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Contents

Critical Issues in Statewide Transportation Planning

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This paper highlights state-of-the-art ideas and procedures that are pertinent to current problems in the statewide transportation planning process. It draws on the critical issues that emerged during the preparation for and participation in a national series of seminars on statewide highway planning. The seminars were sponsored jointly by the states and the Federal Highway Administration. Issues include fiscal problems, public involvement, planning and programming relations, multimodal planning and programming, energy, land use, and surveillance and evaluation. The overriding issue in most states is that expected highway revenues will not meet expected highway needs. The states' responses highlight the need for state governments to manage available resources more effectively. Courses of action available to the states include preservation of the existing transportation system, emphasis on possible rather than desirable improvements, focus on specific corridors for modal trade-offs, more extensive education in energy conservation, land use control to protect highway utility, early and continued public involvement, and management's accountability for implementation of state transportation improvement programs. These activities are discussed and examples are given of how some states are dealing with the issues.

This paper describes the observed trends, state of the art, and expressed concerns and approaches suggested and used by state transportation agency planning and programming officials to deal with critical issues in statewide highway planning. The paper is intended to highlight how some states are dealing with current critical issues. The critical issues that emerge include fiscal problems, public involvement, planning and programming relations, multimodal planning and programming, energy, land use, and surveillance and evaluation. Each of these is discussed separately, although they must be considered together in the management of the statewide transportation-planning program.

FISCAL PROBLEMS

Many states have expressed concern over the current trend of declining growth rate of motor fuel receipts. In a majority of the states that collect taxes on motor fuel, the funds are dedicated by statute or by constitutional amendment to be used only for highway or other transportation purposes. During most of the time that these funds have been in existence, the available revenues have kept pace with the costs of expansion, improvement, and maintenance of the state's highway facilities. However, the past decade has not reflected a similar ability to keep pace, and costs of necessary service have begun to exceed user-tax revenues.

Much of this problem can be related to recent large increases in construction costs. The national construction index has risen from 67 to 220 between 1950-1978 (1). To compound the problem, the absolute amount of fuel taxes collected is projected to decline in many states because of greater fuel efficiency of new vehicles and reduced travel. States have reacted to this situation in several ways. Two approaches have been (a) to reconsider the perceived need for certain transportation improvements or (b) to look for ways to make optimum use of available funding among alternative improvements. Other approaches seek other funding sources or increases in existing sources.

Texas and California handled the question of need by reevaluating the appropriateness of existing improvement standards in terms of the benefits that could be obtained from the improvement. The result was a system-oriented approach (2, 3). Three guidelines are used to generate highway improvements that move a system toward a higher level of total benefits:

1. Design for system balance—Projects developed should balance projected quality of service in safety and mobility (speed) throughout the transportation network.
2. Provide for system continuity—Projects should close gaps in the existing transportation system. One completed facility is likely to offer more benefits than two partially completed facilities.
3. Seek low-cost design alternatives—The broadest range of possible alternatives must include minimum-cost projects. Customary design is often sacrificed to such designs as narrower highway medians, fewer overpasses, less than 20-year design, a combination of freeway and expressway segments, ramp metering and special bypass lanes, and modified interchange design.

In California the recommended system-oriented approach was kept within the existing funding level and new funds were not emphasized. Texas used the system-oriented approach along with a strong appeal and supporting analysis for additional funds. South Dakota has taken an approach similar to that of California and Texas to evaluate individual routes to determine the project mix that would be most cost effective at that scale. This subject of financially restrained plans is discussed further in a paper by Wilson and Cannon in this Record.

Jurisdictional realignments have the indirect effect of making optimum use of available funds. Roads have been added to state highway systems without consideration of the consequences of whether the road serves a state-level interest. Florida, for example, was required by recent state statute to classify all highways functionally to determine those that were of importance to the state and for which the state will take responsibility. Other highways will be the responsibility of county or city governments, as appropriate.

The state of Minnesota Department of Transportation plan dealt with the issue of available alternative revenue sources for transportation programs (4). Seven alternative sources were investigated:

1. A sales tax on motor fuel that would be tied to price,
2. Additional general funds,
3. Increased present motor fuel tax,
4. Increased motor vehicle license fees,
5. Funding of the department of public safety from the general fund instead of from state trunk highway funds,
6. Dedication of an increase in the general sales tax to transportation, and
7. Assignment of revenue from the motor vehicle sales tax to transportation purposes instead of to the general fund, as is currently done.

These alternatives were presented to regional task forces for comments on aspects of the plan development. The task forces thought that user charges should continue to be user supplied; thus policy options 1, 5, and 7 received the most support.

The state of Washington, when in need of increased available funds, chose to raise the motor fuel tax. The approach involves a variable gasoline tax that can fluctuate between 9 and 12 cents, depending on the average retail price of gasoline

PUBLIC INVOLVEMENT

Public involvement in all stages of statewide transportation planning is critical so that a base of support can be established for discussions with the legislators on financing programs and discussions with the public on project development activities. The most commonly used method to gain public input has been public meetings, which are normally held on a regional or community scale. For example, in Iowa critical transportation issues and suggested policy changes were identified by 8 (now 10) regional citizen advisory councils. Continuous involvement is maintained through monthly council meetings, mailbacks, response sheets, and newsletters.

Public meetings have been used in Minnesota as a forum to help identify and deal with issues and problem areas that the transportation plan will address. Additional input is obtained through response to letters and brochures to legislators, other elected representatives, interest groups, and the general public. Public involvement will be maintained through agreements with regional development commissions to assist the department of transportation in periodic revisions of the transportation plan.

During the development of a regional transportation plan for southeast Alaska, the Alaska Department of Transportation and Public Facilities held public workshops in 17 communities. Participants identified transportation services in their communities, listed their likes and dislikes in regard to these services, and recommended priorities for transportation improvements. Several principal transportation system options were considered at another series of public workshops, which led to a preferred transportation plan.

Arizona has held 19 public forums throughout the state to obtain inputs on the future direction of transportation. Attendance ranged from 16 to 150 and averaged about 40 participants. Background information on the status of the systems was provided in a previously circulated report and briefly summarized at the meetings. The participants responded through small workshop groups. A monthly newsletter that covers progress on the plan development and invites response from readers keeps the public involved.

Louisiana holds hearings annually on the state's proposed short-range program. The hearings are conducted by the Joint Legislative Committee on Highways and Public Works. The state department of transportation provides staff to address technical issues at these hearings. The Minnesota, Arizona, and Louisiana participatory processes are discussed further in the Wilson and Cannon paper in this Record. Two common characteristics in the above examples are the early involvement of the public and provisions to keep the public involved and informed on a continuous basis.

Advisory committees, composed of a variety of memberships and structures, are often used in the plan development process. For example, Michigan has established modal committees, including modal carrier representation, for the state's multimodal needs study. Wisconsin uses a broad-based state transportation plan advisory committee to aid in the development of statewide plan alternatives. Alabama has a citizen group that worked closely with the Alabama State Highway Department to develop a long-range plan and financing packages for the legislature.

Several states have used special surveys to gain public opinion. Washington used transportation surveys and television-callback programs to obtain representative public input. Colorado used a modified questionnaire technique to gather information from the public on transportation issues, goals, and alternative state development futures. A 30 percent response rate was obtained. In nearly all of the above examples, some form of written communication was provided to the public, such as reports, minutes of meetings, or newsletters.

PLANNING AND PROGRAMMING

The view taken during the Federal Highway Administration (FHWA)-sponsored seminar series was that the program should be a primary product of planning and both are aspects of planning management. Part of the separation that exists between planning and programming can be attributed to organizational structure and separation of responsibility. Planning and programming officials often report to different individuals and both functions may be carried out independently. Similarly, state highway agencies may centralize planning, although the initial development of the programming is done at the district level. The central office control may only be to ensure that total spending limits will not be exceeded. The relevance of planning to programming is critical and may be improved through a sound, continuous process for decision making and accommodating change. Individuals and issues may change over time and assumptions made during plan development may no longer hold; therefore, effective planning management must be sensitive enough to adjust and respond accordingly.

California's response to a statutory requirement for a quadrennial needs study is an example of this adjustment. Between the 1974 and 1977 studies, officials recognized a need for low-capital intensive improvements and for a shift of emphasis away from dependence on the private automobile (5).

The difference in needs between 1974 and 1977 is summarized in Table 1 (5). There are two major differences between the two programs:

1. In 1974, deficiencies in the system were supposed to be eliminated by construction of new facilities or reconstruction of existing facilities to full modern standards. The 1977 needs estimate contains more proposed improvements but fewer proposals for new facilities. The current estimate includes 480 new highway proposals, whereas the 1500 projects in 1974 were almost all new highway proposals.
2. The 1974 needs were directed almost entirely at capacity problems. Underlying structural, safety, or operational problems added priority to new highway construction but were not usually problems for correction in themselves.

The 1977 needs report was much more comprehensive and included various operational, environmental, and multimodal improvements.

States such as California are developing a system planning process that will allow management to better evaluate success in fulfillment of the agency's mission. Managers also recognize the need for stronger coordination between planning and programming so that data developed by planners will be responsive to the needs of programmers.

MULTIMODAL PLANNING AND PROGRAMMING

True multimodal programs (i.e., a statement of work that recognizes the abilities of each mode to satisfy travel demand and the optimization of these abilities) are rarely developed at the statewide level. One of the reasons is the difficulty in assessing the comparative advantages of each mode. All modes have characteristics that can be defined and measured in similar terms, but these characteristics often are not the significant ones used to make modal trade-offs. For example, speed, frequency of service, capacity, and operating costs can be measured for all modes but do not necessarily indicate the reason why a particular modal choice is made. However, all modes also have unique characteristics that can be defined and measured (in not necessarily similar terms), and these characteristics are significant in making modal tradeoffs. Examples are the rates that can be charged for service, minimum size of shipment, union operating rules, and the degree to which modal choice is influenced by regulation.

For example, nondirect transportation costs in freight movement can have a significant effect on modal choice. Table 2 shows the types of economic considerations related to inventory costs that a freight receiver must make (6). These considerations include annual volume, warehouse costs, the minimum shipment size for various modes, freight rates, and transit time. Our example is for a warehouse that has an annual volume of 163 293 kg (360 000 lb) valued at $8.82/kg ($4.00/lb). The base rail inventory is 77 564 kg (171 000 lb) and the base truck inventory is 28 576 kg (63 000 lb). In the example case, rail transport is $16 200 more expensive than truck transport. Direct transportation costs favor rail; however, the associated inventory costs that arise due to frequency and size of shipment tip the economic scale to favor trucking.

Another problem is that a true picture of freight modal activity is difficult to obtain. Many freight carriers will not release information. This situation has led to a number of alternative approaches. In Texas manufacturers were contacted to obtain the type of goods shipped and modal information; the response rate was 64 percent. Arizona attempted to obtain freight information from shippers and receivers rather than from transportation companies. Oregon will attempt to obtain information only on those commodities that are particularly significant to the state's economy in order to reduce data collection costs.

Subtle issues must be weighed for modal trade-offs of such questions as, What are comparative advantages of intercity bus service relative to automobile service? How large a public investment should be made to support such bus service? Would publicly supported rail adversely affect bus service within the same corridor?

Effective approaches will emphasize modal-specific and corridor-specific issues, show where modes would complement each other, and avoid complex simulations of competing modal systems. For example, Iowa depends heavily on a transportation network that can move grain efficiently during harvest. The state was instrumental in developing a combination rail-barge tariff for corn and soybeans shipped to the Gulf of Mexico for export (7). This tariff eliminates the daily fluctuations common to barge rates and offers the shippers an annually contracted rate.

Multimodal interstate and intrastate studies of passenger movement have focused on bus and air modes. Michigan and Oregon conducted bus studies that include such items as the number of companies operating, routes, schedules, frequency of service, financial statistics, user profiles from onboard surveys, and trip purpose.

ENERGY

The energy issue has become a most important consideration in statewide transportation planning and has some of the most profound long-term ramifications. The transportation sector accounts for about 40 percent of total gross energy consumed when indirect uses are included and over 50 percent of all petroleum consumed. Moreover, the automobile accounts for half of the nation's transportation energy consumption (8). Thus, the transportation sector, and particularly the automobile, are obvious choices for implemention of energy conservation measures. A multitude of options are open to the transportation planner, and literature regarding their implementation and effectiveness is voluminous, yet even reliable sources differ on fundamental considerations. In addition, a lack of consensus on the extent and even existence of an energy problem requires that extensive public education be an integral part of most conservation measures.

Statewide energy conservation measures may seem ineffectual when compared both to the enormity of the energy problem and to the energy savings produced by a national policy, such as the mandating of greater fuel efficiency in newly constructed vehicles. However, state planners should recognize that conservation mea-

Table 1. Construction needs by program element.

Program Element	1974 ($000 000s)	1977 ($000 000s)
Land and building maintenance	-	30
Bridge reconstruction	22	161
Roadway reconstruction	53	315
Highway planting restoration	-	34
Safety roadside rest area restoration	-	2
Resurfacing	-	73
Protective betterments	6	43
Safety improvement	22	397
Noise attenuation	-	381
Highway planting	-	74
Roadside rests	5	45
Vista points and roadside enhancement	-	16
Traffic operational improvements	132	621
High-occupancy-vehicle facilities	11	724
Bicycle facilities	-	24
New highway construction	8295	3698
Miscellaneous	2	9
Total	8548	6647

Table 2. Inventory cost example.

Mode	Rate	Transit Time (days)	Annual Cost ($) Transportation	Inventory Investment at 10 Percent	Total Distribution
Truck	$2.25 on 13 608 kg minimum	2	81 000	25 200	106 200
Rail	$1.50 on 27 215 kg minimum	7	54 000	68 400	122 400

Note: 1 kg = 2.2 lb.

sures may produce a fiscal savings that can offset decreased gasoline tax revenues. Government agencies have been slow to respond to the energy situation, possibly because many conservation proposals do not fit within their traditional framework of responsibilities. Yet their response is necessary. Energy conservation is not a short-term policy. As an increasingly important fact of life, it demands the attention of those whose decisions will determine future energy use.

Transportation system management (TSM) strategies offer urban areas options for increasing the efficiency of their transportation systems. Increased efficiency, in many cases, means decreased energy consumption. TSM strategies in use can be generally stratified into two principal categories:

1. To promote the use of high-occupancy vehicles (HOV) through increased automobile occupancy and shifts to transit and
2. To improve traffic flow.

Regardless of the strategies chosen, they should be assessed in light of potential cost, time to implement and achieve results, degree of impact, and interaction with other goals, as well as their energy conservation potential.

Certain behavioral changes in travel, such as higher automobile occupancy on trips to work, could result in significant energy savings at a minimum level of investment. Unfortunately, these changes often involve perceived inconveniences and are thus very difficult to realize. Therefore, a greater emphasis must be placed on informing the public about energy problems, the need for conservation, and the attractiveness and workability of energy-efficient practices. For example, a New York research report has suggested that an energy audit program be set up to assist citizens in energy use (9). Citizens would volunteer to have their energy usage audited and would request suggestions on how to save energy for their particular situations. Successful implementation of carpools, vanpools, and public transit programs is also dependent on a public education process that emphasizes fuel and monetary savings as well as other personal savings and convenience.

Effective strategies in urban land use planning and control offer potential long-range energy savings. Police powers, taxing policies, and public works investment policies affect land patterns. The location of shopping districts, residential areas, and high-density employment centers can help reduce future demand for travel. Tax breaks are also being considered for industries that locate in urban areas to discourage suburban sprawl.

In the event of a rather sudden energy crisis, such as occurred during the 1973-1974 oil embargo, all levels of government must be prepared to act swiftly to minimize its impact. Some measures, such as a rationing program, must be handled at the federal level, but even then the state and local governments will have responsibility for handling special cases, setting up boards and panels, and conducting a public information program. Each of these activities should be organized as a part of a contingency plan before the emergency so that the transition into the crisis situation is as smooth and expedient as possible.

The North Central Texas Council of Governments has outlined strategies to modify its mass transportation system in the event of an energy crisis (10). Concerns about bus service expansions or reductions include

1. Eliminate or add routes,
2. Purchase extra bus capacity,
3. Provide peak service only along certain routes,
4. Lengthen headways,
5. Eliminate weekend service,
6. Reduce the number of stops,
7. Improve the flow of buses in traffic, and
8. Decrease the number of deadhead bus kilometers.

The Texas plan also recognizes the usefulness of using taxis and ridesharing to provide transportation to low-density areas where bus service would be inefficient.

The nationwide energy savings to be realized by implementation of any one conservation strategy generally falls within a range of 0-5 percent. Two major exceptions are (a) use of taxes to encourage a shift to more efficient automobiles and (b) increase of the price of fuel by at least 50 percent. Both of these strategies will generate considerable savings, as well as controversy. Although national savings due to conservation efforts may not be great, local savings could be significant, depending on the area and the strategy. The value of a conservation program is that it is generally low in cost and it can buy time. The major factor in its success is public support, which can be enhanced through adequate public education.

