial) model. CINDEX, the weighted land-availability index, provides the first micro-macro link that we have developed in accordance with our modeling strategy of identifying and then closing these micro-macro gaps. CINDEX itself is calculated as follows:

$$CINDEX_t = \frac{\sum_j TH_{jt}(AVLAND_{jt})}{\sum_j TH_{jt}} \qquad (4)$$

where TH_{jt} is the total housing currently existing in the subarea j (=1, . . . , 82) at time t, and $AVLAND_{jt}$ is the land available for development in subarea j at time t. In equation 3, $CINDEX_t$ is divided by $CINDEX_o$ (base year for the run) to give a ratio; this serves as a simple valve to slowly shut off demand as the region runs out of land and as $CINDEX_t$ gets smaller relative to $CINDEX_o$.

MODEL DEVELOPMENT TECHNIQUES

In a large-scale simulation model like this one, there is much resilience. Very often, programming and data updates do not produce great changes in the model output. This is reasonable since the model is complex and is highly buffered. Thus, the gross picture of model behavior has remained the same: Vacant land is used up, and the region goes to capacity somewhere between 35 and 45 years. In the last year of work on the model many changes have been made, as described earlier, and many programming errors have been found; in a complex model like this, it is suspected that there are programming errors yet to be found (it is hoped they will not be major). The development process has thus taken much time and has required the attention of a full-time programmer-modeler because complete familiarity is the only way in which bugs can be identified when anomalous results are identified. In fact, the anomalies that signal bugs are usually imperceptible to someone not totally familiar with the program. This points out one of the major advantages of working with a very small group of researchers, programmers, and modelers. Although this model was initially developed in a large-scale program involving dozens of people, we were able to continue its development independently and had infinitely better success than an interdisciplinary team with much overhead and organizational difficulties.

There are two basic kinds of errors we ran across: conceptual and programming errors. Programming design should be such that conceptual errors may be corrected and conceptual changes made without a great deal of reworking. That is, there should be an inherent flexibility in the program, and this can occur by the hierarchic design of modules and submodules of the simulation model, allowing a subwhole to be changed without reworking the matrix in which it is set. Programming errors (bugs) show up as anomalies appear. The program should be writtern to encourage finding anomalous situations.

The first debugging tactic adopted was keeping current on all variables. This means that all changes to components of some totalizer variable should be immediately reflected in the totalizer itself. For instance, if some houses are demolished, the change should be reflected in all the relevant variables: for example, current density, vacancies, and total houses. The reason for this tactic is that the programmer may account for the change later on, but, perhaps in the future, some other programmer will accurately modify one part of the program and forget that the updating was not explicitly done in the segment where the change occurred. This creates a bug. The possible waste of CPU time by accessing the totalizer variables more than one time only at the end of a run is made up for by the programmer's time saved in tracking down an elusive bug (like negative vacant houses). The general rule is that program segments must represent some relatively complete or decomposible subwhole of the model and that updating be done either in that segment or by some integrator routine designed for the job; in any case, it must be done currently when the changes are made.

The second programming tactic evolved was that variables should be reasonably calculated: The program variables should represent easily understood quantities that are calculated as directly as possible. The example here is the current density calculation; last year's version had current density read in as data, and then the data were scaled up or down, depending on the relative changes in housing stocks versus new land acquired. This was initially done to get around a data problem. When the change was recently made to calculate current density directly, that is, by simply dividing housing by the land used, some very strange numbers turned up, specifically very large numbers. Some errors were indicated and were traced back to faulty data. The first programmers to work on the model were aware of this and chose to work around the problem. It is better strategically to acknowledge faults in the data base and even devise dummy data for the interim than to build into the model a device that obscures such problems. When the current densities were calculated directly, understandably, and clearly, many obscure bugs and misconceptions that were interfering with the simulation were uncovered. Model programming should always be done with the design that errors are likely to occur and that any error should stand out. A value less than zero for variables like housing units, vacancies, or land makes no sense in the real world, but the shrewd programmer will not use an if statement to alter a negative value to zero. That negative value indicates a bug somewhere. In the current version of the simulation model, where values such as these are set equal to zero, a message is printed indicating what happened; therefore, the simulation is allowed to continue to the end in a reasonable fashion, but the area where the problem might be is pinpointed. Often the negative value is a very small rounding error and can be ignored, but not always. The basic rule is as follows: When something is wrong, it should be obvious, and good program design will cause errors to be obvious.

ANALYSIS OF OUTPUT

There are two basic types of intervention that we can make with this model. The first type is quantitative intervention in which the magnitude of variables is changed, e.g., land may be frozen, densities changed through a zoning policy, and changes made in transportation facilities so that accessibilities are affected. At our current spatial scale [82 subareas for a region of roughly 600 miles^2 (1554 km^2)], other infrastructure (utility placement) is not meaningful because all 82 areas are serviced; however, subareas within these might not be. The second type is structural intervention in which an alternative model form is chosen; for instance, several feedbacks to migration from other system components have been identified, and any combination of these feedbacks may be switched on or off for a given model run. Figures 6 and 7 show three different simulations under which structural interventions were made. The output exhibits a degree of equifinality (1) defined as the process by which "the same final state or 'goal' may be reached from different initial conditions or in different ways." The backward link (backlink) from the microspatial housing model to the macrospatial housing model tends to make the construction more responsive, and to increase the frequency of the construction cycle as the amplitude is decreased. The addition of the feedback from the weighted land-availability index CINDEX to migration appears to cause an increased pressure on land resources, and migration is reinforced during partial development. However, as full development approaches, migration and construction decline.

These two types of interventions demonstrate the effects of different model structures on the model behavior. In all cases, about the same final point is reached. Full development occurs when all the land is gone. We specifically avoided building in dynamically adjusting density and redevelopment algorithms. We felt that these were the purview of decision makers and preferred to keep the models confined to if-then (if rezoning, then ... ?) types of runs. The terminal year of the simulation thus becomes of interest to decision makers in their attempts to provide more housing and jobs.

Figures 8 and 9 show the response of total regional housing to various scenarios. The university endowment lands (U.E.L.) scenario frees over 2,500 acres (1012 km^2) of land in West Point Grey for residential development at 10 units per acre (25 units/km^2). This is a policy that the provincial government has been contemplating. This large tract of land is located next to a region of predominantly single-family dwellings, much in demand. Figures 8 and 9 also show the basic, unconstrained land act run in which an agricultural land freeze is in effect and a grand up-zoning in which much of the city is up-zoned to higher density housing and multifamily dwellings. On regional level, the only noticeable differences are the smoothing effect of the up-zoning and the fact that the land act has removed much development land so that the region runs out of land much sooner and the maximum amount of units constructed is much less. Up-zoning appears to damp out the construction cycles possibly because it allows a higher single-family/multifamily ratio and because a greater proportion of the people moving into new housing are satisfied and do not reenter the market the next year.

The distinction between up-zoning and land-freeing policy is made clear in Figures 10 and 11, which show, respectively, the effect of a U.E.L. scenario for the total housing units in West Point Grey and an up-zoning scenario for the West End, the high-rise section of the city. Freeing land allows new development to take place, mere up-zoning is restricted because there are already buildings present, and demolition occurs only on initially substandard properties. A fault of the model is that there is no aging process to allow for redevelopment of depreciated properties. This is necessitated by the absence of any age distribution data for the standing stock of buildings. In either case there is a ceiling that, when reached, precludes further development without the freeing of more land in some way. Renewal and removal of standing stock can be read in interactively as policies. As noted earlier, however, they are not accounted for in the dynamics of the present model.

Figure 6. Housing stock—basic run, with backlink, and with backlink applied to housing and migration.

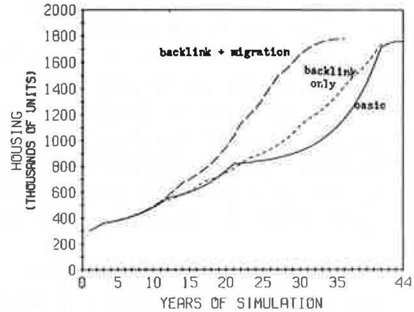


Figure 7. Housing starts—basic run, with backlink, and with backlink applied to starts and migration.

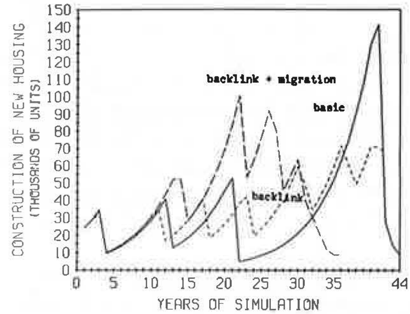


Figure 8. Housing stock—basic run, university endowment lands up-zoning, grand up-zoning in Vancouver, and farmland freeze (land act).

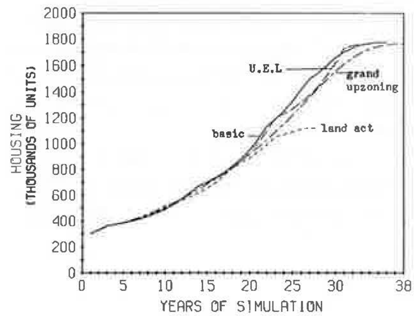


Figure 9. Housing starts—basic run, university endowment lands up-zoning, grand up-zoning in Vancouver, and farmland freeze (land act).

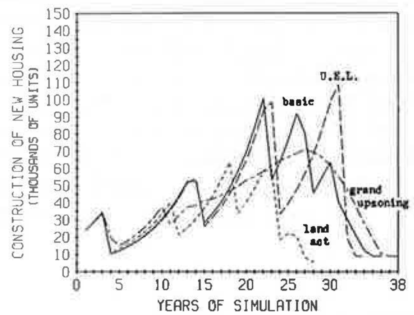


Figure 10. Housing stock—university endowment lands up-zoning and basic run.

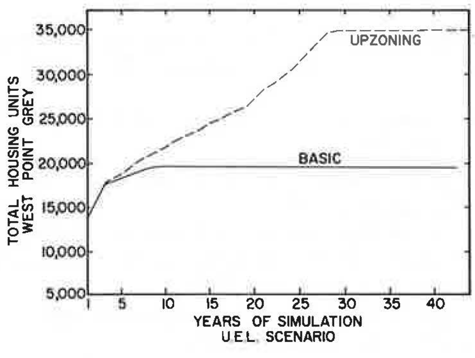
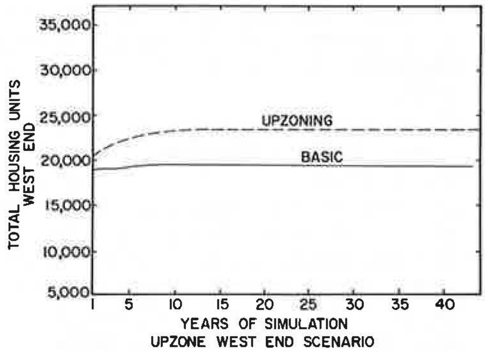


Figure 11. Housing stock—west-end up-zoning and basic run.



CONCLUSIONS

The initial development and subsequent evolution of the housing model contained in the larger simulation module have served as a convenient focus to illustrate the approach to modeling as well as the response of the model to various changes in its structure. The output presented will improve in quality with continued use, calibration, and specification of more appropriate initial conditions. It is presented in its current form primarily to illustrate the process and is not intended to be illustrative of the kind of output needed to aid detailed policy making. Such high-quality output can only result from the development process discussed. Ultimately, it is the usefulness of the module for specific land use and transportation policy testing that will prove its worth. Its refinement to a suitable high degree of realism and accuracy is the goal of the development process presented.

The general conclusions from the present simulation are that available land determines the stopping place for development; zoning to free or freeze-vacant land will have the biggest effect on development, and rezoning of land under existing use for housing or business will have a lesser overall effect. Most of the effect of zoning existing high-use land will be temporal. Full urban development cannot be halted by changing the land use patterns. The implications are that feedbacks to population growth and life-styles will ultimately prove to be the only effective means of limiting the growth of cities.

That the models are highly buffered with respect to policy changes is, as far as we are concerned, an indication of the usefulness of the models. Cities do not exhibit radical departures from their recent history, and the present output exhibits similar characteristics. Clearly different policies will have different impacts on the subareas of the region, although at the regional level (and this is consistent with equifinality) these impacts will be much less apparent. These relationships between subregional impacts and regional impacts are the micro-macro link presented.

By illuminating this link, we hope to develop more meaningful models. Most important, we hope to provide insight to decision makers about how this region works so that they can better plan for its alternative futures and ensure that we have alternatives in the future.

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STATE-REGIONAL PARTNERSHIPS IN WISCONSIN TRANSPORTATION PLANNING

Bruce B. Wilson, Wisconsin Department of Transportation

This paper discusses institutional and process relationships between statewide and regional transportation planning in Wisconsin. The organization, administration, and programs of multicounty regional planning commissions are discussed in the context of their impact on planning programs of the Wisconsin Department of Transportation, particularly preparation of a state transportation plan. The paper describes the factors considered by the department Division of Planning in deciding to implement formal state-regional partnerships in transportation planning throughout Wisconsin. The alternative of providing coordinative support to regional planning commissions is also discussed. The conclusion is that these formal partnerships are providing substantial benefits for both statewide and regional land use and all-mode transportation system planning. These benefits, however, have not come without some problems and delays, particularly in the department's relationships with newly organized regional planning commissions. Even the new commissions, however, are finding that, although their initial interests may be more issue than system oriented, they can play a constructive role in statewide highway, airport, and rail system planning.