LAND USE

The interrelationship of land use activity and travel has been well observed by the transportation system user and the property owner. The basic cycle created has transportation system improvement playing catch up to satisfy need created by development, which, in turn, improves land access, which improves land value and stimulates more development, and so on. The two-edged issue of the role of the transportation system in influencing land use change and accommodating the impacts of land use on the existing transportation system is basic to transportation planning. Analysts have had difficulty in quantifying the relationship (to the extent that feedbacks are obtained, for example, between land use and transportation network models) (11), and institutions have had less than full success in trying to coordinate development with transportation improvements.

The recent shift by the states away from the development of new transportation facilities and toward the preservation of the existing system contributes to these difficulties. Therefore, better land use controls and constraints (such as access control) that will help preserve or improve the utility of the existing transportation system should be added to the land use-transportation cycle. Traditionally, local jurisdictions (cities and counties) are responsible for land use planning and regulation, and planning at the state level is more often oriented to broad policy development and deals more with budgeting and capital improvement than with the specific function of statewide land use planning and regional growth and development objectives.

Another factor contributes to difficulties in achieving a state-level land use-transportation planning integration. Responsibility for land use planning generally rests with local jurisdictions and regional agencies, but the responsibility for certain activities (such as transportation) have been retained at the state level. Thus, the focus from a statewide perspective for these two functional planning areas rests at two different institutional levels. Also, activities within the same level of government related to land use and transportation are often found in widely separated departments or agencies.

A number of relatively recent actions or concerns under study either directly or indirectly affect the land use-transportation issue. For example, state legislation on environmental concerns and access needs of energy resource development is emerging. These issues impact on transportation service. The impact of land development patterns on energy use is also becoming more critical. At the more analytical level, the impacts of transportation development on land development have received considerable study in the past. Typical are the studies on the effects on central business district growth of a proposed bypass and before-and-after studies of growth at freeway interchanges and along corridors of new facilities. On the other hand, studies have included the usual trip generation analysis part of an urban transportation study or a statewide study employing urban travel forecasting techniques. Site analysis of the impact of a proposed traffic generator on the surrounding street system is another example.

Land use control and impacts of development on maintenance of the existing functional class or level of service of a facility have become critical concerns. Protection of the utility of highways that make up an existing highway system at a point in time when few new large-scale facilities are being built increases the need for emphasis on land use control. The Highway Users Federation found that most of the state efforts at control focused on critical areas (12). The following were among the examples mentioned in the report. Other state actions taken more recently are also included.

1. In Connecticut a land use policy map is used as a guide in assessment of the consistency between land use and state public investments.
2. The Florida Environmental Management Act of 1972 allows critical environmental areas to be set aside by officials for protection and allows for protection of major public investments. The act also requires the preparation of a state land use development plan and a review process for projects of regional significance. The availability of adequate transportation service is one of the criteria used in the review of housing and commercial development of regional significance.
3. Coastal states have moved to manage growth better along their coast lines either directly by state legislation or as a result of the Federal Coastal Zone Management Act.
4. Indiana will soon begin an inventory of state resources to set protection priorities under the Indiana Heritage Program. Ten other states have similar programs.
5. Minnesota also has taken a critical area approach similar to that of Florida.
6. A number of states have passed flood plain and wetland protection measures.

As of late 1974, 21 states have a land use planning program under way (13). Twenty-six states have established a policy planning process that includes land use development aspects and some of the approaches are briefly listed below (14).

Alternative Futures

South Dakota has studied three alternative industrial and two farming policies for future growth. Consequences of alternative courses of action can be tested to provide information to decision makers. California has also used the approach. Utah has used economic and demographic analysis and projection to test alternative combinations and consequences of proposed development.

Identification of Significant Issues

In Kentucky the focus was on key decisions to be made within state management to achieve improved policy development. In Maryland decision makers were provided guidance in relating long-range goals to short-term actions.

Public Investment Planning to Guide Growth

California has studied development strategies to renew and maintain existing urban areas. Massachusetts has taken actions to guide capital investment in central cities. In Vermont state and local officials looked at development proposals as part of the state's overall plan to guide public investment.

In addition to the above examples, the experience in Oregon is significant. The state passed a Land Use Act in 1973, which created the Land Conservation and Development Commission to develop and adopt statewide planning goals and identify critical areas for additional study. The approach used in Oregon is significant in the way it incorporated citizen concerns and attitudes on land use planning and land development. The public was invited to 56 workshops, which were held to obtain this input. Public hearings and other workshops were held to review drafts of the statewide goals. The goals were adopted in 1974 and are currently used as guides for developing comprehensive plans by the state and local jurisdictions. A citizen involvement goal was also adopted to ensure adequate input during the plan development stage.

SURVEILLANCE AND EVALUATION

Surveillance and evaluation are distinct but closely related procedures. The objective of surveillance is the observation of characteristics of the transportation system, including its uses, and the items that may affect it. The objective of evaluation is to form judgments as to the implication of the changes noted through surveillance and determine alternative responses. The key is (a) a clearly stated state transportation or highway policy, (b) a set of objectives that implement the policy statement, and (c) criteria that can measure success of the policy.

Surveillance and evaluation activities have received increased emphasis since the nation's highway agencies have entered a period of extremely limited monetary and personnel resources. The response at the state level is found in recommendations such as in Pennsylvania for performance standards and a department report card in order to communicate the level of performance to the legislature and the public (15).

Surveillance and evaluation procedures should meet these basic objectives:

1. Provide an early-warning system to identify external trends and events that call for the review of existing policies and activities or the establishment of new policies and activities, and
2. Provide a system of accountability for agency functions and identification of what has been accomplished with public funds.

The surveillance activity should be guided by the principles of the agency's mission and the guidelines embodied in a plan or program document. The data collected should relate directly to the anticipated mission and related objectives. This implies that the plan or program is specific enough to relate to the physical effects that would accompany its development.

Evaluation takes the information obtained through surveillance, determines changes, and makes a judgment about the effect that the changes will have on the success of the agency's mission. The following are some of the typical uses of data that would be developed by the surveillance and evaluation activity:

1. Review of progress and trends in the provision of transportation services will include identification of problem areas and progress that has been made;
2. Decisions on resource allocation will be guided by the highlighting of problem areas (a comprehensive approach to determining the need for changes will help to temper demands that may be made by special interest groups);
3. Budget formulation can be enhanced by reference to the issues noted by the surveillance and evaluation process; and
4. Surveillance and evaluation would provide the types of data necessary for detailed program evaluation and analysis of future options.

The major questions management needs to answer are, Has its management been successful? and Do observed trends indicate the achievement of management's objectives? Positive responses to these questions will require that management be able to determine meaningful criteria to measure success and develop a clear understanding of what trends are worth watching.

The state highway agency's goal may be to provide fast, safe, and economical transportation. However, objectives may have been overshadowed during the attempt to achieve some intermediate goal, such as plan development, certification, or approval of an annual element or annual program. This approach has led to rather constrained perceptions of problems and an associated set of prescriptive techniques. What is lacking in these approaches has been an evaluation of management in terms of the agency's true objective. For example, the existence of an accepted plan is not the same as transportation that is actually faster, safer, or more economical than before the plan existed. Suppose, instead, certain levels of achievement could be set, such as (a) improve travel during the peak hour by 1 km/h over the next 5 years, (b) decrease highway-related deaths by 5 percent, and (c) use 7 percent less energy per kilometer of travel. After the levels of achievement are set, the participating states, cities, or counties could develop proposals that would achieve the objectives along with methods of measuring their success. Certainly, this approach could be more difficult to manage than the prescriptive approach since the methods of meeting the objectives would be more numerous; however, it would have great payoff in testing many approaches to solving a problem. Most importantly, it would deal with the actual objectives of the agency and not surrogate goals.

The work in California described earlier presents an interesting example of how a well-managed expenditure of funds can actually be more beneficial than an indiscriminate expenditure. On a dollar-for-dollar basis, the system-oriented approach provided 30 percent more benefits than did the previously used project-oriented method (3).

A surveillance and evaluation process, in general, will only be instituted at the demand of upper-level officials. Even with top-level backing, a surveillance and evaluation system may be criticized initially by those who feel the old methods are achieving desired results or that enough, or possibly too many, data are already being assembled. In the face of such criticism, advocates of surveillance and evaluation can point out that many data now being compiled do not address the impact of proposed alternative courses of action. Similarly, the increasing use of planning, programming, and budgeting systems and management by objectives constitutes a demand for regular information about agency and program effectiveness.

CONCLUDING REMARKS

Various issues must be dealt with as though they are related and not disparate and must be linked to key statewide planning products. The overriding issue in most states is that expected highway revenues will not meet expected highway needs. As a result, state transportation managers have to determine how best to preserve the transportation service improvement gains that have been made so far. Responses include jurisdictional realignment, redefinition of appropriate improvement standards, and consideration of additional sources of revenue.

The plans and programs that are now being developed out of this utilitarian ethic emphasize the possible over the desirable. Plans are more closely scaled to the funds expected over the long haul. Programs are more responsive to preservation of the existing transportation system and reflect a need to deal with project decisions in a system context.

Many states are trying to ensure early and continued input by the public and interested agencies. Typical approaches include public meetings on specific topics, advisory committees, and greater use of the media. Approaches seek to determine the true issues and desires of the state and the communities that are affected. Early involvement is critical to establishment of support for proposed programs and project development activities.

Multimodal planning and programming solutions to specific short-term problems tend to focus on particular issues and corridors in a state and to stay away from complex simulations of competing modal systems. Either-or questions are not asked as much as are questions of appropriateness of a particular modal service, either as the solution to a capacity problem within a corridor or as the response to the transportation needs of a particular segment of the public.

Energy has become a significant issue in program development. It spans modal choice and fund availability. Most of the transportation-related energy issues emphasize conservation as opposed to technological or economic substitution and thus must be keyed to a good public information program. TSM strategies seek to make optimum use of available facilities and to reduce energy consumption.

The move toward comprehensive state transportation plans has occurred at the same time as the focus has turned to statewide land use planning. Past difficulties in interrelating these two efforts have stemmed from the different levels of state control and interest in each type of planning. Also, land use and transportation activities within the same level of government are often found in widely separated departments or agencies. Active coordination in these two planning functions is critical and is receiving increased consideration.

Surveillance and evaluation are necessary management activities. Decision makers need to be aware of issues before they become crises and to measure their successes. Greater efficiency in the use of personnel and funds, as measured under performance criteria, has become the manager's goal.

In summary, state transportation agencies must focus on these issues as a part of improved overall management of the transportation planning program. The courses of action in dealing with the issues must move toward

1. Efficient management of scarce resources (energy, financial, social, community, and natural),
2. Preservation of the existing transportation system and maintenance of service improvement gains made so far,
3. Emphasis on possible rather than desirable standards and less emphasis on capital intensive improvements,
4. Focus on corridors to better analyze trade-offs between modes,
5. Better education of the public toward an energy conservation ethic,
6. Increased emphasis on land use control to protect highway utility (existing functional class and performance level),
7. Early and continued public involvement, and
8. Effective surveillance and evaluation through a clearly stated policy, a set of objectives that implement the policy statement, and criteria that can measure success of the policy.

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New Approaches in State Transportation Planning

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This paper provides a review of significant developments by various state agencies in two key areas of statewide transportation planning: (a) public involvement in plan and program development and (b) financially constrained state highway system plans. Brief synopses are presented of the statewide public involvement processes in Minnesota, Iowa, Arizona, and Louisiana and the plan development processes in Tennessee, South Dakota, California, and Texas. Some general similarities among the eight planning processes are discussed. The activities in these two areas reflect the realization that planning is an increasingly important resource. State transportation agency managers and state legislators are seeking public input on key elements of statewide planning, such as identification of issues, evaluation of policy options, and development of plans and programs. Also, managers and legislators are looking for (a) planning options that satisfy travel desires but also recognize limited financial resources and (b) methods of controlling the planning, programming, and letting schedules. The desire for public involvement is a recognition of the need for public officials to respond to transportation problems identified by the public and an attempt to involve the public in some of the complexities of the transportation program.

A series of statewide highway planning seminars was held throughout the country during 1977 and 1978. They were sponsored by the Federal Highway Administration (FHWA) in cooperation with state departments of transportation and state highway agency planners. The seminars focused on basic concepts, present procedures and problems, and significant new developments in statewide highway planning. Although the focus was on highways, intermodal relations and interagency and citizen involvement in planning were also covered.

This paper concentrates on two subject areas covered by the seminars. We believe that these topics represent significant new planning emphases: (a) public involvement in plan and program development and (b) financially constrained highway system plans. The paper describes specific examples of what a few states are doing in each area. The criteria by which the examples were chosen were (a) the availability of a fairly specific level of documented information and (b) the ability to illustrate useful and important concepts and techniques.

PUBLIC INVOLVEMENT IN PLAN AND PROGRAM DEVELOPMENT

The large body of literature on citizen involvement is mainly in regard to urban and project-level issues. The need to bring out concepts and experiences pertinent to state-level system planning and programming was a specific concern of the seminars. The concern was timely. Several noteworthy efforts have been made to obtain public input to the development of state transportation plans and programs. This section describes methods used to develop public inputs to transportation plan development in Minnesota, Iowa, and Arizona and to develop inputs to capital improvement programs in Louisiana.

Minnesota

Minnesota's new department of transportation places a strong emphasis on early and continuous public involvement in the development of the state transportation plan. The plan development process was carried out in three distinct phases: (a) Phase 1 developed the problems, issues, and concerns that will be addressed by the plan; (b) phase 2 developed alternative ways of dealing with the issues; and (c) phase 3 developed a draft and final plan.

The public input for phase 1 was gained in three ways: (a) Letters were sent to legislators, elected representatives, interest groups, and citizens; (b) public meetings were held in each regional planning district and in the metropolitan area; and (c) a brochure was prepared that requested information from the general public on transportation issues. Over 600 letters and returned brochures were received. These and statements at the regional public meetings identified over 4000 issues. These were reviewed and grouped into the 13 basic categories listed below:

1. Energy;
2. Economic development;
3. Environment;
4. Land use concerns;
5. Safety, health, and recreation;
6. Problems of the elderly, handicapped, and other transportation-disadvantaged persons;
7. Funding or financial concerns;
8. Regulations;
9. Intermodal issues;
10. Goods movement;
11. Decision-making strategies;
12. Operations and maintenance; and
13. Specific transportation projects.

The specific transportation projects covered all modes, not just highways. For example, there were specific recommendations about barge terminals, bus and commuter rail services, bikeways, and airport improvements. Recommendations were both positive and negative, and sometimes more complex than that. For instance, recommendations were made to improve route X as a four-lane expressway or as a two-lane facility, as well as some recommendations not to improve route X as a four-lane expressway.

Each of the 12 non-project-oriented areas listed above includes a wide range of specific issues. For example, in the financing and funding area, issues covered included modal or multimodal transportation funds, waterway-user charges, rail branch-line subsidies, and potential Amtrak competition with intercity buses. The details on the various areas and associated issues are covered in the published phase 1 report (1).

Phase 2 of Minnesota's process involved development and evaluation of alternative ways of handling the issues that had been identified in phase 1. Issue teams were established to develop background information and policy alternatives for each issue. These issue teams included planning staff from the Minnesota Department of Transportation as well as other interested persons.

Advisory task forces were established in each of the state's 13 planning regions to evaluate the policy alternatives developed by the issue teams and to indicate their preferred alternatives. They also identified transportation project needs and identified and ranked project selection criteria. They sponsored public meetings in each region to obtain additional inputs.

The published phase 2 report (2) documents the development of the issues. Discussion of each issue includes background data, a list of policy alternatives, the impacts of those alternatives, and a tabulation of the alternatives selected by the regional task forces. Policy alternatives selected by the regional task forces for the issue of alternative revenue sources are shown in Table 1.

The published phase 2 report did not cover all issues in detail. For those issues not covered in depth, the report provided a mailback postcard so that the reader could request the detailed material not included in the report. Phase 3 of Minnesota's plan development, now under way, is a draft and final plan. As with the earlier phases, this will provide for substantial outside involvement, including the regional task forces and a series of public meetings throughout the state.

Iowa

Iowa has 10 regional citizen advisory councils as one means for getting citizen input to transportation planning. When the state developed its first statewide transportation plan (Transplan 76), it established three statewide advisory councils, which represented private, government, and specific interest sectors. These original councils recommended establishment of regional councils to obtain more representative involvement and geographic coverage.

Membership in the councils is open to anyone interested in participation, and the latest reported membership was 950. Each council elects its own chairperson. Meetings are held bimonthly. Some examples of areas in which citizen advisory councils have provided input include the identification and ranking of critical transportation issues, review of a waterway-user charge proposal, review of various specific modal and terminal planning studies, and review of the five-year transportation improvement program.