•CURRENTLY, 8 multicounty regional planning commissions in Wisconsin serve 64 member counties. The oldest of these commissions, the Northwestern Wisconsin Regional Planning and Development Commission (RPDC), was created in 1959. The newest of these commissions, the North Central Wisconsin Regional Planning Commission (RPC), was created in 1973. As shown in Figure 1, all but 8 of the state's 72 counties are now members of multicounty regional planning commissions. Of these eight, one has formed a single county regional planning commission, another has joined a bistate metropolitan council, two have withdrawn from regional planning commissions, and the remaining four have petitioned the governor to jointly create a ninth multicounty regional planning commission in the state. Thus, all counties in Wisconsin have been involved in some form of regional planning activity.

Although the Wisconsin Department of Transportation has historically worked with regional planning agencies both ad hoc and formally, the virtual blanketing of the state with regional planning commissions recently has required that the department develop a uniform approach for working with these commissions on transportation planning. Respective roles and responsibilities had to be defined or redefined in relation to statewide, substate, metropolitan, and local transportation planning programs. This paper describes this ongoing definition-redefinition process.

As given in Table 1, two of the eight established multicounty commissions are currently recognized as metropolitan planning agencies by the U.S. Department of Housing and Urban Development (HUD), the U.S. DOT, and the state of Wisconsin. These agencies are the Southeastern Wisconsin RPC for the Milwaukee, Racine, and Kenosha urbanized areas and the East Central Wisconsin RPC for the Appleton and Oshkosh urban-

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Figure 1. Wisconsin regional planning agencies.

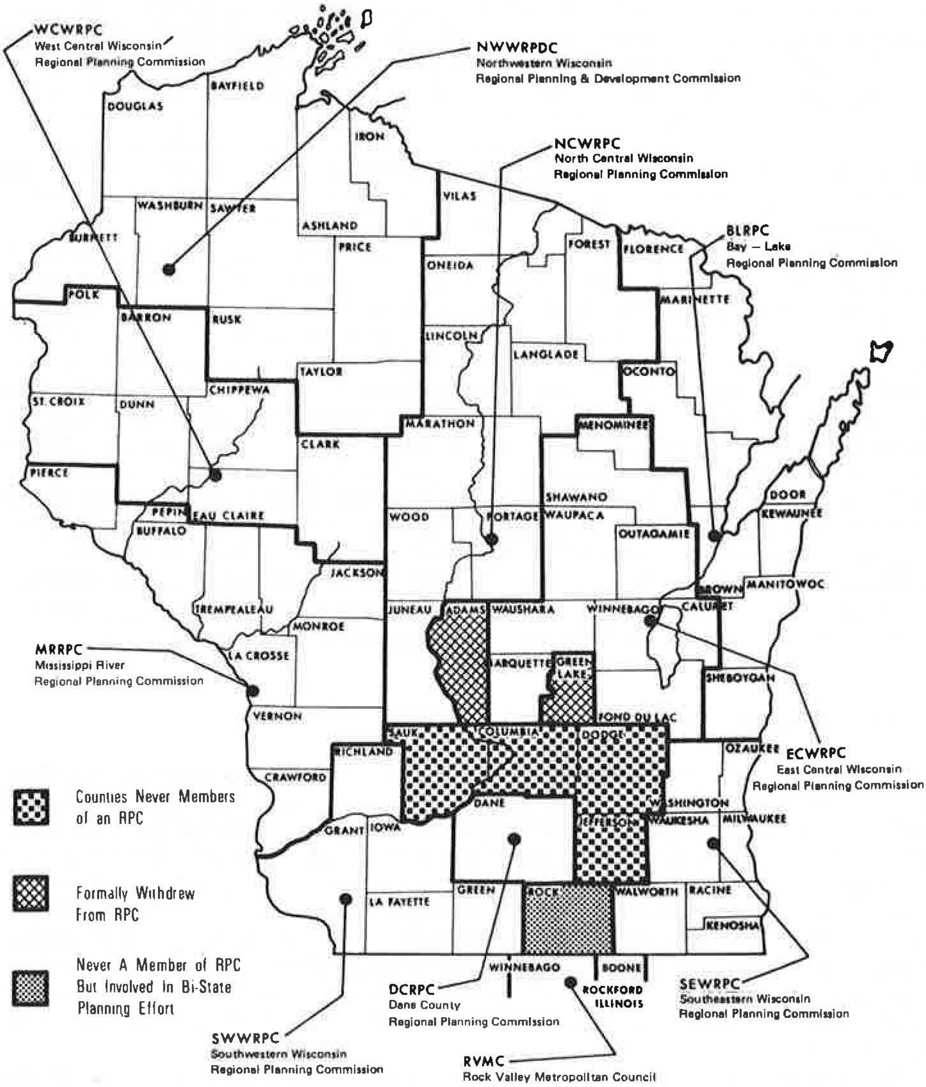


Table 1. Multicounty regional planning commissions in Wisconsin.

Commission	Year Organized	Number of Counties	Major Cities or Urbanized Areas	1970 Population*	Type of Agency	Year of Initial Regional Transport Plan	Year of State-RPC Contract for Continuing Planning
Northwestern Wisconsin RPDC	1959	10	Superior	155,000	Nonmetropolitan	1969	1974
Southeastern Wisconsin RPC	1960	7	Milwaukee, Racine, Kenosha	1,756,000	Metropolitan	1966	1969
Mississippi River RPC	1964	9	La Crosse	238,000	Nonmetropolitan	1970	
Southwestern Wisconsin RPC	1970	5		129,000	Nonmetropolitan		1974
West Central Wisconsin RPC	1971	7	Eau Claire	269,000	Nonmetropolitan		1974
East Central Wisconsin RPC	1972	9	Appleton, Oshkosh, Fond du Lac	458,000	Metropolitan		1973
Bay-Lake RPC	1972	8	Green Bay, Manitowoc, Sheboygan	441,000	Nonmetropolitan		1974
North Central Wisconsin RPC	1973	9	Wausau	315,000	Nonmetropolitan		

*Rounded.

ized areas. The department is a full partner in cooperative urban transportation planning with these two commissions and nine other areawide planning agencies. The cooperative urban transportation studies (four for urbanized areas and five for large urban areas) will be discussed in this paper only as they relate to multicounty regional planning.

The increasing presence of nonmetropolitan planning agencies in the state has generated a growing department interest in these agencies. It was inevitable that the department would, one day, seriously consider the possibility of complementing ongoing metropolitan planning assistance efforts with formal state-regional partnerships in nonmetropolitan areas. Efforts to explore and develop the concept of cooperative rural transportation planning were initiated in the late 1960s when the department provided ad hoc technical assistance to the Northwestern Wisconsin RPDC in the preparation of a regional highway plan. Since that time this commission has steadily increased its involvement in transportation development. In May 1973, the department was requested to assign a staff person to the commission to help the regional staff with regional transportation matters. This request triggered the inevitable serious consideration of a full-scale regional transportation planning assistance program in the Wisconsin DOT. The result is that the department is well on its way to implementing formal state-regional partnerships in transportation planning on a statewide basis, both metropolitan and nonmetropolitan, and that this policy is seen by the department and others to have substantial benefits for both statewide and regional land use and all-mode transportation planning.

It is hoped that this paper will offer useful evidence and analysis to the current debate on optimum strategies for statewide transportation planning. In this regard, appropriate reference is made, in the conclusions and recommendations, to the reported findings and recommendations on state and regional development from the Transportation Research Board Conference on Statewide Transportation Planning (1).

OVERVIEW OF REGIONAL PLANNING IN WISCONSIN

RPCs in Wisconsin are organized under authority granted by section 66.945 of the Wisconsin statutes. Subsection 9 of this statute states that, "... the regional planning commission shall have the function and duty of making and adopting a master plan for the physical development of the region." Of particular importance to statewide transportation system planning, the regional master plan may include "... the general location, character, and extent of main traffic arteries, bridges and viaducts; ... parkways; ... airports; waterways; ... routes for public transit; ...." The current RPC involvement in transportation planning ranges from permanently staffed, continuing transportation planning processes in the metropolitan RPCs to those recently formed RPCs not yet having addressed transportation issues. To date, three of the RPCs have prepared regional transportation plans (Table 1).

In 1966, the Southeastern Wisconsin RPC completed the first regional transportation plan in the state and is effectively carrying out the function of intercity transportation planning in its region. The regional transportation plan prepared and adopted by this commission and approved by the seven constituent county boards is the only multicounty regional transportation plan endorsed by the Wisconsin DOT to date. This regional plan served as input and, for the most part, was incorporated into the department's State Highway Plan, which was originally approved in 1966. The Southeastern Wisconsin RPC is currently reevaluating its land use-transportation plan and is also completing a regional airport system plan that is intended to be incorporated into the department's State Airport System Plan now under development.

In the case of regional transportation plans developed by the Northwestern Wisconsin RPDC and the Mississippi River RPC, the department acted in a strong technical advisory capacity. Particular emphasis was placed on interpretation and refinement of the previously prepared State Highway Plan with reference to regional development proposals.

For the most part, the nonmetropolitan, multicounty RPCs are only modestly staffed and funded. Their initial planning efforts have been aimed at gaining planning certifications to make local communities eligible for federal grants and at attaining

A-95 review agency status so that they can screen and comment on federal grant requests. These agencies have also become involved in some of the more current transportation issues, such as proposed highway jurisdiction adjustments, roadside sign control, and rail line and service preservation. Wisconsin DOT has provided technical assistance to the planning commissions in these matters.

As given in Table 1, organizational activity for new RPCs was basically nonexistent between 1964 and 1970. Between 1970 and 1973, no less than five new multicounty RPCs were organized, one metropolitan and four nonmetropolitan. The spurt of organizational activity during these latter years was brought about by several factors, including

1. Promotional activity of the Wisconsin Department of Local Affairs and Development (DLAD),
2. Pressure for increasing federal areawide planning requirements for capital grant programs,
3. Increase in state and federal financial support for regional planning programs and decrease in support for local planning assistance to individual units of government, and
4. Creation of state uniform administrative districts.

As the multicounty regional planning concept emerged between 1970 and 1973, some regional planning seemed to be forced into being. State agencies in Wisconsin could react in several ways:

1. Basically ignore the existence of RPCs whenever possible and continue to observe traditional relationships with local units of government;
2. Maintain a neutral position toward regional planning agencies and wait for cooperative state-regional planning opportunities to develop of their own accord; and
3. Assist Wisconsin DLAD in promoting the regional planning concept, actively seek opportunities for cooperative state-regional planning, and make adjustments in traditional relationships with local units of government.

Since the late 1960s Wisconsin DOT has moved from a position of moderate interest toward active promotion of the regional planning concept.

DEPARTMENT CONSIDERATION OF ALTERNATIVE COURSES OF ACTION

As Wisconsin DOT moved gradually to accept the regional planning concept, the department's Division of Planning staff (Figure 2) began to realize that some means of formal continuing cooperation with the existing and newly forming RPCs would be required. This need was realized because

1. Wisconsin DOT had had experience in planning coordination and cooperation with planning agencies at all levels;
2. Substantial Wisconsin DOT experience with various planning agencies indicated the inevitable efficiencies of working with permanent, areawide, comprehensive planning agencies as opposed to ad hoc groups of local officials and citizens;
3. Increasing attention and support was being given to RPCs by the U.S. HUD and Wisconsin DLAD; and
4. Wisconsin DOT would react positively to these new agencies because they were assuming A-95 review responsibilities and Wisconsin DOT has always maintained close communication with its A-95 agencies.

Wisconsin DOT directives for the Division of Planning Objectives for calendar year 1973 included the following:

> Expand technical assistance to established and developing rural regional planning commissions and investigate possibilities for DOT financial and staff assistance. Aid in carrying out comprehensive

updates of completed 701 plans will be solicited from the regional planning commissions. Endorsement of additional local plans will be sought.

The other section of the division's 1973 objectives, which pertains directly to the subject of this paper, deals with preparation of the Wisconsin DOT State Transportation Plan (STP):

1. Produce a status report on the STP, probably entitled "Transportation in Wisconsin—A Status Report."
2. Continue other advance work leading to preparation of an STP. Activities scheduled for 1973 include:
   a. Continuing work toward developing a methodology for multi-modal transportation planning.
   b. Completing an Interim STP for preliminary review and reaction.
   c. Completing preparation of an Interim Waterport Plan for Wisconsin.
   d. Investigating preparation of a state-wide Rail System Plan. Such a plan might serve as a guide in reviewing proposed rail abandonments.
3. Complete the National Truck Commodity Study. Use the results of that study, plus rail waybill sample and U.S. Census of Transportation information, to investigate rail and highway commodity movements.

Examination of these 1973 objectives shows that the methodologies for developing an STP and for initiating a formal regional planning assistance program in Wisconsin were both in an exploratory stage in early 1973. Since that time, these two activities have developed and progressed, and Wisconsin DOT personnel have increasingly realized that these were not separate and distinct activities. Although conceived independently, they have in fact turned out to be naturally supportive of each other in many ways as discussed later in this paper.

Even before the request for Wisconsin DOT assistance was received from Northwestern Wisconsin RPDC in May 1973, the Division of Planning was attempting to structure specific alternatives for a regional planning assistance program for nonmetropolitan planning. A request from Wisconsin DLAD to Wisconsin DOT and other state agencies in early 1973 questioned how state-level functional planning activities should relate to RPCs. Two kinds of alternatives emerged from Wisconsin DOT answers to questions concerning (a) coordinative support for RPCs and (b) cooperative programs with RPCs.