One such review is worth mention. Comments from citizen advisory council members on a regulatory study

Table 1. Responses of the regional task forces to the question: What alternative sources of revenue (if any) should be used to fund transportation programs?

Region	Gasoline Sales Tax	General Funds	Increase Gasoline Fees	Increase Vehicle Fees	Dedicate Vehicle Sales Tax	Public Safety from General Funds	Increase Sales Tax
1	X			X	X	X	
2[a]							
3	X	X		X	X	X[b]	X[b]
4	X				X		
5	X				X	X	
6E	X				X	X	
6W					X	X	
7E	X				X	X	
7W	X				X		
8[c]			X		X	X	
9		X	X		X	X	
10	X		X	X	X	X	
11					X	X	

[a] Did not consider issue.
[b] The recommendation of the region 3 task force was divided among a number of alternative revenue sources. Most agreed that revenue from the motor vehicle sales tax should be assigned to transportation and that the department of public safety should be funded from the general fund rather than from the state trunk highway fund.
[c] The region 8 task force agreed that sales tax money generated by the sales of motor vehicles should be dedicated to transportation purposes. Members suggested that 50 percent of these receipts go to the department of public safety and the other half to the highway trust fund. Additional funds for public safety would then come from the general fund. In addition, the task force suggested that 3 cents instead of 4 cents of the gasoline tax revenue go to the federal government and that 10 cents instead of 9 cents go to the state.

indicated significant difficulties in understanding the material. Subsequent detailed review of the material by council members and Iowa Department of Transportation staff helped to develop a report that the department of transportation believes will be easier for the public to comprehend.

Although Iowa makes intensive use of its citizen advisory councils, the councils are not a substitute for more general public involvement. The state also holds informal public meetings to obtain input from the general public on its plans and transportation programs and more formal public hearings for key planning products (e.g., state rail plan).

Arizona

In the early stages of development of its first multimodal transportation plan, the Arizona Department of Transportation scheduled a series of public workshops throughout the state. The considerable preparation for these workshops began with the development of the Arizona Transportation Directions report (3), which provided background information on Arizona's transportation system and limited projections and indication of the wide range of possible future transportation directions.

To publicize the workshops, letters of invitation and copies of the Arizona Transportation Directions report (3) were mailed to government officials, interest groups, and citizens. Flyers were mailed to communities for posting in public locations, and about 1200 telephone calls were made to invite individuals to the meetings. Press releases sent to the media resulted in some 50 newspaper articles and spot announcements from about 25 radio stations. Each of the 18 communities throughout the state held workshops (Tucson held two). Altogether, about 800 people attended; average attendance at individual meetings ranged from 15 to 150.

At the start of each workshop, Arizona Department of Transportation personnel made a brief explanation of the workshop purpose, followed by a slide presentation based on the Arizona Transportation Directions report (3). Participants then broke up into small informal discussion groups of about 8-14 individuals. An Arizona Department of Transportation representative was in each group to encourage discussion on broad transportation questions. Discussions were taped, and a reporter was selected from the participants in each group. At the conclusion of the group discussions, participants convened in one large group to hear the reporters summarize the results of the discussions. Individuals were then given the opportunity to make additional comments.

The results of these workshops are given in another report (4). This report includes a list of issue areas, analysis by issue, and a proposed action on each issue. An example of the analysis and action on the issue of coordination of public transit services follows:

Coordination of public transit services was a frequently mentioned issue. Problems cited include (a) schedule connections between intercity services; (b) schedule, facility, and lack of service connections between intercity and urban services; and (c) coordination among urban services. Some stated results of these problems were long (timewise) trips, which often include long layovers, inability or inconvenience in completing trips, and inefficient use of vehicles because of many single-purpose services (e.g., elderly, handicapped, and school bus services).

The action chosen is that the Arizona Department of Transportation will, as part of its public transit planning program, coordinate with transit operators, the Arizona Corporation Commission, and users to identify and seek solutions to specific service coordination problems.

Louisiana

Recent legislation in Louisiana (Act 334 of 1974) has defined specific roles for the Louisiana Department of Transportation and Development and for the legislature in the development of the state's highway construction program. By doing so, the law has also provided an explicit and open forum for public input.

The act requires the department to evaluate needs, establish priorities, and prepare a preliminary construction program. The legislature's role under the act is carried out through its Joint Committee on Transportation, Highway, and Public Works. This committee gives the department estimates of available program funding, conducts public hearings on the proposed program in each highway district, reviews comments, recommends changes to the department, reviews the final program, prepares implementing legislation, and monitors progress in program implementation.

Prior to the hearings, the department sends advance copies of the preliminary program to each highway district; the public hearing notice advises that the document is available for public inspection. The joint legislative committee mails advance copies to each legislator. The legislative committee conducts the hearings; however, department staff are available to answer technical questions. Not only does the public have the opportunity to provide inputs, but the elected representatives also have the opportunity to appear in front of their constituents and plead their cases before the committee. An added benefit is that the committee has gained improved insights into the highway problems of the state.

FINANCIALLY CONSTRAINED HIGHWAY SYSTEM PLANS

The shortage of funds for capital improvements is one of the major realities of transportation planning today. This has led several states to appraise what they can do to improve transportation service and yet recognize the inescapable relationships among project costs, funding levels, and the size of the system for which they are responsible.

Four states have varying approaches for consideration of limited resources in their statewide plan developments. Tennessee uses a series of alternative needs studies that have variations in standards and improvement types to develop the state highway plan. The alternative plans and various financing packages provide the decision makers with planning options for their evaluation and consideration. South Dakota developed a comprehensive way, on a route basis, to appraise and report costs of alternatives in relation to funding resources. This method, although not conceptually unique, seems to have merit because of its ability to communicate, in a very understandable way, the realities of the relations among standards, length of road, and funding levels. California and Texas' financially constrained plan-development process, although reported in the literature (5, 6) is also reviewed briefly in this paper. Specific emphasis is given to the Texas management process that ties the system development policy to the program of improvement projects. Note that the material presented in the system plan development concept was used in the four states at one point in time. These approaches have been or probably will be modified in the future; however, we feel they have had tremendous influence on the development of the highway program in each state.

Tennessee

Tennessee, as a part of its state transportation planning effort, did a traditional needs study with one exception: They determined improvement costs based on three alternative 1995 systems in which scope of improvement program and standards were varied. The three alternatives were titled desirable, American Association of State Highway and Transportation Officials (AASHTO), and tolerable (7). The desirable system is based on the provision of a supplemental freeway system for the majority of the 2620 km (1625 miles) of principal arterials. The AASHTO system is based on the state's current highway design standards not supplemented by a freeway system. The tolerable system differs from the other two systems in that arterials would be improved only to the extent that they accommodate adequately an average highway speed of 88 km/h (55 mph) throughout the state. The total system costs in 1995 and the revenue deficiencies anticipated for all Tennessee highways and streets for the three alternative systems are given below.

System Alternative	Plan Cost ($000 000s)	Revenue Deficiency ($000 000s)
Desirable	13 347.0	8215.2
AASHTO	11 083.3	5951.5
Tolerable	8 906.3	3774.5

The following assumptions were made for the development of the revenue deficiencies:

1. Current highway revenue sources continue to be applied to the highway system,
2. Travel trends continue at present rate, and
3. New automobiles will achieve a 40 percent increase in fuel efficiency by 1985 over the efficiency of 1975 automobiles.

The traditional financial base for highways, fuel tax per liter, was examined for the funding packages. From an inflationary standpoint, this financial base was determined to be inadequate during periods of high inflation. A preferable tax base that is less vulnerable to inflationary pressure would be a tax on the percent of value of fuel sold.

Several funding packages were developed that are linked to the system alternative. Some sample funding proposals are illustrated below. These various alternative 1995 highway system plans and associated alternative funding packages provide options for the necessary action to address the highway program in the future (note: 1 cent/L = 3.8 cents/gal).

System Alternative	Fuel Tax Increase Only (¢/L)	Fuel Tax Increase Only (%)	Fuel Tax Plus Vehicle Registration (% + $/vehicle)
Desirable	7.45	29.7	17.8 + 75.00
AASHTO	5.40	18.2	9.5 + 55.00
Tolerable	3.42	7.1	4.3 + 7.00

South Dakota

South Dakota faced increased construction and maintenance costs, increased backlog needs, and a predicted cash-flow deficit in 1980. The state decided that the financial and functional needs picture would require public and legislative exposure if an impending crisis was to be averted. So, the state had two major objectives for its needs identification process (8) and target year improvement plan: (a) The procedure must be capable of producing output in a short period of time and (b) the procedure and output must be understandable to the public. As a result, a route-by-route analysis process was developed. The route improvement plan provides the following information:

1. An approximation of the year the level of serviceability of each segment of highway regresses to the point that some improvement is required,
2. An analysis of the alternative level of improvement that might be applicable for each project (the alternative levels of improvement considered are spartan, moderate, ultimate, and "downscoped"; to determine these alternatives, the existing conditions, geometrics, and functional classification are analyzed and evaluated),
3. An estimate of the construction cost for each alternative level of improvement being considered,
4. A tabulation of the number of kilometers and the estimated construction cost for each of the alternative levels of improvement (the information is stratified by the year in which the serviceability is anticipated to regress to an intolerable level), and

5. A financial forecast of projected revenue anticipated for the route.

Definitions of the alternative levels of improvement follow. Spartan improvement is intended to maintain the status quo of the facility by extension of the service life of the surface 8-12 years without improvement to the general geometrics. This improvement would normally include a minimum leveling course plus a 3.5-cm (1^3/$_8$-in) bituminous overlay. The cost of construction of the structures that are in poor condition and the structures that are narrower than the driving lanes will be included in this level.

Moderate improvement is intended to improve the load-carrying ability of the highway and extend the service life of the surface by 17-20 years without improvement to the general geometrics. This improvement would normally include a 2.5-cm (1-in) leveling course plus a bituminous overlay of sufficient depth and strength to allow the legal loads to be hauled year round. The cost for improving structures in poor condition will be included in this level. Also, costs will be included for widening structures that have widths less than the driving lanes on minor arterials or less than the driving lanes plus 1.22 m (4 ft) on principal arterials.

Ultimate improvement will improve the facility to current design standards. Downscoped improvement is based on designs that provide for more rolling grade lines, not surfacing the full shoulder width on previously graded projects, steepening the shoulder slopes from 6:1 to 4:1, constructing narrower shoulders on new projects, narrowing the right-of-way, and doing shoulder widening and resurfacing rather than complete reconstruction.

Figure 1. South Dakota—US-14 route analysis.

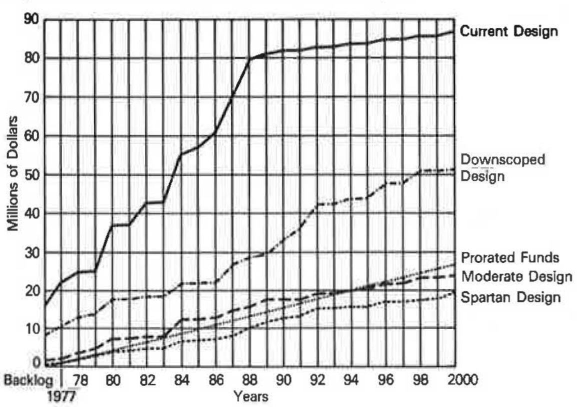

Table 2. South Dakota revenue proposals.

Funding Proposal	Revenue Shortfall ($000 000s)
Current funding	2611
Current funding + $10 million/year	2070
Current funding + $0.02 gasoline tax in 1978	2130
Current funding + $0.01 gasoline tax in 1978, 1980, 1982	1990
Current funding + 4 percent tax + $150 million bonding	1586
Current funding + 4 percent tax + $300 million bonding	1397
Current funding + $0.10 gasoline tax in 1978 + $0.02 in 1990 + $0.02 in 1995	+28[a]
Current funding + $0.02 every other year	150
19 percent of consumer price of gasoline	355
16 percent of consumer price of gasoline	991
Current funding + 4 percent sales tax on gasoline	1773

[a]This proposal generates $28 million in excess revenue.

The US-14 sample (Figure 1) demonstrates some of the output of the planning process. The financial forecast of revenue for study purposes on the route was a proration of 1977 state revenues for the federal-aid primary highway system based on the ratio of length of US-14 to the total length of state highways. The graphic plot in Figure 1 shows the various alternative levels of improvement for US-14.

Since the gap between projected revenues and projected construction costs is wide, the state decided that highway designs must be downscoped if tolerable driving conditions are to be preserved on all state trunk highway systems. The state found that even a 0.514 cent/L (2 cents/gal increase in the gasoline tax every other year for the next 20 years will not permit enough capital to consider improvements at a level greater than the downscoped design alternative.

The route studies presented the state with a picture of total state highway needs based on alternative levels of improvements. This information and a series of revenue proposals, which considered various funding alternatives, were forwarded to the state legislature. Table 2 shows some of these proposals (9) and the anticipated shortfall of revenue in the year 2000.

California

In the late 1960s, problems developed in the very successful California highway program. Some of these problems suggested an approaching crisis:

1. Increases in vehicle travel and associated congestion problems;
2. Rising costs due to inflation;
3. Repeated upgrades of design standards and expanded project scope;
4. Leveling off of revenue, including reduction in federal dollars and an effective reduction of state money as the rate of travel growth was less than the rate of inflation; and
5. Growing public concern and questioning of the impact of the highway program on neighborhoods, community development goals and objectives, and quality of the environment.

This crisis became more apparent when the total program was evaluated. Despite capital improvement expenditure in excess of $600 million/year, the highway needs were outstripping the rate of highway development. Backlog needs had increased from $2.8 billion in 1960 to nearly $10 billion in 1972 and were expected to reach $20 billion in 1980.

This problem of increasing backlogged needs was, on analysis, revealed to be the result of the existing project-by-project planning process. This process consisted of (a) identifying deficiencies, (b) developing projects to respond to deficiencies, (c) adding projects to a needs inventory, (d) beginning project development on new and 10-year needs, and (e) scheduling projects for construction as funds became available. This project-by-project approach was highly effective in the early stages of the highway program and produced an excellent highway system in the 1950s and 1960s.

Some of the weaknesses uncovered in the project-by-project planning process were its deterministic design policies, which forced the designer to plan large, expensive improvements for a deficiency; its assumption of unlimited funding; and its lack of a system orientation. As a result, a system-planning approach was developed by a consultant for the California Department of Transportation (10). The objective of the system-planning approach was the establishment of a balanced future highway system that could be funded and controlled.

A generalization of this new system approach is illustrated in Figure 2. It departs from the project approach by the addition of one step in the planning process—planning controls. The controls are basically: (a) forecasted funding limits or targets and (b) criteria for development and evaluation of project proposals to obtain a system-balanced level of service. Details of the system-planning approach, including guidelines for maximum system benefits and flow diagrams of the revenue forecasting and economic evaluation, are discussed in the literature (5, 10). However, worthy of note is that the system-planning approach provided at least 30 percent greater service than did the project approach. This is reflected in savings in operating, delay, accident, and maintenance costs.

California more recently applied the system-oriented approach to a legislatively required needs study (11). The comparison of needs by improvement type for the 1974 (project approach) report is summarized in Table 3.

There are two major differences between the two needs reports. In the 1974 report, deficiencies in the system were eliminated by construction of new facilities or reconstruction of existing facilities to full modern standards. The 1977 needs estimate contains more proposed improvements but fewer highways on new location. The 1974 estimate contained 1500 projects, compared to 6000 in the current estimate. However, the current estimate includes 480 highway proposals on new location whereas the 1500 projects in 1974 were almost all highways on new location. The 1974 needs were directed almost entirely at capacity problems. Underlying structural, safety, or operational problems added priority for highway improvements but were not usually problems for correction in themselves. The latest needs report was much more comprehensive and included various operational, environmental, and multimodal improvements.

Figure 2. California system-planning process.

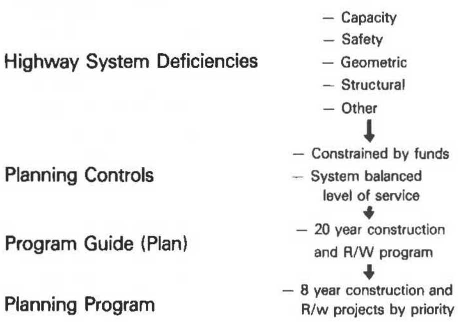

Table 3. Construction needs by program element.