The coordinative support alternative could be described as an application of Wisconsin DOT earlier involvement approach in 701 local planning programs to the new regional planning programs, i.e., acting in some close technical advisory capacity to every RPC (2). Central and district office personnel would be made available to

1. Assist the RPC in defining regional transportation problems and issues,
2. Assist the RPC in developing its work program,
3. Help to coordinate state transportation planning with regional planning,
4. Assist the RPC in refinement of statewide system planning for their region,
5. Serve as members of RPC technical advisory committees,
6. Provide available technical data and assistance in interpreting the data,
7. Review and comment on regional plan development at its various stages, and
8. Prepare a statement of department endorsement of the adopted regional transportation plan.

The cooperative program alternative could be described as an expansion of the department's cooperative urban transportation study programs out to regional planning boundaries. As we are all well aware, the Federal-Aid Highway Act of 1962 required the establishment of cooperative state-local studies to encompass no less than Wisconsin urbanized areas as delineated by the U.S. Bureau of the Census. As in other states, the Wisconsin DOT and the designated metropolitan planning agency for each area jointly endorse, guide, direct, fund, and undertake continuing urban transportation studies. State-local planning agreements continue in effect, and the Wisconsin DOT and the metropolitan planning agency approve annual work programs. Depending on the area, these annual work programs provide for work to be performed by a combination of Wisconsin DOT, metropolitan or local agency staff, and consultants. Completed and revised plans are subject to planning agency adoption, local unit approval, and Wisconsin DOT endorsement.

Because the original urban transportation study program for the Milwaukee, Racine, and Kenosha urbanized areas was conducted within a regional planning framework, the Southeastern Wisconsin RPC seven-county regional land use-transportation plan was recognized by Wisconsin DOT not only as the currently valid metropolitan transportation plan for the three urbanized areas but also as a substate regional plan for incorporation into the State Highway Plan being prepared at about the same time. A continuation of the current Wisconsin DOT-Southeastern Wisconsin RPC partnership and the development of similar partnerships with all other multicounty RPCs in the state, regardless of their degree of urban development, would be one means of implementing this alternative (i.e., cooperative program) approach.

Looking at these two alternatives in a more theoretical or abstract framework tends to highlight differences that may seem somewhat subtle when a comparison of real-life examples is attempted. Table 2 gives my attempt to assemble and list some theoretical differences in these two approaches. It is incomplete and somewhat arbitrary, but it illustrates some of the debate on state-regional relationships taking place in Wisconsin. One will quickly recognize that any real-life regional transportation planning assistance program will undoubtedly fall between the extremes given in Table 2. When the May 30, 1973, request from the Northwestern Wisconsin RPDC for the assignment of a Wisconsin DOT staff person to the regional planning staff was received, the department was not ready to make a decision on the matter. The Division of Planning was favorably inclined to honor this request because of the past precedent of staff loans and assignments to the metropolitan planning agencies. But, because such an assignment would set a precedent for meeting requests for assistance from other newly organized multicounty, nonmetropolitan RPCs and because the Division of Planning wanted to ensure full support of the Division of Highways in any department course taken, it was decided that the views of the various district highway offices would be sought.

D. F. Haist, deputy administrator of the Division of Planning, and A. L. Gausmann, director of the division's System Planning Bureau, visited each of the district highway engineers and their planning section staffs during the summer of 1973. Haist and Gausmann concluded that formal requests for Wisconsin DOT assistance would inevitably be forthcoming from each of the existing six nonmetropolitan RPCs. The need for increased transportation planning efforts at the regional level was strongly supported by the district offices. In-depth discussion of a staff loan option did reveal some problems, however. None of the districts felt that they could afford to assign the relatively high-level staff people that appeared to be required for preparation of a regional transportation plan. Furthermore, the transportation planning done by state highway personnel for the region might be suspect in terms of state-level bias and other-mode restrictions. Regional plans prepared in this manner simply might not be acceptable to citizens of the region. Similarly, the prospect of a district planning engineer performing an A-95 review of his or her own highway project while on loan to an RPC was something to be avoided.

The recommended alternative that emerged from these in-house Wisconsin DOT deliberations was a financial assistance program to support the RPCs' hiring of their own transportation planner and the related costs. Wisconsin DOT personnel might still be assigned to nonmetropolitan RPCs from time to time, but they would work, as in the metropolitan planning agencies, under the direction of the RPC transportation planner. Such an arrangement would permit beginning-level district personnel to supplement RPC staff and receive valuable training at the same time.

INITIAL WORK PROGRAM DEVELOPMENT

Based on Wisconsin DOT experience in the metropolitan planning assistance program, it was decided that financial assistance to the nonmetropolitan agencies would be based on review and approval of an annual work program. During the fall of 1973, Wisconsin

DLAD requested advance copies of 1974 comprehensive planning work programs from those RPCs receiving U.S. HUD funds channeled through the state. Representatives of various state agencies, including Wisconsin DOT, were invited by Wisconsin DLAD to participate in a joint review of these programs for the first time.

The draft program submitted by the Northwestern Wisconsin RPDC for federal and state comprehensive planning assistance funds provided the starting point for detailing the first nonmetropolitan transportation planning work program to be financed by Wisconsin DOT. General statements concerning transportation planning needs had to be converted to specific work elements, cost estimates, and proposed sources of U.S. DOT-Wisconsin DOT financing. Data for the final version of the Northwestern Wisconsin RPDC transportation work program are given in Table 3.

Similar work programs have now been developed in cooperation with the Southwestern Wisconsin RPC, the Bay-Lake RPC, and the West Central Wisconsin RPC. On February 8, 1974, T. J. Hart, administrator of the Division of Planning, officially informed the chairman of the Northwestern Wisconsin RPC of the intention of Wisconsin DOT to fund a transportation planner for the region. Wisconsin DOT technical assistance would continue to be provided. This action initiated the Wisconsin DOT regional planning assistance program for nonmetropolitan planning and has set the stage for development of state-regional partnerships throughout the state. It should be pointed out that the district highway offices are providing valuable assistance in the drafting of transportation planning work programs to meet regional needs. District planning engineers will also be members of technical coordinating committees being established for each of the RPC programs to ensure continuing RPC-district liaison. As given in Table 1, Wisconsin DOT now has agreements for continuing transportation planning with six of the eight multicounty RPCs in the state, and the other two RPCs have indicated interest.

REGIONAL PLANNING COMMISSION INPUT TO STATE TRANSPORTATION PLAN DEVELOPMENT

On February 8, 1974, Wisconsin DOT decided to move away from the traditional coordinative support approach to RPCs and more toward cooperatively funded programs in all regions. This decision had immediate implications for the Wisconsin DOT STP effort.

Although the Wisconsin DOT Division of Planning had contemplated the preparation of an all-mode STP for some years, the requirement of the Federal-Aid Highway Act of 1970 for state action plans provided a strong impetus to accelerate STP development. A Federal Highway Administration publication (PPM 90-4) provided the official interpretation of this federal act and required Wisconsin and all other states to develop their own policies "... to assure that possible adverse economic, social, and environmental effects relating to any proposed highway project on any Federal-Aid System have been fully considered in developing such projects...." At the start, Wisconsin DOT chose to comply with the act not only in regard to highways but also through a voluntary broadening of its Action Plan approach to include procedures for planning all transportation facilities currently or potentially under its jurisdiction. This was particularly appropriate in light of the requirement for the Action Plan to provide for in-depth studies of alternative project solutions ranging from doing nothing to selecting other forms of transportation where they would better serve the public. Thus it was only natural that the Wisconsin DOT Action Plan called for development of an all-mode STP to meet the needs of the state and its rural, urban, and metropolitan communities. RPCs were at first concerned that the need for regional transportation planning was no longer to be recognized by Wisconsin DOT. This was definitely not the intent, however. The Wisconsin Action Plan specifically called for the RPCs to cosponsor public involvement activities for the state transportation planning process and to give their comment, counsel, and reactions during the development of alternative all-mode state plans (3).

On April 27, 1974, the Wisconsin DOT transportation planning council (TPC), consisting of the three highway commissioners and the administrators of the Divisions of Aeronautics and Planning, briefed the recently reactivated Wisconsin Council of Regional Planning Organizations (CORPO) on the state transportation planning process.

Figure 2. Organization of Wisconsin DOT Division of Planning.

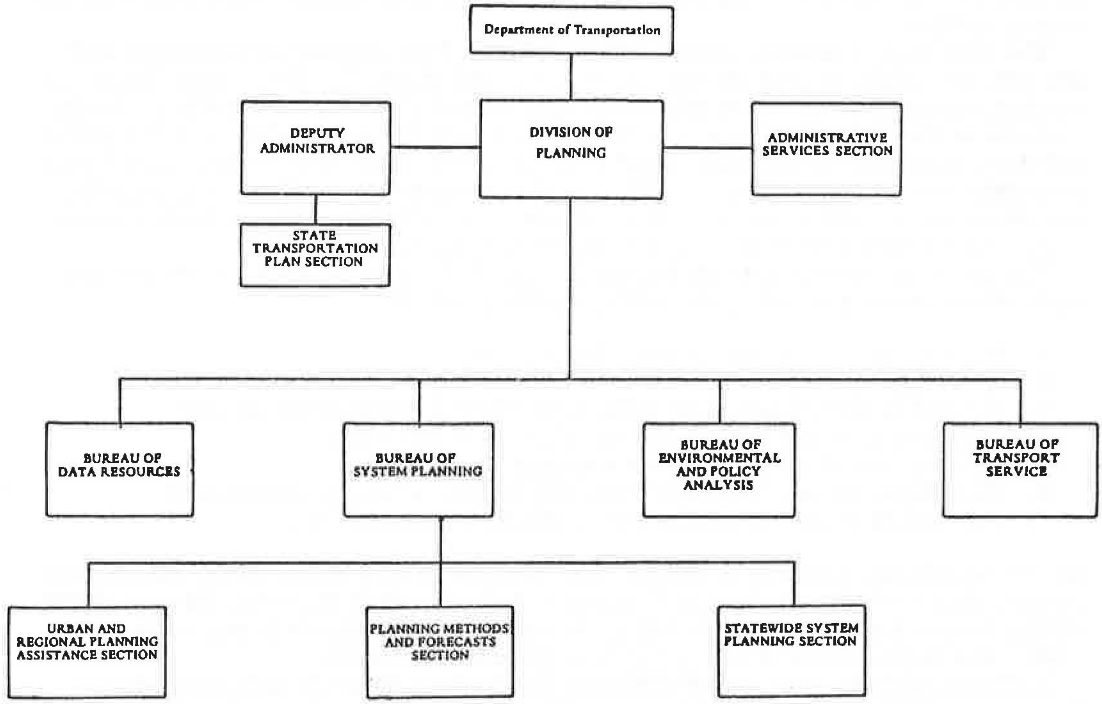


Table 2. Characteristics of two regional transportation planning assistance alternatives.

Coordinative Support	Cooperative Programs
State DOT assumes strong leadership role in transportation planning, and many issues are defined as matters of statewide significance; the need to resolve interregional conflicts is stressed; coordination with regional planning is sought as benefits to the state become apparent.	State DOT shares leadership role with RPCs for transportation planning on a substate basis; RPCs in turn must assume some of the responsibility for coordinating local input.
State DOT directly undertakes a centralized planning program; state goals and objectives are recognized and accepted by RPCs for preparing regional refinement of statewide transportation plans; state DOT relies basically on other state agencies to provide land use and socioeconomic input.	Regional-local input is actively sought on transportation issue identification, planning, and development; independent regional transportation plans are prepared, district DOT boundaries become aligned with RPC boundaries.
State retains primary responsibility for public involvement activity in transportation planning; uniform statewide approach is used.	Continuing regional-local input to transportation planning is coordinated by the RPC, maximum response to changing local values
Highest and controlling goals, objectives, and priorities are set by the state; regional-local goals, objectives, and priorities must conform to those of the state.	Goals, objectives, and priorities are set jointly by state and local units in regional planning framework.
Regional planning and other related means of local input to state planning are seen as optional; generally, requests for coordination are generated locally; state DOT develops local liaison staff as required.	Regional planning is actively supported and state DOT-RPC formal partnerships are sought; state DOT financial assistance is required.

Table 3. Northwestern Wisconsin Regional Planning and Development Commission transportation program data.

Element	Total Cost	Federal-State Highway Planning Funds	State All-Mode Planning Funds
Refinement of regional highway plan in two counties and recommendation of jurisdiction changes	1,903	1,903	0
Provision of staff support to RPC transportation advisory committee, which meets quarterly	1,903	952	951
Liaison and participation in study of transportation impact of new Apostle Islands National Lake Shore	1,903	951	952
Local planning assistance, transportation project initiation and review	951	476	475
Initiation of assessment of regional rail service with consultant assistance	6,768	0	6,768
Review of environmental impact statements and participation in public hearings	3,632	2,724	908
Program administration-overhead	4,120	1,689	2,431
Total costs	21,180	8,695	12,485
Wisconsin DOT share*	18,000	7,390	10,610

Note: All values are in dollars.
*85 percent.

On May 29, the TPC officially requested the RPCs to help arrange STP public involvement activities.