Program Element	Cost ($000 000s) 1974	1977
Land and building maintenance	-	30
Bridge reconstruction	22	161
Roadway reconstruction	53	315
Highway planting restoration	-	34
Safety roadside rest area restoration	-	2
Resurfacing	-	73
Protective betterments	6	43
Safety improvements	22	397
Noise attenuation	-	381
Highway planting	-	74
Roadside rests	5	45
Vista points and roadside enhancement	-	16
Traffic operational improvements	132	621
High-occupancy vehicle facilities	11	724
Bicycle facilities	-	24
New highway construction	8295	3698
Miscellaneous	2	9
Total	8548	3647

Texas

The Texas statewide planning approach was similar to the California process, including development of revenue forecasts, identification of needs, development of design alternatives, assemblage of subsystem plans, evaluation of subsystem plans, development of the statewide highway plan, and control of the program. Public input to the subsystem plans is gathered through public hearings and meetings with local officials. Texas placed more emphasis than California did on a system to manage and control the short-range capital improvement program and increases in available revenue.

Three documents were developed to ensure that commitments, plans, and work efforts matched financial realities:

1. The system plan—a 20-year financially constrained long-term planning tool and basic control documents,
2. The letting plan—the short-range plan of projects that rank highest in priority and that can be constructed in the next 5 years, and
3. The advance letting schedule—the projects scheduled for construction in the next year.

Table 4. Documents for controlling the highway program.

Variable	System Plan	Letting Plan	Advanced Letting Schedule
Key element	Identifies most desirable system improvement projects and their scope and concept in light of funding constraints and systemwide benefits	Defines high priority projects that should proceed to letting within the next 5-year period, given the known funding constraints	Identifies specific projects that are ready and planned to be let within the next year
Purpose	Provides for a reasonably complete, functioning network that maximizes benefits to the system within finite time period and funding outlook Provides a mechanism for recording decisions and communicating intentions of the department Limits work activities to projects that are likely to be financed	Focuses work efforts on the most critical projects so that they may proceed to letting as soon as practical Prevents diversion of scarce design and planning resources to projects that cannot be constructed for many years	Provides a vehicle for managing the control of letting functions
Project activity	Location surveys and determination of right-of-way data Project design, route, and environmental studies	Plans, specifications and estimates Preparation of right-of-way data	Submission of plans for final review and approval
Time horizon (years)	20	5	1
Frequence of update	Every 4 years	Annually	Quarterly

Table 5. Application of preference criteria.

		License Fees		Motor Fuel Taxes		Sales Taxes			
Preference Criteria	Set Department of Public Safety Budget at $20 Million/Year, Not Taken from State Highway Funds	Increase Fixed Rate on Weight Basis	Adjust Basis to Change in Vehicle Value	Increase Fixed Rate of Tax per Liter	Adjust Rate on Basis of Price	Transfer Motor Vehicle Sales Tax to State Highway Funds[a]	Transfer Parts Sales Tax to State Highway Funds[b]	Special Funds[c]	Refinery Tax
Tax highway users	X	X	X	X	X	X	X		
Provide inflation protection	X		X		X	X	X		
Minimize interaction with other agencies		X	X			X	X	X	
Minimize appearance of large, abrupt tax increase	X		X		X	X	X	X	
Provide vehicle to potentially take advantage of state surplus	X					X	X	X	

Note: X = satisfies criteria.
[a]Currently based on vehicle price. [b]Currently based on price. [c]Includes revenue sharing, general fund allocation, and grants.

The schedule for updating the system plan, letting plan, and schedule is 4 years, 1 year, and 3 months, respectively. These control documents and further description are reflected in Table 4 (5).

Two system plans were prepared for the 20-year plan. The first is based on the current funding outlook and the second assumes a modest increase in long-term revenue sources. Some revenue sources that were considered and preference criteria used are shown in Table 5 (5). Four revenue packages were developed that include various combinations of revenue sources. An essential feature of each package is inflation protection. Revenue recommendations were forwarded to the governor and the legislature. The funding approved in April 1977 guarantees that the department of highways will receive a fixed sum of money that includes an inflation adjustment factor based on the highway cost factor. The funding sources are a combination of dedicated highway user revenue and general funds.

SUMMARY

Several states have mounted a serious effort to get public input to transportation plans and programs. The inputs themselves have pointed to specific issues to be addressed by the plans as well as indicating specific projects and kinds of projects that the public does and does not want. Such inputs are likely to help guide planning along a more productive path.

Activities in the states discussed reflect the following:

1. Early consideration of future financial resources in the highway planning process and use of those forecasts in planning, programming, letting, and controlling of the highway improvement programs;
2. A willingness to depart from deterministic design standards and to consider a wider range of alternatives and project improvement types;
3. An attempt to give the legislature and the public information in a simplified format;
4. A desire to provide management and legislators with optional programs and funding packages for decision-making deliberations; and
5. An effort to seek revenue sources that provide inflation protection.

The eight state planning processes reviewed indicate some variation in approach, yet they also offer some consistency. The variation is not unexpected because each planning program is directed to respond to specific conditions in the particular state. Threads of consistency are generally visible in each process. First is the focus toward the development of a short-range capital improvement program for improving transportation service. This program, which has an annual letting or budget, serves as the end product of the statewide transportation planning phase of the transportation improvement process. Next is the strong interest shown in financing—this interest is in either building a case for additional funds or in making maximum use of the financial resources currently available. Last, and probably most important, is the interaction of state legislators and the public regarding issues, policies, and programs.

In addition to those consistencies, each statewide planning program appears to follow a broad, overall planning process. The key sequential activities of these statewide transportation planning processes are as follows:

1. Policy development—problem and issue identification, issue analysis, alternative policy investigation, and policy selection and action; and
2. Plan and program development—transportation service deficiency identification, planning controls for deficiency analysis (guidelines for service improvements and financial constraints), target-year transportation plan, priority determination (including social, economic, and environmental analysis) and short-range program and contract letting schedule.

These steps were not always visible in the eight planning processes reviewed. Again, this depends on the state and the nature of the problem in the state. For example, those states that have new departments of transportation (Minnesota, Iowa, and Arizona), because of legislative or management emphasis, have concentrated efforts in the policy development areas. In some instances activities were conducted concurrently (e.g., in Minnesota issue identification and transportation service deficiency were discussed in the same regional meetings). Also, in general, the public involvement was greater in the policy and priority-program development activities and less in the technical areas of plan development.

CONCLUSION

As a result of emphasis on public involvement and limited financial resources, planning is becoming an important resource for management. In many states, management actively seeks public input on key elements of statewide planning, such as identification of issues, evaluation of policy options, and the development of transportation plans and programs. Also, because securing public funds is increasingly difficult, long-range plans are being financially constrained, and improvements that maximize the use of the existing system are being developed. Management also has a keen interest that planning efforts be focused toward program development and that central documents be developed that firmly link together financial resources with plans, programs, and letting schedules.

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Resort Transportation Improvements: Case of Little Cottonwood Canyon, Utah

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The objective of this study was to adopt a practical methodology for short-range transportation improvements that are fully responsive to the typical problem of recreational resources near an urban area. The methodology was applied to alleviate the transportation and related problems of ski resorts of Little Cottonwood Canyon of Utah. Specific evaluation data related to the canyon; however, the breadth of the system considered, the parameters developed, and the decision-making process suggested were structured so that the concept could be adopted as a consistent planning tool to resolve problems in similar recreation resorts. Emphasis was placed on simplicity and practicality of the developed methodology as well as on maximum accessibility and minimum negative environmental impacts. A specific park-and-ride bus transit system has been recommended for the study resort on the basis of economic factors and community responses. Application of the suggested methodology stressed intangible factors as well as strictly monetary factors.

The demand for leisure activities has caused serious transportation and related environmental problems at many recreation resorts. Obviously, the traditional dependence in the United States on private vehicles for recreation access has been a major contributor to these problems. Due to the recent energy shortage and high road construction cost, we must concentrate on more than just improvements to the existing highway system. In order to maintain a high level of recreational participation and enjoyment and also attain broader local and national goals (energy conservation, environmental improvements, equity for transit dependents, and preservation of natural aesthetics), transportation and recreation planners must now investigate a wide range of innovative transit systems to improve the accessibility of recreational resources.

As an example, Little Cottonwood Canyon, southeast of Salt Lake City, Utah, is the setting for excellent skiing activities. Its proximity to the major transportation facilities of the Salt Lake Metropolitan Area (SLMA) affords this canyon an opportunity to be a major ski resort complex on a local and national basis. In recognition of this potential, private developers have independently undertaken the construction of major resort facilities at the canyon. However, development of ski resorts (Alta and Snowbird) in the canyon has progressed with little coordination or consideration of existing transportation facilities. The only access road to the canyon (UT-210) is a narrow, winding, two-lane highway, which traverses rather steep grades over most of its length. The yearly increase in the number of private automobiles that use the access road often exceeds the road design capacity, and thus restricts the road in efficient and safe handling of traffic. Furthermore, the transportation problem is intensified by a shortage of parking space and the extreme peaks of weekend visitors.

In addition to the problems that traffic volumes create for highway users, they also have serious negative environmental impact on the canyon. The vehicles that use the canyon road produce air, noise, and water pollution. Specifically, water pollution may render the canyon water unsuitable for traditional water treatment in the near future; the canyon now provides approximately one-fifth of the water supply for the SLMA (1).

STUDY OBJECTIVE AND SCOPE

The basic objective of this study was to use a developed methodology to solve existing and potential transportation and related problems of Little Cottonwood Canyon. The methodological framework for this resort transportation improvement study was intended to be applicable, in general, to public decisions constrained by financial, social, economic, political, and environmental factors and situations in which the decision has to stress intangible, not strictly monetary, factors. Therefore, the study of Little Cottonwood Canyon was designed to be a prototype for development of a consistent planning tool to be used in resolution of problems in similar recreation resorts.

A bus system can be implemented quickly and without major capital investment, and thus can serve as an immediate alternative; therefore, determination was made as to the acceptability of a park-and-ride bus transit system. Economic factors and community responses were considered in this study. Such a transit system would improve canyon accessibility and also maintain environmental quality and conserve fuel energy and natural aesthetic qualities. The selection of transportation improvement alternatives required a clear understanding of the attitudes of all interested parties.

METHOD OF APPROACH

The following general procedure was employed in this study:

1. Establishment of goals and objectives—Great emphasis was placed on the establishment of transportation goals and objectives that adequately represent the values of the community. Only through the use of representative goals and objectives can a transportation plan be developed to successfully meet the needs of the community.
2. Inventory of bus transit potential—A procedure was developed to analyze the existing transportation characteristics and to determine travel demands, both for now and for the future. Included were preferred mode of travel and time of travel. Maximum use was made of existing data sources.
3. Analysis of desires and definition of potential service—Estimates were made of quantity and location of existing and future travel desires that might be attracted to the proposed bus transit system for different levels of service. Also, from the inventory data and subsequent analyses, current and future travel desires were ranked in order of ability to be served by bus transit.
4. Formulation and evaluation of alternative bus system—Based on the analysis of service potentials, several alternative bus transit concepts were delineated. Each alternative concept was critiqued as to general benefit/cost and community response in terms of economic benefit, level of service, environmental impact, financial considerations, and political acceptability.
5. Selection of an alternative for implementation—The final determination of an alternative bus system was based on the recommendations and analyses previously completed.

In this study, benefit/cost analysis and a rating scheme were applied to assist the decision-making body in identification of a preferred choice from all possible alternatives. The suggested methodology is considered a practical way to assess the desirability of alternatives by which the enumeration and evaluation of total cost-effectiveness are implied.

Establishment of Goals and Objectives

The goals of this study can be expressed in terms of how well the transportation facilities meet the travel demands and the environmental quality standards and also which of the alternative systems that is capable of servicing the demand does so at the least annual transportation costs. The goals of transportation agencies may at some points be in conflict with the goals of certain nonusers, whose goals are not met or ill served by the transportation improvement.

Specification of Relevant Alternatives

Seven different alternatives were considered:

1. Exclusive use of large buses (40 passengers) that originate from five park-and-ride terminals at specified locations in the SLMA and terminate in the ski resorts of the canyon,
2. Exclusive use of large buses that originate in the mouth of the canyon and terminate in the ski resorts (a large park-and-ride facility will be provided at the mouth of the canyon),
3. Exclusive use of small shuttle buses (14 passengers) that originate in the five park-and-ride facilities in the SLMA and terminate in the ski resorts,
4. Exclusive use of small shuttle buses that originate from the mouth of the canyon and terminate in the ski resorts (a large park-and-ride terminal will be needed at the mouth of the canyon),
5. Combined use of small shuttle buses and large buses in such a way that both vehicles will originate from the five designated park-and-ride facilities in the SLMA and terminate in the ski resorts (in this system large buses will be used during the peak demand periods, and small shuttle buses will be used primarily during the off-peak periods),
6. Combined use of small shuttle buses and large buses in such a way that both vehicles will be used for transport service between the mouth of the canyon and the ski resorts based on the demand fluctuation, and
7. Use of the current system (do-nothing alternative) (this alternative is considered for comparison).

Both small and large buses must be specially designed to provide ample space for carrying ski equipment. Alternatives 1, 3, and 5 require five park-and-ride facilities to be built at selected locations in the SLMA. The locations of these terminals were selected on the basis of population density, availability and cost of land, and equity of accessible service to all users in the SLMA. After visitors have parked their automobiles in these parking facilities, they will be carried by bus to the canyon ski resorts and back. For all proposed alternative bus systems, the area of ski resorts is assumed to be an automobile-restricted zone; however, canyon residents, road maintenance crews, and service personnel are allowed to drive to and from the canyon at all times.

COST ESTIMATION

The costs considered in this study are the direct costs of the transportation facilities and equipment plus the indirect costs of the transportation systems. The direct costs of the current automobile system include the cost of the parking facilities, the cost to operate and park automobiles, and the cost to improve and maintain the roadway. The direct costs of the bus system are the capital, operating, and maintenance costs of bus equipment; the cost to improve and maintain the road traversed; and the cost to build and maintain park-and-ride facilities. Indirect cost factors are limited to travel time costs and accident costs, due to lack of data on others. For dual-mode trips (automobile and bus), costs are calculated according to an approximation of the length of travel by each mode. Inflation was not considered in this analysis, since the rate would be the same for all of the proposed alternative systems and thus would not affect the comparative results. An interest rate of 10 percent/year was used in the economic cost analysis of this study.

ENUMERATION OF BENEFITS

Most benefits (such as the environmental and economic impacts) are subjective in nature, and an estimation of them in measurable terms is often difficult. In this study, the user benefits of a given transportation improvement were expressed in terms of engineering economy, including savings in user's travel time, vehicle operating and maintenance costs, accident costs, and road maintenance costs. All nonuser benefits were considered in the decision-making process through a rating scheme.

DEVELOPMENT OF EVALUATION AND DECISION PROCESS

The evaluation and decision made use of the rating method combined with benefit/cost analysis to rank different alternatives. This was proposed because many project effects are not easily measured in comparable units. Consequently, a productive approach is to organize project impacts according to those factors that can be evaluated in dollar terms to be included in benefit/cost analysis and those nonqualitative community impacts to be incorporated into the rating procedure. The overall procedures are briefly outlined as follows.

First Step—Determining Benefit/Cost Ratio

The benefit/cost ratio method expresses the ratio of equivalent uniform annual benefits (or their current worth) to the equivalent uniform annual costs (or their current worth). In most highway benefit/cost analyses, the costs and the benefits are expressed on an annual basis. Any alternative that has a benefit/cost ratio greater than 1.0 is assumed to be economically feasible. This part of the analysis is limited to tangible factors only.

The following equation illustrates the general form of the benefit/cost ratio used in this analysis:

$$B/C = [-(U_P - U_B) - (K_P - K_B)] \div -(I_P - I_B)(CR,i,n) + (T_P - T_B)(SF,i,n) \quad (1)$$

where

U = uniform annual road-user costs, exclusive of road-user taxes but inclusive of travel time value and accident costs when so designated;

K = total uniform annual expense of administration, traffic services, highway operations, and highway maintenance;

I = construction investment at time 0 or at any time subsequent to time 0, or the equivalent present worth of all investments;

T = terminal value at the end of the analysis period (in most analyses for economic evaluation and for project formulation, the terminal value may be assumed to be 0);

B = the base alternative (the existing situation or defender);

P = the proposed alternative (the challenger);

(CR, i, n) = capital recovery factor; and

(SF, i, n) = sinking fund factor.

Equation 1 uses the concept of cash-flow diagrams, wherein cost of investments and annual expenses of highway maintenance or road-user expenses are negative and the flows of income or benefits are positive.

The benefit/cost ratio ordinarily will be negative because the numerator (benefits) usually will be positive and the denominator (costs) will be negative; when the numerator is positive, a positive sign will be affixed to the benefit/cost ratio; when the numerator is negative, the net benefits are negative and the alternative should not be considered further.