The first item of business in the STP process is TPC adoption of an interim STP that will essentially reflect existing statewide modal plans, modifications of them, and supplemental policy objectives while a comprehensive STP is in preparation. Public reaction to the modal plans and proposed general policies of the interim STP at public meetings is seen as an important input to development of new and refined plans during preparation of the comprehensive STP. Each of the multicounty RPCs was an active cosponsor for an area planning conference and supporting activities related to gaining public comment on a draft interim STP during the fall of 1974.

The proposed general policies for the interim STP relate to many issues that are matters of current concern to the RPCs, and they include

1. State-local highway jurisdictional exchanges,
2. Development of scenic routes and rustic roads,
3. Airport improvements compatible with existing and planned land use,
4. Improved intercity bus service to all areas of the state,
5. Development of a statewide bikeway plan,
6. Restoration of rail passenger service to areas formerly served, and
7. Prevention of further abandonments of rail freight service.

The transportation planning work programs being developed by the RPCs and financed by Wisconsin DOT are addressing themselves to issues such as these. Several of the RPCs, for instance, are already taking strong advocacy positions in regard to the retention and improvement of rail freight and passenger service.

A recent planning grant of $90,000 from the Federal Railroad Administration to Wisconsin DOT has accelerated the timetable for preparation of a statewide rail plan. The RPCs are playing a role in the development of this plan. In particular, they have reviewed draft goal statements for the rail plan, recommended branch-line segments for detailed study, and provided assessments of regional economic development related to future rail service. District highway offices have cooperated with the RPCs in carrying out these assignments and have assisted in reviewing the accuracy of rail segmentation maps and listings and in documenting the current use of abandoned railroad rights-of-way. Several RPC representatives have been appointed to the State Rail Plan Advisory Committee. The initial Wisconsin DOT-RPC agreements helped to provide financial support for these RPC activities.

Wisconsin DOT sees this emerging state-regional partnership in rail system planning as being applicable to statewide planning for other modes as well. RPC representatives have for over a year served on a technical advisory committee established to provide input to the development of the State Airport System Plan. The newly initiated RPC work programs are also concerned with refining the State Highway Plan within their respective counties with respect not only to proper functional designation of roads but also to recommendation of the appropriate jurisdiction in accordance with land service and traffic criteria. In effect, the RPCs in cooperation with the district highway offices are serving as true middlemen in implementing the State Highway Plan. How all of this will eventually relate to the systematic preparation and update of statewide modal plans and a comprehensive STP is hard to predict in Wisconsin at this early stage of state-regional partnerships. One thing is certain, RPCs are helping to achieve public involvement and consideration of alternatives in state transportation planning in accordance with the objectives of the Wisconsin DOT Action Plan.

PROBLEMS IN IMPLEMENTING STATE-REGIONAL PARTNERSHIPS IN TRANSPORTATION PLANNING

So far, this paper has stressed the positive aspects of state-regional partnerships in transportation planning. No objective evaluation of this subject would be complete without recognition of the problems and pitfalls involved. In no particular order of priority these problems involve

1. Lack of uniform response from RPCs to form state-regional partnerships,
2. Problems in recruiting RPC transportation planners, and
3. Lack of RPC interest in system planning.

Uniform Response

To date only six of the eight multicounty RPCs have responded fully to the Wisconsin DOT offer to form state-regional partnerships in transportation planning, and the other two RPCs have indicated interest and will respond inevitably. Start-up tasks will consume the initial attention of new RPCs, and thus there will probably always be a planning lag between the first and the last RPC to respond. To the degree that Wisconsin DOT might look for each RPC to perform identical tasks with the same degree of professionalism, such a uniform input to a statewide planning effort would simply not be forthcoming. Some RPCs will always be ahead of others in certain planning efforts. If their regions are urban, they will be ahead on urban public transit; if their regions are rural, they will be ahead on scenic routes and rustic roads. Each RPC will tend to input first those things most important to its region in any statewide planning effort. A statewide coordinating mechanism will certainly be required to pull the varying pieces together.

Recruiting of Regional Transportation Planners

My opinion is that we are experiencing a run on available starting, supervisory, and management types of transportation planners. The Federal-Aid Highway Act of 1973 with its provisions for mandatory funding of metropolitan transportation planning staffs has seemed to cause at least a temporary drain on the supply of transportation planners for regional planning positions. A subjective review of a mid-1974 American Society of Planning Officials-Technical Abstracts Bulletin indicated a strong nationwide interest in the recruitment of transportation planners. The first round of advertising for a transportation planner for the Northwestern Wisconsin RPDC resulted in many responses but only one from a qualified applicant. It is thus possible that initial nonmetropolitan regional transportation planning programs in Wisconsin might have to get under way with some consultant help. Readvertising of RPC staff positions in a broad range of planning and transportation publications is now attracting additional qualified candidates, and initial staffing of nonmetropolitan RPCs is under way.

Regional Planning Commission System Planning

Examination of the initial nonmetropolitan RPC transportation planning programs submitted for Wisconsin DOT financing indicates a strong inclination toward issue-oriented rather than systematic-comprehensive planning. Wisconsin DOT system planners will need to find a way to combine and meld statewide transportation system planning with regional planning that is at present largely unsystematic and issue oriented. It is likely that the metropolitan RPCs with their urban transportation planning experience may be more easily able to interface with state planners. On the other hand, the times are forcing state planners to also depart from traditional system planning concepts and be more responsive to individual issues. The outcome of this apparent dilemma is yet to be made clear.

CONCLUSIONS AND RECOMMENDATIONS

The recent Wisconsin experience tends both to confirm and deny some of the major findings and recommendations on state and regional development from the TRB Conference on Statewide Transportation Planning (1). Following are my conclusions, based on the conference observations on public policy and regionalism and regional transportation processes.

1. Public support of regionalism on a multistate and substate district basis. Public support for regional planning has solidified in Wisconsin over the past 2 years, and the state has been virtually blanketed with multicounty RPCs. This is not unanimous as evidenced by the withdrawal of two counties from Wisconsin RPCs, but in most respects, regional planning is an activity that is maturing in Wisconsin and gaining increasing public support. Key state agencies in Wisconsin are also providing increasing support for regional planning. In addition to the activities of Wisconsin DOT described in this paper, the state's Department of Administration (DOA), in the development of a state land use policy, sees the RPCs as an important institutional mechanism for gaining public exposure and discussing policy alternatives. According to the Wisconsin DOA, RPCs will also be instrumental in further detailing land use policies; tailoring them to the unique objectives, needs, and priorities of the region; and working with local governments that will be the major policy-implementing agents. Both Wisconsin DOA and DLAD have been promoting the increased provision of RPC technical planning services to local units of government. Regional planning continues to be one of the highest priority programs of Wisconsin DLAD. State regional planning aids administered by DLAD now amount to $339,000 annually.