The different parameters in the benefit/cost ratio for this study are

1. U_B (present system in terms of annual costs) + costs to operate and park the automobiles + travel time costs + accident costs,
2. U_P (proposed system in terms of annual costs) = bus fare cost + road maintenance costs + park-and-ride terminal access costs,
3. K_B (present system in terms of annual expenses) = road operation costs + road maintenance costs,
4. K_P (proposed system in terms of annual costs) = road operation costs + road maintenance costs + bus facilities operating expenses + bus facilities maintenance expenses,
5. I_B (present system) = sunk cost that has already been invested in the road facility and has no relevance to the future, and since it is the same for all of the alternatives, there is no need to consider it in the analysis,
6. I_P (proposed system) = capital costs of the buses + costs of building park-and-ride facilities,
7. (CR, i, n) = (CR, 10%, 5 years), and
8. $(T_P - T_B)$ is assumed 0.

Second Step—Assigning Weights to Alternative Effects

A simple procedure to establish the relative importance of categories in the intangible factors (with and without benefit/cost ratio derived from the tangible factors) is to allocate 100 points to each member of an advisory group that represents all community sectors and citizen groups. Each member is asked to assign these points in accordance with personal perception. After all members have voted for their interests, the points are averaged. The results of average points for all alternatives would be the weights that represent the collective preferences of all parties involved.

Third Step—Rating Alternative Effects

Since intangible factors cannot be put in a common unit such as the dollar, a relative scale must be established for rating the merits of alternative transportation plans. A scale of -3 to +3 is used to indicate the estimated magnitude of alternative effects. Using the current system as a base for comparison, the positive value of the scale reflects favorable effects, whereas the negative value means unfavorable effects. All concerned effects are assigned a large, medium, small, or negligible rating for each alternative plan. The values that correspond to the general ratings are multiplied by the weights for the concerned effects, and a total is then assigned to each alternative. After all alternatives are subjected to this procedure, they are ranked based on their total scores. The alternative that has the highest score in the final analysis is chosen to alleviate the canyon transportation problems (2).

DATA COLLECTION AND PROJECTION

As indicated earlier, this study was concerned with an immediate action program of transportation improvements in the canyon. A two-year time lapse (1978-1980) was assumed before the implementation date. Analysis data were obtained from various published sources or through interviews with related agencies. Due to space limitation, this paper avoids a lengthy discussion of data collection and projection procedures involved in this study. The reader may refer to the full project report for further information (3). Only the following specific facts are presented briefly:

1. Automobile data—A previous study indicates that the average vehicle occupancy of canyon traffic is 2.7 persons/vehicle. The heavy traffic volumes and concentration of the daily and hourly peaks normally occur in the winter months (19 percent of the 30 highest peak hours occurred in January and February). The morning peak hours (9:00-11:00 a.m.) and the evening peak hours (4:00-6:00 p.m.) for the weekends carry, respectively, 60 and 40 percent of traffic during that period (4).
2. Small shuttle bus data—The capital cost of a shuttle bus was estimated to be $19 000. The operation and maintenance costs per bus were estimated to be about $1.30/km ($0.80/mile). The average speed of small shuttle buses in both directions between five park-and-ride terminals in the SLMA and the mouth of the canyon was predicted to be approximately 70 km/h (45 mph). The average speed of small shuttle buses in both directions between the mouth of the canyon and the canyon ski resorts was assumed to be 40 km/h (25 mph).
3. Large bus data—The capital cost of a large bus was estimated to be $80 000. The operation and maintenance costs per large bus were estimated to be about $2.60/km ($1.60/mile) for the canyon road conditions. The average speed of large buses in both directions between five park-and-ride terminals in the SLMA and the mouth of the canyon was taken to be approximately 65 km/h (40 mph). The average speed of large buses from the mouth of the canyon to the ski resorts was estimated to be approximately 35 km/h (20 mph).
4. Parking data—Based on the available data, the parking operation and maintenance costs at the ski resorts were taken to be about $250/space in 1980. The total cost of building park-and-ride facilities at the selected SLMA locations is estimated to be about $1 800 000 in 1980. Also, a park-and-ride facility at the mouth of the canyon would cost approximately $2 200 000 in the same year.
5. Road and bus use cost data—It was assumed that the road operation and maintenance costs would be the same for all different alternative systems. There are basically two reasons for such an assumption: (a) a lack of accurate data to specify the cost for each system and (b) although the road operation and maintenance costs seem to be higher for the heavier vehicles like buses, the less frequent use of the road by these vehicles (due to a larger passenger capacity) tends to offset the additional cost. Regardless of small or larger buses in use, $2.00/person from the park-and-ride terminals in the SLMA to the ski resorts and back was assumed, whereas a fare of $1.00/person from the mouth of the canyon to the ski resorts and back was used.
6. Estimated travel demand data—Statistics show that the increase in traffic on the canyon access road has been a function of recreational and lodging facilities at the ski resorts. The current total lift capacity is approximately 6000 skiers/h and the total lodging available is about 650 rental units. Approximately 20 percent of vehicles surveyed were out-of-state vehicles (4). Based on all available historical data and estimated increase in ski facilities in the future, a traffic projection was made for 1977-1982. The average daily traffic during this period was found to follow a leveling-off trend, as depicted by the dotted line in Figure 1. This future trend would be largely brought about by limitations in the skiing space and the ski lifts to be available.
7. Weighting survey data—The goal and objective priorities used in the evaluation analysis were measured by 14 questionnaires, which were sent to all interested parties, including the Utah Department of Transportation, Salt Lake County Planning Commission, Alta Planning Commission, Ski Developers, and skiers. Only 8 questionnaires were completed and returned. The percentage of the total used to reflect trends was based on the returned questionnaires.

EVALUATION OF ALTERNATIVE SYSTEMS

Based on a 12-h daily operation, the average number

Figure 1. Average daily traffic projection of canyon access road.

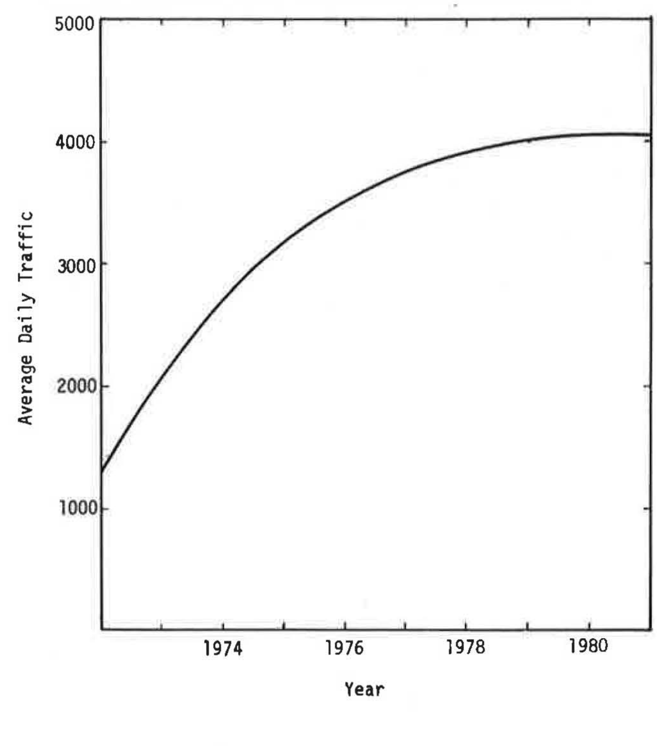

Table 1. Proposed alternative bus systems characteristics.

Type of Vehicles	Number of Buses	Operational Headway (min) Between SLMA Terminals and Resorts	Between Canyon Mouth Terminal and Resorts
Large buses (40 passengers)	11	15	10
Small shuttle buses (14 passengers)	32	3.5	3
Mix of large and small buses			
Large buses	5	35	25
Small shuttle buses	18	6.5	4.5

Table 2. Overall score of alternative bus systems.

Effects	Alternative 1	2	3	4	5	6
Cost/benefit	46	92	92	138	46	138
Natural resources and quality of environment	31	31	93	93	62	62
Economic impacts	0	23	23	23	23	23
Total	77	146	208	254	131	223

Note: Score = weight x rating.

of buses and headways required to fulfill the need of proposed alternative systems for the years 1978-1980 are given in Table 1.

The value of the benefit/cost ratio for each one of the proposed alternative systems was calculated using Equation 1 with $(T_P - T_B) = 0$. The results are given below.

Bus System Alternative	Benefit/Cost Ratio
Exclusive use of large buses between five SLMA terminals and ski resorts	1.20
Exclusive use of large buses between canyon mouth terminal and ski resorts	1.65
Exclusive use of small shuttle buses between five SLMA terminals and ski resorts	1.45
Exclusive use of small shuttle buses between canyon mouth terminal and ski resorts	1.91
Mixed use of large and small shuttle buses between five SLMA terminals and ski resorts	1.36
Mixed use of large and small shuttle buses between canyon mouth terminal and ski resorts	1.77

Responses to survey questions regarding possible transportation-related changes revealed clear public preferences for selected future transportation policies. The benefit/cost analyses combined with the weighting survey have produced the final overall score for each alternative system. The tables below give the results of the conducted weighting survey.

Respondent	Environmental Quality	Economic Impact
1	70	30
2	40	60
3	50	50
4	70	30
5	65	35
6	85	15
7	60	40
8	25	75
Average	58	42

Respondent	Intangible Factors—Environmental Quality and Economic Impacts	Tangible Factors—Elimination of Traffic Congestion and Parking Problems
1	60	40
2	30	70
3	40	60
4	70	30
5	85	15
6	60	40
7	40	60
8	50	50
Average	54	46

The survey results indicate that 58 percent of the respondents rate the effects of improved transportation on the environment to be more important than the economic impact on the community. Also 54 percent thought that the intangible factors are more important than the tangible factors. A linear utility function was assumed for simplicity in this study so that the scales of rating project effects are employed in the following manner. For the tangible effects, the benefit/cost results from 1.20 to 1.40 in value are assigned a scale of +1; those from 1.40 to 1.70, a scale of +2; and those from 1.70 to 2.00, a scale of +3. Each alternative system was assigned a scale based on a subjective evaluation of the adverse intangible effects produced by that system relative to the other systems. The overall evaluation of the results is tabulated for all of the proposed alternative systems in Table 2. From the final scores, the most favorable alternative would be alternative 4, which is exclusive use of small shuttle buses between the mouth of the canyon and the canyon ski resorts. The second and third best are alternatives 6 and 3, respectively. Each of these three alternatives has a score above 200 and is superior to the other alternatives (1, 2, and 5). Although alternative 4 has the highest score, alternatives 6 and 3 are quite comparable and should not be completely precluded for consideration (if for one reason or another alternative 4 cannot be implemented). The score is an arbitrary rating of such alternatives, but the rating result allows some objectivity in comparison of alternatives. Decision makers may use the rating for guidance but ultimately will remain responsible for their decision.

CONCLUSIONS

The purpose of this study was to adopt a practical methodology for short-range transportation improvement that is fully responsive to the typical problems of recreational resources. The methodology was tested by using the case of Little Cottonwood Canyon of Utah. The breadth of the system considered, the parameters developed, and the evaluation and decision-making process were structured so that the material can be used in similar recreation resorts. Emphasis was placed on simplicity and practicality of the methodology, maximum accessibility, and minimum negative environmental impacts.

In order to alleviate transportation problems and protect environmental qualities, this study suggests that a park-and-ride bus transit system, directed toward low-capital-cost improvement as an immediate-action program, would be feasible for the canyon service. Comparison of several alternative bus transit operations shows that private vehicles should logically be replaced by public transit in response to increased ski demand and environmental degradation in the ski season. The comparative analysis included consideration of level of transport service capacity, capital and operating costs, and essential nontransport impacts. All interested parties were consulted to determine the desirability of proposed alternatives. The alternatives were compared by adding the individual ranking for a score through the suggested procedure. The exclusive use of small shuttle buses to provide transportation service between the mouth of the canyon and the ski resorts was found to be relatively more attractive on the basis of economic factors and community responses.

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Impact of Population and Energy on Transportation Needs: Multimodal Approach

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This paper documents a computer process developed to explore the potential diversion of automobile trips by purpose and length for various population growths and energy futures and the impact this diversion will have on transportation needs. The technique is a straightforward method of using the existing statewide transportation model to generate statewide highway trip tables for each possible future. These tables are split by trip purpose based on analysis of actual statewide origin-destination data and then split into modes based on trip purpose and length information gained in the survey of air, rail, and bus travel characteristics. Information on the modal split in other mass transit corridors in the United States is also used as a guide. The variables in this process are easily understood and thus may be quickly adjusted to reevaluate transportation needs and to reflect various planning policies. Once the modal trip tables are generated, they are assigned to a statewide air, rail, or bus network based on station accessibility; the remaining trips are assigned to the highway network. The end product is a computer plot that shows the potential travel volumes by mode and the probable impact of each population growth and energy future on state highway needs. This technique is being applied in rural portions of 13 of Michigan's 14 planning regions.

Determination of which highway construction projects are necessary and establishment of priorities requires analysis of numerous alternatives. Since planners must be aware of potential changes in social and economic conditions, a process of measuring the impact of these changes on travel patterns and demands must be developed to identify critical deficiencies and to evaluate various construction programs.

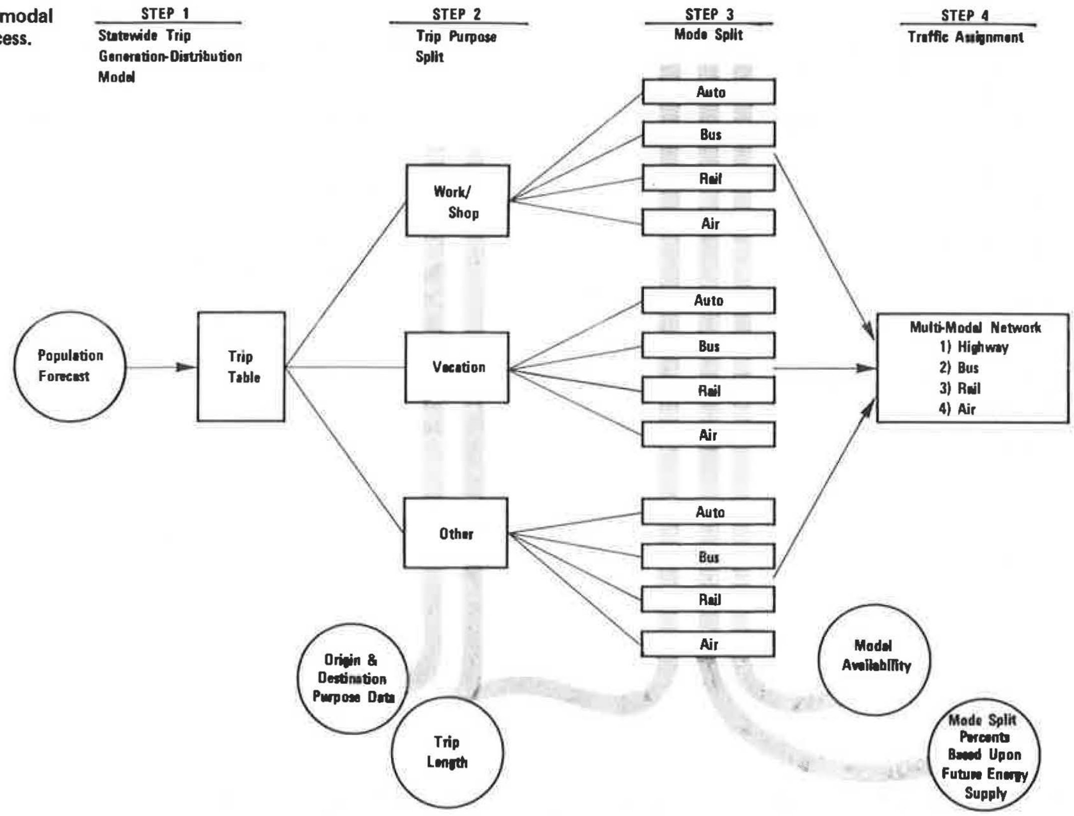
Recent federal legislation, increased public involvement, and changes in social and economic problems have created many new issues that must be resolved by transportation agencies. The Federal-Aid Highway Program Manual (1) states, "It is the FHWA's [Federal Highway Administration's] policy that... appropriate consideration be given to reasonable alternatives, including the alternative of not building the project and alternative modes." It further states that an action plan should identify procedures to be followed to ensure that "... alternatives containing new transportation modes or improvements to existing modes are adequately considered, where appropriate."

Many alternate transportation modes suffer due to population dispersion and erratic public response; but recent public emphasis on energy conservation may cause future travel patterns and demands to change. Consequently, in order to forecast future transportation needs, a transportation planner must be able to estimate population growth rates and identify major areas of change. It has, therefore, become imperative for transportation agencies to consider the effects and interaction of at least three major influences on travel patterns:

1. The related effects of energy availability and cost,
2. The increased emphasis on alternative modes, and
3. A growing and potentially shifting population.

The problem of defining future transportation needs

Figure 1. Multimodal assignment process.



and deficiencies is further complicated by the interaction between energy costs, population shifts and growth, and the accessibility of alternative modes. Until recently, addressing all of these issues and their resulting impact on travel effectively has been difficult. Now, Michigan's Bureau of Transportation Planning has developed a process that combines origin and destination information and existing statewide traffic forecasting model tools to measure these impacts and to aid in a number of different planning activities.

The various steps that are performed by this new multimodal process are shown in Figure 1. The analysis begins with future highway trip tables produced by the existing statewide transportation modeling system for selected projected populations. The trip length and the purpose data derived from approximately 70 actual origin and destination studies are then used to divide the trip tables by purpose. A summary for the northwest region (region 10) follows:

Trip Purpose	Average Trip Length (min)	Total Trips (%)
Work	31	36
Personal business	29	8
Shopping	23	20
Vacation	92	7
Social-recreational	31	19
Other	26	10

The trip purpose tables are then divided by mode, using statewide and national mode split information and additional bus, rail, and air origin and destination data. Modal split data from the northeast corridor of the United States were also used as reference material. These mode split percentages vary to reflect expected modal usages for each selected future energy condition. The modal split process is selective in that trip purpose and length and modal accessibility are determined before any trip is assigned to a particular mode. Therefore, the resulting link volumes display the sensitivity of different types of trips to any given energy condition as reflected through various modal splits and the related impact on highway deficiencies under differing transportation plans.

TOTAL TRIP TABLE GENERATION

The state of Michigan and contiguous areas outside of the state are divided into 547 zones. Zone sizes and boundaries were determined on the basis of population, land area, and political boundaries.

The initial total trip table is generated by the existing statewide transportation modeling system and simulates future travel between these 547 zones. Zonal population forecasts are used to develop this table. In this report, the generated total trip tables represent a year 2000 forecast. Three different population forecasts are used to simulate travel for high-, medium-, or low-growth futures. Although these trip tables are derived from highway-oriented data, they are assumed to represent all travel generated by all modes because the current bus, train, and air data reveal that these modes contribute only a very small percentage of total intercity passenger travel in Michigan.

Division of Total Trip Table by Trip Purpose

The objective of this process was to explore the potential diversion to other modes of various automobile trip purposes for various futures and the impact the diversion would have on transportation needs and deficiencies. A common concern expressed is that certain trips, like vacation trips, will not be good candidates for public transportation. However, other trips, like work trips, because of generally low vehicle occupancy and short travel distance, could become potential transit trips.

Table 1. Estimated modal split by trip length, trip purpose, and energy future.

Energy Future	Trip Purpose	Travel Reduction (%)	Mode	Trip Length (min)[a]					
				0-30	31-60	61-90	91-120	121-300	300+
Abundant	Work	0	Automobile	99.9	99.6	98.6	97.0	94.6	88.8
			Bus	0.1	0.2	0.6	1.0	2.0	2.0
			Rail	0.0	0.2	0.8	2.0	2.0	2.0
			Air	0.0	0.0	0.0	0.0	1.4	7.2
	Vacation	0	Automobile	99.9	99.6	98.6	97.0	96.2	90.1
			Bus	0.1	0.2	0.6	1.0	2.0	2.0
			Rail	0.0	0.2	0.8	2.0	1.0	1.5
			Air	0.0	0.0	0.0	0.0	1.0	6.4
	Other	0	Automobile	99.9	99.6	98.6	97.0	94.7	88.7
			Bus	0.1	0.2	0.6	1.0	2.0	2.0
			Rail	0.0	0.2	0.8	2.0	2.5	2.5
			Air	0.0	0.0	0.0	0.0	0.8	6.8
Conserved	Work	0	Automobile	93.0[b]	93.0[c]	97.0	94.0	91.0	84.0
			Bus	5.0	2.0	1.0	2.0	4.0	4.0
			Rail	0.0	0.0	2.0	4.0	4.0	4.0
			Air	0.0	0.0	0.0	0.0	1.0	8.0
	Vacation	5	Automobile	100.0	99.0	97.0	96.0	93.0	87.0
			Bus	0.0	1.0	1.0	2.0	4.0	4.0
			Rail	0.0	0.0	2.0	2.0	2.0	2.0
			Air	0.0	0.0	0.0	0.0	1.0	7.0
	Other	5	Automobile	95.0	99.0	97.0	93.0	90.0	84.0
			Bus	5.0	1.0	1.0	3.0	4.0	4.0
			Rail	0.0	0.0	2.0	4.0	5.0	5.0
			Air	0.0	0.0	0.0	0.0	1.0	7.0
Restricted	Work	0	Automobile	85.0[c]	84.0[d]	97.0	93.0	87.0	81.0
			Bus	10.0	5.0	1.0	3.0	5.0	5.0
			Rail	0.0	1.0	2.0	4.0	7.0	7.0
			Air	0.0	0.0	0.0	0.0	1.0	7.0
	Vacation	20	Automobile	100.0	98.0	97.0	94.0	90.0	84.0
			Bus	0.0	1.0	1.0	3.0	4.0	4.0
			Rail	0.0	1.0	2.0	3.0	5.0	6.0
			Air	0.0	0.0	0.0	0.0	1.0	6.0
	Other	20	Automobile	90.0	95.0	97.0	91.0	85.0	78.0
			Bus	10.0	4.0	1.0	4.0	6.0	6.0
			Rail	0.0	1.0	2.0	5.0	8.0	10.0
			Air	0.0	0.0	0.0	0.0	1.0	6.0

[a] Based on approximate automobile driving time.
[b] Includes 2 percent shift to carpools.
[c] Includes 5 percent shift to carpools.
[d] Includes 10 percent shift to carpools.

The previous statewide transportation modeling system generated only total travel and could not be used to assess potential diversion from the automobile by purpose. Therefore, additional information about actual trip purpose and length was obtained from various origin and destination surveys. Analysis of the major and minor origin and destination surveys was subsequently performed for all terminal trips and the results were evaluated by the northwest regional planning team. Trip purposes were summarized into three typical categories: work, vacation, and other. Driving time was used as a measure to group the trip length categories. The final derived percentages by some of the categories are as follows:

Trip Length	Work (%)	Vacation (%)	Other (%)
0-30 min	60	0	40
61-120 min	59	7	34
181-240 min	50	21	29
300+ min	35	40	25
All travel	60	2	38

Vacation trips represent only 2 percent of the total travel. Normally, this would not warrant a separate trip purpose for analysis. But in Michigan vacation travel is significant on many roads because of the trip length. Therefore, vacation trips were considered separately. Also, vacation travel may account for 30-40 percent of the trips generated from the heavily populated Chicago zones destined for Detroit zones. Vacation trip percentages increase as the trip length increases, and work trip percentages decrease as the trip length increases. This relation between a trip's purpose and length is an important travel characteristic and was considered in the development of the statewide modal split percentages used in the analysis process.

The present statewide model uses average daily traffic (ADT) volumes in travel impact analysis. The multimodal analysis process developed in Michigan uses person trips; therefore, vehicle trips were converted to person trips by use of average vehicle occupancy rates for the various trip purposes, which were obtained from actual origin and destination data. Occupancy figures averaged 1.61 for work trips, 3.15 for vacation trips, and 2.19 for all other trips surveyed in Michigan.

Modal Split of Trip Purpose Trip Tables

The process described is intended to show a simulated traffic assignment by mode for selected population and energy futures. Once a total trip table is divided into the various trip purposes for a selected population projection, it then becomes necessary to analyze potential modal use by trip purpose and length. The traffic mode split must also be dependent on the energy future being considered. Probable modal split percentages were derived for abundant-, conserved-, and restricted-energy futures. The mode split for the abundant-energy future favors automobile travel; the restricted- and conserved-energy futures show an increased use of other transportation modes. Table 1 shows the modal split percentages by energy future that were used for the northwest regional study (2). The figures are intended to represent estimates of the possible modal selections derived after examination of national, state, and Northeast Corridor modal data and experiences and are not based on an extensive modal split model. Although several energy and transportation related studies have been conducted, there is not a consensus of opinion about the probable use of alternative transportation modes in an energy-deficient future. Trips assigned to alternative transportation modes based on the modal split percentages were further examined to determine the feasibility of that mode. If the access and egress time to the other mode was excessive in comparison to total automobile travel time, the trip was returned to the automobile trip table. Access and egress time includes a 20-min wait period at both origin and destination stations. This eliminates short-distance trips. Thus, a computer process was developed that would be flexible enough to assume any desired modal split assumption. Experience indicates that use of three energy futures; three population growth futures; modal accessibility measures; and the trip purpose, trip length, and vehicle occupancy data provide the desired flexibility and sensitivity. A few observations about Table 1 follow.

Abundant-Energy Modal Split Percentages

Since this energy future is expected to simulate present travel habits, some modal split data are available. A 1972 National Travel Survey (3) for passenger travel and a 1975 General Aviation Activity Survey (4) for trips over 160 km (100 miles) in length were used to obtain some of the modal split percentages. Information on trips shorter than 160 km in length was not readily available, so a modal split percentage that reflects a dominance of automobile travel was selected for these trips. Air and rail modes did not warrant consideration for the shorter trips regardless of purpose, and the percentage of trips to be diverted to bus was based on present travel patterns.

Conserved-Energy Modal Split Percentages

The basic strategy used to develop modal split tables for the conserved- and restricted-energy futures focuses attention on the short-distance work trip. This trip is considered the most likely candidate for transit use in an energy-short future. For the conserved-energy future, 5 percent of the automobile trips were diverted to bus. This 5 percent applies only to the 0- to 30-min work trip. Because carpooling is likely to increase as energy costs rise, the short work trips for the conserved- and restricted-energy futures decrease by 2-5 percent. The respective modal split percentages are fairly consistent with those for the abundant-energy table for the other trip-length categories.

The vacation trip is not considered a potential transit trip because of its high vehicle occupancy. Therefore, the automobile mode continues to dominate this trip purpose for the conserved-energy future. The other trip purpose category has features common to the work and vacation trips, so some diversion to alternative modes is indicated. Within this trip category are recreation and social trips. Charter buses are already used for some long-distance weekend trips. In an energy-short future, one would expect an even greater percentage of this kind of trip to use alternative modes, despite a possible reduction in the actual number of trips. These possibilities are reflected in the modal split percentages. Short-distance social trips may also shift to other modes, especially in urban areas where improved transit services would already be available. The air and rail modes are a relatively small percentage of total travel for this future. Also note that, for the vacation and other trip purposes, trips were reduced by 5 percent before the modal split to reflect an increased tendency to consolidate and eliminate some of these trips.

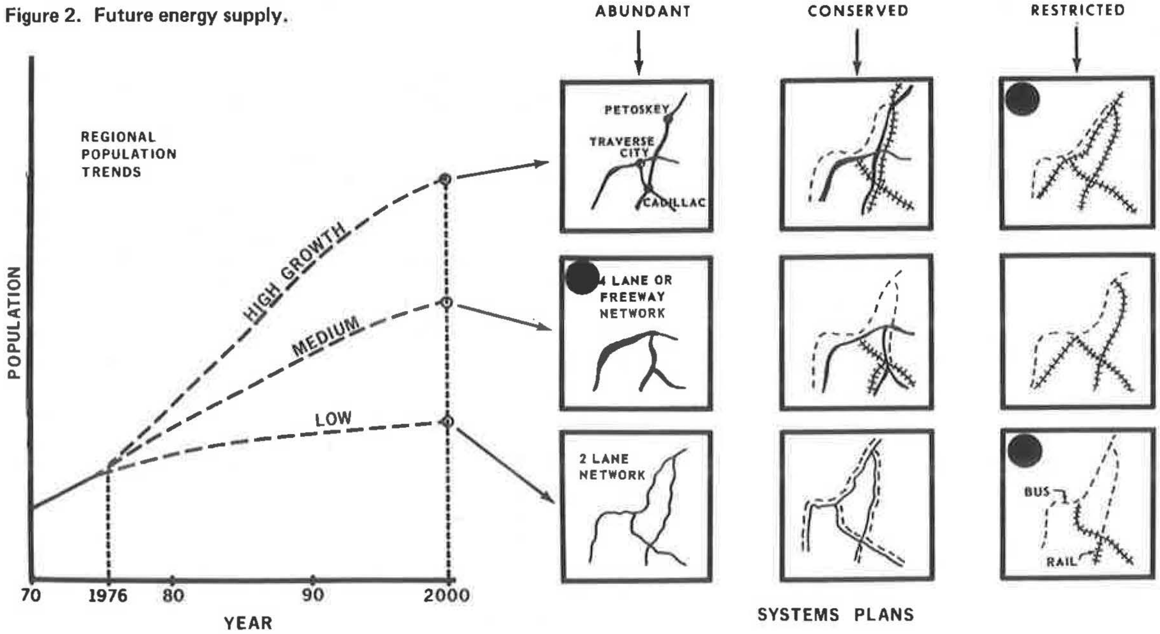
Restricted-Energy Modal Split Percentages

For the restricted-energy future, the modal split percentages show a 10 percent diversion from automobiles for the short-distance work trip as well as a 5 percent shift to carpools or vanpools for the short work trips and a 10 percent shift for 31- to 60-min work trips. Bus and rail traffic increases, and air travel begins to decrease slightly. This prediction is debatable since few data are available to support any assumptions about air travel. For the restricted-energy future, a 20 percent travel reduction factor is applied to the vacation and other trip categories to indicate a greater reluctance to travel as costs grow.

TRAFFIC ASSIGNMENT BY MODE

The traffic assignment portion of this process uses essentially the same techniques as incorporated into the existing statewide highway model. The air and rail net-

Figure 2. Future energy supply.



work plots were reviewed by their respective modal planning sections; and, with this addition to the existing highway network, intermodal assignments were then generated.

The basic traffic assignments follow the minimum time paths for each modal network. The potential bus network is assumed to be equivalent to the highway network since any highway corridor that shows great bus passenger potential could easily become a bus route. At this time, private ownership and operation of bus, rail, and air modes are not incorporated into the analysis. These considerations are important for current project planning activities; however, the potential exists for increased state subsidy of private operations, especially in northern Michigan. Therefore, some systems analysis is appropriate within these constraints and should be beneficial to the project planning phase.

NORTHWEST REGION APPLICATION

Michigan's northwest regional planners recently made use of the multimodal process to assist in development of regional systems plans. The application of this process requires one to select and define probable futures of population growth, energy availability, and cost. Since each future must be evaluated for each of four travel modes, it is advantageous to select only a few futures. For the northwest region, nine such futures were selected, based on three possible population growth trends and three possible energy situations. These futures and some generalized systems plans derived from the multimodal process for the northwest region are displayed in Figure 2. The purpose and modal split ratios discussed earlier were used for this study. The three futures selected for detailed comparison in this report are indicated in Figure 2 by large dots. A plot for each travel mode per future is required to display the projected assignments adequately. Figure 3 shows a simplified example of such plots and depicts the area around Cadillac and Traverse City. This area contains roads that are used extensively for long-distance vacation trips (such as US-131) county roads used mainly for local travel, and state trunklines (such as MI-55), which mainly serve regional travel. Note that, because the splits by trip purpose depend on trip length, the assignments reflect a sensitivity to these different road characteristics.

The plots in Figure 3 contain four numbers on each link. The first number is the number of work trips assigned, the second is the number of vacation trips, the third is the number of other-purpose trips, and the last number on every link is the total trip assignment. The 547-zone system is too coarse to adequately predict local traffic, especially in urban areas and on local roads. Nevertheless, some interesting aspects of this multimodal method may be displayed by comparison of assignments on various types of roads. Figure 3 shows some assignments for the medium population growth with an abundant-energy future. Table 2 summarizes the assignments on the links indicated by the numbered arrows in Figure 3.

These assignments confirm expectations based on the known travel characteristics for each of these roads. For instance, travel on US-31 drops rapidly as one travels north from Traverse City. In the abundant-energy, medium-population future, work and shopping travel on US-31 is 56.7 percent of its total assignment, compared to 8.6 percent for vacation travel. On US-131, 44.8 percent of the assigned trips are work-shopping trips and 26.4 percent are vacation trips, which strongly supports actual origin and destination studies of vacation travel on US-131. The logical pattern for vacation trips is also evident on MI-55; vacation travel is 7.8 percent, but only 2.2 percent of the travel on Alden Highway (a county road in southern Antrim County) is vacation travel. The fluctuation in work-shopping, vacation, and other purpose percentages by individual road types may be compared to the statewide percentages of 60 percent work and shopping, 2 percent vacation, and 38 percent other for all three abundant-energy futures, as shown in Table 3. The strong vacation attraction of the northwest region is clearly reflected in the assignments, which show that even local roads are above average in the ratio of vacation trips to total trips.