One point that should be emphasized is that Wisconsin state agencies have not made eligibility for federal aid the primary rationale for promoting regional planning (even though some new RPCs initially thought this was the case). Rather, the idea emphasized that RPCs serve to meld and define the viewpoints of local units of government within the region on issues of areawide significance. As previously mentioned, state agencies are strongly encouraging RPCs to strengthen the local assistance portions of their work programs. In essence, to be effective partners in planning with state government, RPCs must retain close ties with constituent local units of government.

2. State general transportation policy frameworks consistent with state general comprehensive policy frameworks. Wisconsin DOT has had some problems in establishing a continuing, productive relationship with the statewide comprehensive planning process, even though the importance and value of this has been realized. One basic reason for this is the changing nature of statewide comprehensive planning depending on the agency, office, and leadership involved in managing this effort. The visible process today tends to be almost totally short term and issue oriented. The remnants of areawide comprehensive planning in Wisconsin are stored and nurtured in RPC offices; therefore, Wisconsin DOT has concluded simply that long-range land use and transportation system planning will not be closely coordinated on a statewide basis in the foreseeable future. The successful planning partnerships we have had and are continuing to have now with RPCs assume even greater importance as we strive to maintain some connection with comprehensive planning in our planning process.

3. U.S. Office of Management and Budget (OMB) requirement that all federal agencies provide all financial planning assistance and implement planning requirements through comprehensive statewide agencies. Wisconsin DOT should reconsider this recommendation in light of the state experience. If comprehensive statewide planning agencies have difficulties in effectively developing and managing long-range land use planning programs, they certainly will have no less difficulty in transportation. Functional state agencies such as state DOTs should retain a strong lead role in the administration of federal financial assistance for planning in cooperation with RPCs established in accordance with state statutes.

4. OMB proposal to Congress on provision of public highway funds in the form of incentive bonuses to states with a statewide planning agency discharging multimodal responsibilities (i.e., coordination of transportation with housing) at the multicounty

and substate district levels. This recommendation is similar to some recommendations of the Wisconsin Governor's Study Committee on Mass Transit, which called for the creation of a state planning agency that would be responsible for coordinating the functional planning of all state agencies to ensure conformance with statewide goals, policies, and standards. It also recommended that any public body that does not adopt a land use plan that is consistent with a duly adopted regional land use and transportation plan becomes ineligible for state transportation aids (4). Again, the Wisconsin approach is to place as much emphasis on coordinating land use and transportation planning at the regional level as is placed at the statewide level.

5. Inadequacy of intermodal and multimodal transportation processes despite the progress made over the past 10 years. Regional transportation planning has been basically a highway planning process because highway planning funds have been available in abundance and other-mode planning funds were not so available. Wisconsin DOT has stretched federal and state highway planning dollars to the ultimate in providing financial assistance to the metropolitan RPCs in the past. Fortunately, Urban Mass Transportation Administration funds are now generally available, and in due course we might expect the Federal Aviation and Railroad Administrations to join in the shared financing of continuing regional transportation planning. In addition, Wisconsin DOT planning assistance funds are now all-mode planning funds through changes in the Wisconsin DOT budgeting process. As adequate financing is provided, RPCs in Wisconsin are addressing other-mode planning concerns in increasing detail. The initial activity of the RPCs in state rail planning as discussed in this paper particularly supports this.

6. Increase in citizen participation in decisions made on fundamental state transportation policies through umbrella multijurisdictional organizations (UMJOs) responsible for providing citizens with factual information and for convening appropriate hearings about regional plans and programs. This finding is fully confirmed by the Wisconsin experience. The Wisconsin DOT Action Plan is geared to this kind of philosophy and approach as discussed previously in this paper. The success or failure of this approach is of course yet to be determined, but RPCs in Wisconsin are accepting the role of cosponsor of all public involvement activities related to preparation of the STP, and their efforts are helping to gain significant public input into the statewide planning process.

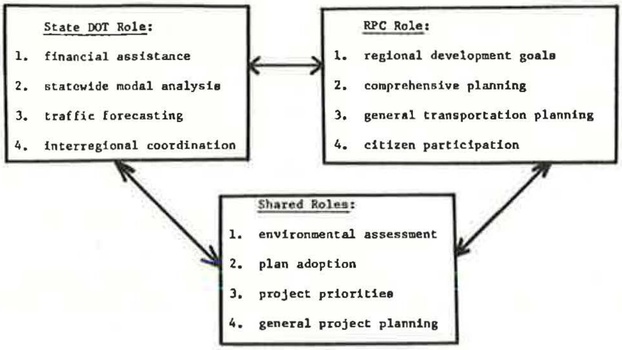
7. Encouragement of effective multimodal programs and linkages by much federal and state financial planning, program development, and program implementation assistance for public transit, rail rapid transit, existing railroad branch lines, experimental nongas private vehicles, and other types of transportation alternatives. Such financing for other-mode planning will help to achieve statewide and regional multimodal programs and linkages (comments in item 5 are also applicable).

8. Focus of substate transportation planning on land use, public works, public facilities, and services without priority attention given to recommendations intended to affect public and private sector transportation policies at every governmental level. RPCs will give priority attention to transportation policies when adequate funding is provided (comments in items 5 and 7 are also applicable).

9. Encouragement of every state DOT by the Transportation Research Board to develop and publish guidelines or procedures [e.g., (5)] that establish precisely how regional transportation processes are to be carried out by UMJOs and others. Although I have not yet reviewed the California guidelines (5), I can say that Wisconsin DOT has given some preliminary considerations to preparing a similar document principally because we want to standardize the new regional transportation planning assistance program to some degree and establish some uniformity in the planning product we are financing. We are somewhat hesitant to produce precise guidelines. Flexibility will be required to enable each region to better define and attack transportation issues of regional importance while assisting in statewide planning efforts. Final Wisconsin DOT guidelines (if any) will perhaps await more definitive thinking on the order of the first comprehensive STP. In the meantime, RPCs in Wisconsin are already beginning to decide how the STP should address itself to regional concerns.

In summary, the Wisconsin experience does not project precise roles for state DOTs

Figure 3. State-regional planning partnership.



and multicounty RPCs in cooperative transportation planning. It does, however, suggest some directions to consider. As shown in Figure 3, the state's role must include financial and technical assistance and coordination across RPC boundaries. The RPC must have the opportunity to speak for the citizens of the region and their collective goals. Coordination of transportation and comprehensive planning will occur principally at the regional level. Finally, since we have the capability of learning from the earlier, evolving urban transportation planning process, some probable shared roles can be suggested for state DOTs and RPCs in full-scale regional transportation planning. Advantage should be taken of the interdisciplinary staff capabilities of RPCs in such areas as environmental assessment and general project planning. Importantly, state and local improvement programs should reflect adopted regional plans and priorities.

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