Table 3 also displays the statewide effects of various energy futures. One notes that in the conserved-energy future and the abundant-energy future each of the trip purposes is affected about equally. Trips by all purposes decrease, but the other-purpose trips decrease most. Only in the restricted-energy futures does trip purpose seem to play a significant role—vacation and other trip purposes decrease considerably faster than do work trips. This reflects the assumptions expressed in the modal split percentages (Table 1), where the 5 and 10 percent travel reduction factors were applied for the conserved- and restricted-energy futures, respectively, for both vacation and other trip purposes. Work-shopping trips were also reduced somewhat to include possible shifts to carpools for short-distance trips.

Table 2 shows that total automobile travel in the restricted-energy, high-population-growth future drops compared to the abundant-energy, medium-population-growth future for each of the five links studied. However, work-shopping trips increase on the US-31 and US-131 links, and vacation and other-purpose trips drop considerably. Work-shopping trips show the same reluctance to drop on Alden Highway and MI-55. Thus, one could infer that roads that have a high percentage of work and shopping trips will be least affected by rising energy costs, regardless of the rate of population growth. This may be confirmed by comparison of the assignments for the restricted-energy, low-population-growth future with the abundant-energy, medium-population-growth future.

Table 3 shows that the low-population-growth future generates 91.7 percent as many trips as the high-population-growth future. However, when one examines the assignments in Table 2 for the restricted futures, one finds a ratio near 75 percent on all links except MI-55, which has a ratio of 93.7 percent. The other factors of trip purpose, trip length, and modal accessibility cause this ratio to fluctuate as road usage changes. The US-31 and US-131 assignments are well above the average 9 percent increase between low- and high-population growths; however, the predicted change in travel on MI-55 is slightly less than might be expected based on the statewide average. More detailed analysis will have to be done to fully explain these fluctuations in travel growth, but a few assumptions might be made. Of the five links listed in Table 2, MI-55 is the only link likely to serve mainly average-distance trips. Referring back to the mode split ratio (Table 1), one sees that trips between 30 and 120 min in length are considered least apt to select another travel mode. Another special feature of the MI-55 link is that it is the only link not likely to serve trips between Cadillac, Traverse City, and other major cities. It is also an east-west route; the major traffic movement in this region is north-south. Since most population growth would occur around major cities, particularly southern Michigan cities, this growth will probably affect MI-55 the least of any of the five links.

The preceding paragraphs help verify that this multimodal process is sensitive to energy costs, population growth, road use, and trip characteristics. The planning assumptions concerning the various energy futures are reflected by the assignments in varying degrees, de-

Figure 3. Modal plots, medium population growth, and abundant-energy future.

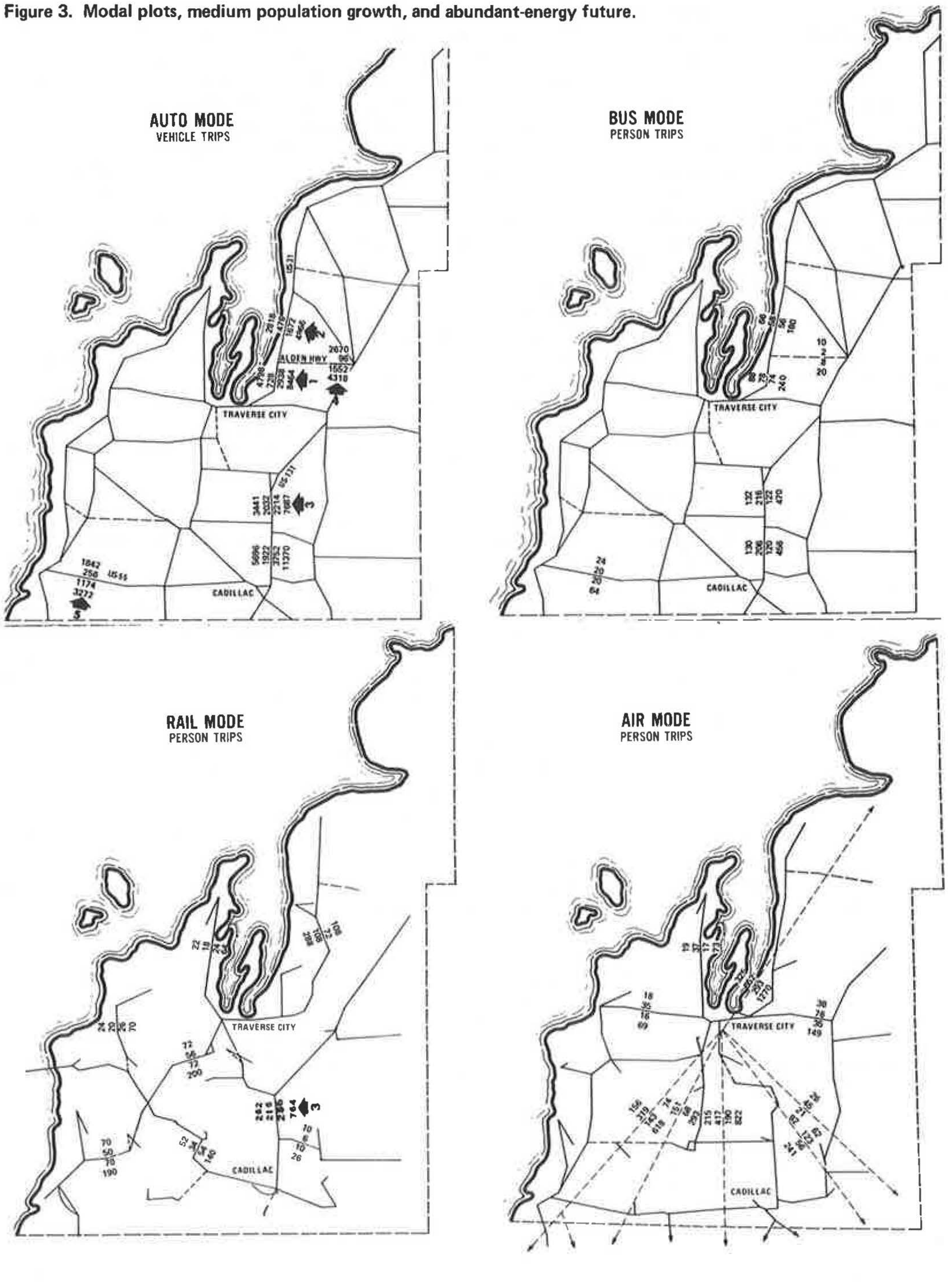


Table 2. Highway assignments on selected links.

Energy Future	Trip Purpose	US-31 (South)	US-31 (North)	US-131	Alden Highway	MI-55
Abundant—medium population	Work-shopping	4798	2818	3441	2670	1842
	Vacation	728	478	2032	96	256
	Other	2938	1672	2214	1552	1174
	Total	8464	4968	7687	4318	3272
Restricted—low population	Work-shopping	3598	2126	2734	1932	1554
	Vacation	490	320	1386	64	182
	Other	1868	1082	1418	1012	824
	Total	5956	3528	5538	3008	2560
Restricted—high population	Work-shopping	4940	2852	3562	2538	1660
	Vacation	612	404	1640	86	200
	Other	2566	1450	1834	1328	872
	Total	8118	4706	7036	3952	2732

Table 3. State total automobile trips.

Population Growth	Energy Future	Work-Shopping Trips Number	Work-Shopping Trips Percent	Vacation Trips Number	Vacation Trips Percent	Other Trips Number	Other Trips Percent	Total
Low	Abundant	5 579 907	59.9	146 367	1.57	3 584 013	38.5	9 310 287
	Conserved	5 214 456	60.5	136 261	1.58	3 271 416	37.9	8 622 133
	Restricted	4 788 209	63.6	112 667	1.50	2 625 848	34.9	7 526 724
Medium	Abundant	·5 869 675	59.9	158 617	1.62	3 756 616	38.4	9 793 908
	Conserved	5 486 016	60.5	147 671	1.63	3 438 320	37.9	9 072 007
	Restricted	5 038 576	63.6	122 104	1.54	2 760 432	34.8	7 921 112
High	Abundant	6 080 147	59.9	168 745	1.66	3 896 532	38.4	10 145 424
	Conserved	5 683 460	60.5	157 105	1.67	3 558 894	37.9	9 399 459
	Restricted	5 220 889	63.6	129 907	1.58	2 857 804	34.8	8 208 600

pending on the road and trip characteristics. These same effects apply to the bus, rail, and air modes, but are somewhat less evident because of the much lower travel volumes for these modes. Before examining the assignments for the alternative transportation modes, a few explanations are necessary.

The bus mode is the most easily obtained alternative mode. Since bus routes need not be any more limited than automobile routes, the potential bus network is assumed to be equivalent to the highway network. Naturally, this will lead to at least a small assignment on each link, thereby subtracting some travel from the automobile mode for even very improbable bus routes. However, this is not a serious problem—the transportation planner may quickly spot the most promising bus corridors for any given future and the remaining links, which contain low bus assignments, will have very little effect on automobile travel. Future use of this process may utilize a bus network that is distinct from the highway network and accessible only at actual bus stations.

The railroad network was used for the rail mode assignments. Initially, for the northwest study, this network contained all tracks now in service, including the Mackinac Straits and Lake Michigan Ferries. Every current freight station was assumed to be a potential passenger station and rail trips were assigned to begin at the station nearest the trip origin and to continue on rail to the station nearest the trip's destination; thus access and egress times were minimum. However, since rail travel is dependent on existing tracks and train frequencies, two other factors were used. The first factor assigned a 20-min wait period at both ends of the rail trip. This excludes many short-distance trips that were assumed illogical for rail travel. The second factor compared rail access-egress times to total highway times for each trip. If the access and egress time was 30 percent or more of the highway time, the trip was not assigned to the rail mode, since few people would drive long distances to use rail service. This factor eliminated medium-distance trips that did not have good rail service available. Neither of these two restraints, however, affected the longer-distance rail trips, particularly those to and from the Upper Peninsula. Those trips contributed to large volumes on the north-south rail lines in the northwest region, which were considered unreasonable, especially since the Mackinac Ferry and other rail lines in the Upper Peninsula are unlikely to ever provide rail passenger service. This was compensated for by subtracting from all rail links any trips that use the Mackinac Ferry, which resulted in much more acceptable numbers. Elimination of other tracks that have little or no rail passenger potential and restriction of passenger stations to major towns or cities would also have been possible. Such a modification of the rail network has produced realistic passenger estimates, but also reflects some planning bias because likely passenger routes are predetermined. Using a complete rail network, a planner should be able to confirm probable passenger routes by comparisons of modal assignments for each rail corridor.

The wait time and access-egress factors used for rail were also used for air travel. The air network consists of all direct flights scheduled during July 1977. This network is restricted only by airport locations and hence is subject to frequent minor changes that are somewhat difficult to predict. It is easily possible, however, to make changes to determine the potential effects on such changes by addition or deletion of flights. Air travel characteristics are quite different from other travel modes; people will travel greater distances to airports than to other modes and will drive to major airports even though local airports provide reasonable connections. Transportation planners cannot agree about the effects of high energy costs on air travel largely because of the distinct characteristics of air travelers. Because the time savings is generally a major factor in decisions to travel by air, schedule and flight connection information is essential to estimate potential travel demand accurately. The multimodal process cannot currently use such information adequately; hence the air mode assignments are likely to be unrealistic in some cases. Given more data for present air travel, this mode could be greatly improved to better reflect actual demand. Meanwhile, air mode assignments could help determine potential air corridors if used with caution.

The plots for the rail and air modes (Figure 3) differ from automobile and bus plots in that they show the access links (i.e., the highway links used to get to and from the rail stations and airports). Comparison of automobile travel to rail and air travel is somewhat difficult since the corridors necessarily differ, and hence the paths between any zone pair may logically be radically different. For example, if one compares the assignments on the US-131 link north of Cadillac, which was numbered 3 in Figure 3, one finds the following assignments for the medium-population, abundant-energy future:

Automobile—7687 vehicle trips
Bus—470 passenger trips
Rail—764 passenger trips

It would appear unrealistic for rail trips to so greatly exceed bus trips. Even the modal split percentages would seem to contradict these futures. Only when one considers the different zone-to-zone paths and the greater flexibility of bus routes do these assignments make sense. Trips from southern Michigan north by rail have only two logical gateways, one at Cadillac and the other at Bay City. Furthermore, the rail lines through Cadillac provide the most reasonable service to the entire northwest region. Therefore, to compare bus assignments with rail assignments, one should consider all of the potential north-south bus routes that serve the area.

The multimodal process also assumes that every rail, bus, and air corridor provides equal service, and hence are equally attractive to the traveler. Obviously, this is a faulty assumption, but it should create no real problem if the transportation planner remembers that the process is designed to help locate the most feasible corridors for alternative modes and to measure the probable impact of the alternative modes on highway needs.

CONCLUSION

This paper describes a newly developed multimodal process designed to help measure the interrelated regional or statewide impacts of energy availability, population changes, and an increased emphasis on mass transit. It should help in location of potential mass transit corridors for rail, bus, and air and also evaluate the effect that such corridors could have on highway needs. Highway corridors that show grave deficiencies in all probable futures can be located by studying the travel assignments for each of the futures. Such corridors may then be assigned a high priority, and deficiencies that show in only a few of the probable futures may be assigned lower priorities.

The objective of this paper was to describe a process that enables a state or region to explore the potential diversion of different automobile trip purposes for various futures and the impact the diversion would have on transportation needs and deficiencies. The variables most often discussed by administrators, transportation planners, and citizens have been defined simply and are easily explained. This enables one to quickly and easily change desired variables and evaluate transportation needs to accurately reflect current issues. The application of the process in the northwest shows that the impacts are extremely complex. Changes in population or energy availability, for example, do not always cause uniform changes in all travel corridors. Transportation deficiencies and demands vary considerably, depending on the travel characteristics of any route.

The application of this process in the northwest region is described in detail to help show that the process is sensitive to all of the desired variables. These variables include not only the assumptions about modal selection in energy-short futures, but also population changes and general road use characteristics. Furthermore, the multimodal process uses tools previously developed for Michigan's statewide modeling system and so is completely compatible with that system. This compatibility ensures that all pertinent additions and improvements to that system will be immediately available for use in the multimodal process.

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Transportation Energy Overview: Emphasis on New York State

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This paper summarizes recent work by the New York State Department of Transportation on transportation energy analysis, consumption, and conservation. Current uses and sources of American transportation energy are reviewed. Particular emphasis is on New York. Transportation energy (gasoline, diesel, and jet fuel) comes primarily from domestic sources, Africa, and the Middle East, and is used primarily for automobiles, commercial vehicles, and air travel. New York uses a relatively higher share of transportation energy in transit and air travel than does the rest of the United States. The paper also shows gasoline use by trip purpose and location in upstate New York, describes baseline transportation energy forecasts and the importance of increased automobile fuel efficiency on conservation, and reviews public attitudes toward conservation and changes in travel behavior during the energy crisis of 1973-1974. Possible conservation actions and their potential are also summarized.

The energy crisis of 1973-1974 increased the awareness of government, industry, and the general public to the problems of energy consumption and supply. Such awareness may have been short lived [four months at most (1)]; however, for a short period of time national attention was focused on that one issue. The Arab oil embargo, which precipitated that crisis, affected the availability and price of gasoline. Although other energy sectors were also affected, in retrospect, the transportation sector appears to have been particularly vulnerable. This is not surprising: In the United States transportation consumes over half of petroleum products and automobiles account for well over half of transportation energy. Clearly, because of the particular vulnerability of the transportation sector to petroleum sources and the large capital costs already made in transportation and transit facilities as well as in vehicles, transportation planners must understand and prepare for the impacts of such embargoes and other energy-related futures. The purpose of this paper is to provide relevant information for transportation planners and decision makers and to describe the kinds of practical actions that might be taken to plan for these uncertain futures. The objective of this paper is to provide an overview of the energy situation in the transportation sector and to look at the following key issues:

1. The sources and uses of transportation energy,
2. The forecasts of transportation energy,
3. The public's view of transportation energy conservation, and
4. The conservation actions or policies that make the most sense for the short and long term.

ENERGY SUPPLY AND DEMAND

Numerous reviews describe the supply and demand of energy by sector and source in the United States (2-5). They generally show the overview described below for 1976 (note: 1 J = 0.001 Btu) (3, 6).

	Supply (%)	
Source	New York	United States
Hydroelectric	7.5	4.1
Nuclear	4.0	2.7
Petroleum		
Residual	24.3	
Distillate	16.4	
Gasoline	19.0	
Jet fuel	4.2	
Kerosene and liquefied propane gas	1.5	
Subtotal	65.4	47.3
Coal	8.2	18.6
Natural gas	14.9	27.3
	100.0	100.0
Total (EJ)	4.31	78.07

	Demand (%)		
Sector	New York		United States
Residential	22.6		19.9
Commercial	12.4		
Industrial	9.7		24.9
Transportation	26.1		26.2
Electric		2.4	
Petroleum		97.6	
Electric utility	29.2		29.0
Total	100.0		100.0

For the United States in general, and even more so for New York, petroleum products and natural gas are the main sources of energy. New York is generally more dependent on petroleum than is the nation and less dependent on natural gas and coal. The three largest demand sectors (residential and commercial, electric utility, and transportation) account for almost 80 percent of U.S. energy consumption; transportation is about 26 percent of both New York and national consumption. New York's energy consumption differs from the nation's in the industrial and in the residential sectors because it is primarily a cold-weather state and has relatively less industrial activity than other states.

Certain fuels are used primarily in certain sectors. Figure 1 shows the flow from source to demand sector for New York in 1976; similar charts are available for the United States. Jet fuel and gasoline are two commodities used exclusively in the transportation sector. A small amount of distillate (diesel fuel), residual, and electricity are also used in this sector. Clearly, the transportation sector is extremely dependent on two specific energy sources: gasoline and jet fuel.

Transportation energy resources come primarily from Africa and the Middle East, mainly from Nigeria and Saudi Arabia (7). Figure 2 shows the distribution of true dependence (i.e., both refined and crude oil sources) of New York and the United States on different foreign and domestic sources for four major petroleum products. Both the United States and New York are highly dependent on foreign sources for residual oil, which is used primarily for space heat and for the generation of electricity (Figure 1). The United States and New York depend primarily on Middle Eastern and African nations for lighter products. New York's dependence is significantly higher than that of the United States and averages 72 percent overall.

The largest share of transportation energy goes into the automobile (Table 1). Commercial vehicles, particularly trucks, use significantly less energy, but nevertheless they use a greater share than that used by any of the other modes of travel (8). Although specific numbers are not available for New York, the national data show that less than 1 percent of transportation energy is used for buses (New York's number would be higher). The implications are that significant energy conservation measures must be oriented to the use and efficiency of automobiles and trucks. Some savings are possible in other modes through diversions; however, it is apparent that their current shares of energy consumption are so low that significant savings relative to those achievable by the automobile will generally not be possible.

New York, by comparison, uses somewhat more automotive gasoline than does the nation and somewhat less energy for trucking. This is because of New York's relatively smaller industrial sector, in comparison to other states. On the other hand, New York uses more transportation energy for air traffic (primarily because of the heavy air traffic in the New York City area) and somewhat more vessel energy. Not all states have waterways or extensive harbor facilities. Both these functions are, of course, regional in character.

The distribution of New York's gasoline use is shown in Figure 3 (9). The data represent annual 1975 gasoline consumption for upstate New York, which totals about 11.4 billion L (3 billion gal) of gasoline annually. Certain shares are obvious (such as home and work travel, which constitutes the major portion of weekday energy consumption), and a significant share of energy is used in personal business, shopping, and social recreation travel.

FORECASTS

Oak Ridge National Laboratory (3) recently summarized numerous forecasts of transportation energy conservation made by the U.S. Department of Energy (DOE) and others. Tables 2 and 3 summarize 1985 and 2000 forecasts for the baseline, assuming an increase in new automobile fuel economy to 11.7 km/L (27.5 miles/gal),

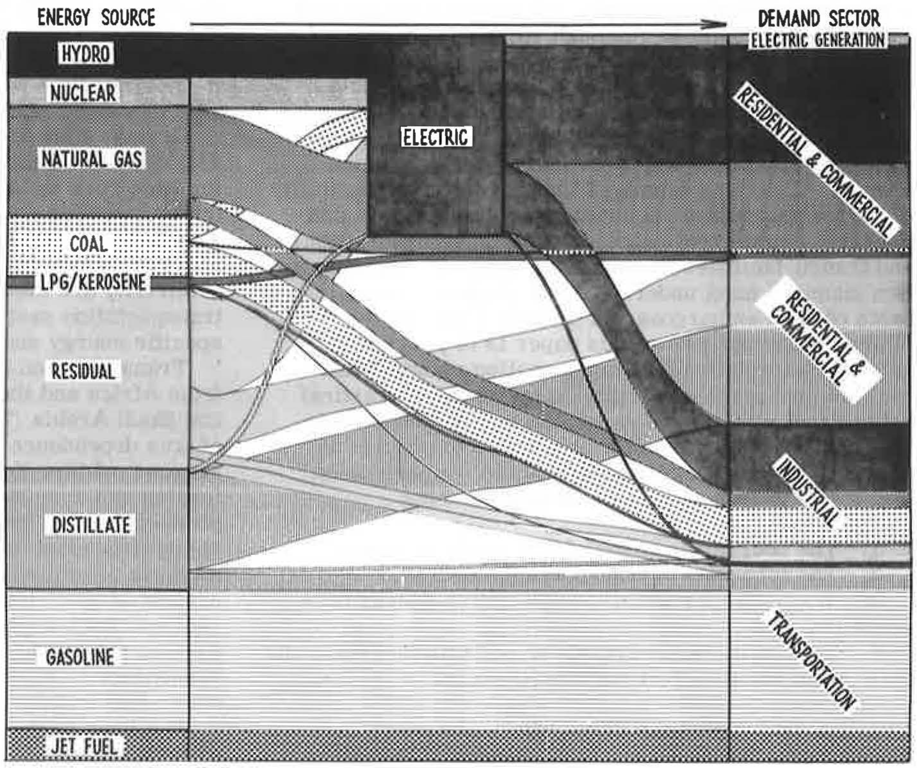


Figure 1. New York energy flows in 1976.

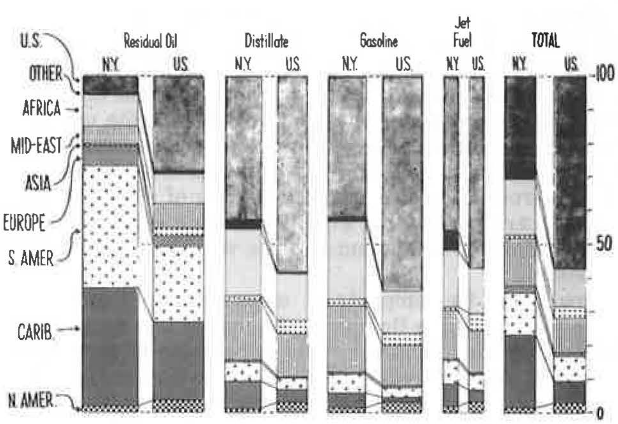


Figure 2. Sources of petroleum products.

Table 1. Transportation energy use.

Mode	New York-1976 (%)	United States-1974 (%)
Automobiles	64.1	57.5
Trucks—commercial	10.7	25.2
Railroad—intercity	1.6	3.7
Transit buses, subway, and commuter rail	1.9	0.5
Vessel	5.9	5.0
Air—commercial	15.8	8.1
Total	100.0	100.0
Transportation sector, total direct transportation energy (1 EJ)	1.144	16.892

Note: 1 J = 0.001 Btu.

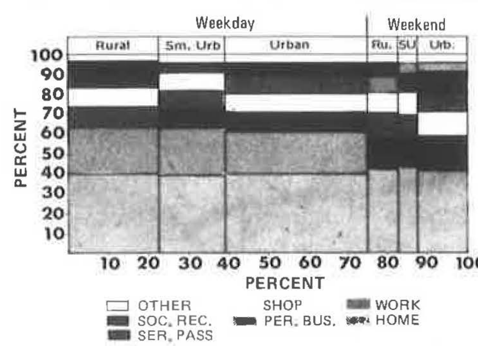


Figure 3. Upstate New York gasoline energy in 1975.

but no other conservation actions (3). The forecasts show that projected improvements in the efficiency of new automobiles are more than sufficient to support both significant increases in automobile vehicle kilometers of travel and increases in population and real per capita income. The tables show that, for the period 1975-1985, approximately a 37 percent increase in automobile travel could be sustained, with a 16 percent reduction in automotive fuel consumption. Beyond that time frame, certain fuel substitutes and blends may change automobile fuel requirements significantly. The analysis further suggests that savings in automotive fuel permit other subelements of the transportation sector (such as truck travel and air) to increase in both use and energy consumption. The total growth in transportation energy use over the 10-year period 1975-1985 is only about 7 percent. Thus, for achieving transportation energy conservation, the importance of improvements in automobile fuel economy and their acceptance by consumers is difficult to overstate.

The New York State Department of Transportation has conducted similar analyses. Econometric models were constructed that relate gasoline price and availability to gasoline demand (8). The models were built for each of the nine metropolitan areas of New York and the remainder of the state and have the following general form:

$$VKT_F = VKT_{75}(POP_F/POP_{75})[1 + e(\Delta x/x75) + \ldots] \quad (1)$$

where

VKT = vehicle kilometers of travel,
POP = population,
x = gasoline price availability, and
e = elasticity.

Therefore,

$$GASOLINE_F = VKT_F/EFF_F \quad (2)$$

where EFF = average automobile efficiency (km/L). The models assume that increases in travel will be a function of (a) increases in population and (b) changes in various background factors, including gasoline prices and availability. The model is operated in an iterative fashion: Gasoline consumption is its output and gasoline supply its input (gasoline availability is defined to be an estimate of gasoline used times average automobile efficiency). The model may, therefore, be operated in feedback fashion to solve for equilibrium prices, automotive fuel efficiency, or other variables that balance supply and demand against various assumptions about vehicle kilometers of travel and other factors. The model has been constructed as an iterative tool, intended to shed light on the general question of gasoline consumption in New York.

Calibration of the demand equations is achieved through least-squares regression of 48 monthly data points for the period 1972-1975. This period encompassed the energy crisis and was characterized by rapid rises in gasoline price and radical shifts in gasoline availability. Therefore, the data contain enough variation to be extracted by calibration. Calibration consisted of regression of the monthly data against trends in regional traffic counts, and then computation of elasticities at the mean values (9). The elasticities that result for each area are shown in Table 4.

Forecasts made by use of the tool are summarized in a number of reports (8-11), and in Table 5 and Figure 4. Test A, which summarizes the baseline forecasts, consists of an assumed turnover of the vehicle fleet along the guidelines of federal standards toward 11.7 km/L (27.5 miles/gal), projected moderate increases in gasoline price, and trend increases in vehicle kilometers of travel. The analysis shows, similar to the studies previously described at the national level, that considerable growth in vehicle kilometers of travel and reasonably stable gasoline prices can be achieved with about 18 percent less gasoline consumption than in 1975, assuming that the average efficiency of automobiles increases as mandated under federal law. This is, of course, a very attractive world, and it underscores the importance of vehicle fleet turnover in achieving gasoline consumption.

Tests B and C assume, for comparison, that such turnover would not occur as rapidly but would rise only to 9.4 km/L (22 miles/gal) instead of to 11.7 km/L. Test B assumes that the same amount of gasoline (18 percent) would be conserved (i.e., the conservation ethic would be maintained). The trade-off required to achieve such conservation under a less rapidly increasing efficiency is a significantly lower rate of increase in travel (13 percent over the 15-year period) and a very rapid rise in the nominal price of gasoline. Alternatively (test C), if one wishes to discard the conservation

Table 2. Baseline transportation energy travel forecast before conservation.

Mode	Demand in 1975 (000 000s)	Percentage Change 1985	2000
Vehicle kilometers of automobile travel	1641	37	90
Vehicle kilometers of personal truck travel	151	66	156
Total and weighted average of personal travel	1792	39	95
Vehicle kilometers of other truck travel	965	44	151
Passenger kilometers of bus travel	82	62	186
Passenger kilometers of air travel	256	94	146
Megagram-kilometers of rail travel	1386	34	100
Megagram-kilometers of marine travel	897	83	150
Megagram-kilometers of pipe travel	1114	5	31

Note: 1 km = 0.62 mile; 1 Mg = 1.10 ton.

Table 3. Baseline transportation energy forecast before conservation.

Mode	Energy in 1975 (PJ)	Percentage Change 1985	2000
Automobile	9 959	-16	-7
Personal truck	1 097	20	52
Total and weighted average of personal travel	11 056	-13	-1
Other truck	3 133	28	103
Bus	95	44	144
Air	1 498	33	98
Rail	528	34	160
Marine	675	80	134
Pipeline (other)	1 329	2	19
Miscellaneous	1 361	12	26
Total and weighted average	19 675	7	42
Population	213 500 000	9.6	23
Real per capita income	$5 062	31	96

Note: 1 J = 0.001 Btu.

Table 4. Elasticities of travel with respect to background factors.

Place	R^2	Overall F	Elasticity: Real Gasoline Price	Gasoline Supply	Retail Sales	Labor Force	Unemployment
New York City	0.78	30.2	-0.21	0.34	-	1.47	-
Buffalo	0.72	22.4	-0.13	0.08	0.36	-	-
Rochester	0.71	26.7	-0.09	0.39	-	-	-
Albany	0.84	57.0	-0.11	0.38	-	-	-
Syracuse	0.79	38.3	-0.10[a]	0.58	-	-	-
Utica-Rome	0.84	46.1	-0.10[a]	0.83	-	-	-
Binghamton	0.81	30.7	-0.10[a]	0.31	-	-	-0.29
Poughkeepsie	0.84	44.4	-0.10[a]	0.54	-	-	-
Elmira	0.80	34.3	-0.10[a]	0.37	-	-	-
Rest of state	0.89	59.6	-0.10[a]	0.28	-	-	-0.15

Notes: Models also include season indices.
Real gasoline price = nominal price/consumer price index; gasoline supply = gasoline available x average automobile efficiency.

[a] Assumed.

Table 5. New York forecasts for automobile gasoline demand.

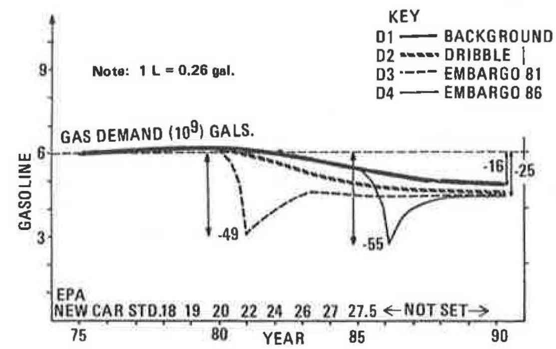
Test	Change 1975-1990[a] Gasoline Demand (%)	Change 1975-1990[a] Vehicle Kilometers of Travel (%)	1990 Nominal Price ($/L)
A—Full fleet turnover (11.7 km/L)	-18	36	0.26
B—Partial fleet turnover (9.35 km/L) with conservation	-18	13	0.46
C—Partial fleet turnover (9.35 km/L) without conservation	6	36	0.26
D-1—Best guess background[b] (11.7 km/L)	-16	45	0.24
D-2—Dribble away of supply (11.7 km/L)	-25	30	0.23
D-3—50 percent embargo 1981-1982 (11.7 km/L)			
1981	-49	-40	0.57
1990	-25	31	0.32
D-4—50 percent embargo 1986-1987 (11.7 km/L)			
1986	-55	-33	0.69
1990	-25	29	0.33

Note: 1 km/L = 2.35 miles/gal; 1 L = 0.26 gal; 1 km = 0.62 mile.

[a] 1975 levels: gasoline demand = 22.7 billion L, vehicle kilometers of travel = 10.39 x 10^{10}, and price of gasoline = $0.13/L.

[b] Increasing price elasticity, higher vehicle kilometers of travel.

Figure 4. Forecasts of gasoline demand.



ethic, growth in travel may be maintained at reasonably low real prices, but the cost will be approximately 24 percent more gasoline use (18 + 6 percent) than could have been saved through conservation.

A number of additional tests were constructed to represent declining supply scenarios. Test D-1 is a revised background projection and is similar to test A except that it assumes increases in price elasticity (such as a price threshold) and a slightly higher growth rate of vehicle kilometers of travel; it shows a 16 percent drop in gasoline demand over 1975-1990. Test D-2 (dribble) assumes a slow decline of supplies by 5 percent annually for five years, beginning in 1980. This results in approximately 25 percent reduction in gasoline demand over the five-year period but could probably be achieved at reasonably stable prices. Tests D-3 and D-4 are intended to simulate the shock effects of significant embargoes in the 1981-1982 period or alternatively in the 1986-1987 period. In both cases, significant rises in gasoline price occur immediately but retreat somewhat to prices in the range of $0.40/L ($1.50/gal) by 1990.

PUBLIC VIEWS AND RESPONSE

Since the implementation of conservation policies would require positive action by consumers and government, planners must understand and recognize the kinds of policies that are generally acceptable to the public. Our knowledge of consumer response to transportation energy constraints or price increases is limited. Most summaries of aggregate behavior come from the period of the energy crisis during the winter of 1974. The period resulted in a 15-20 percent shortfall in gasoline and a 60 percent increase in price. At that time a number of studies conducted by transportation analysts and others concentrated on changes in travel behavior and attitudes toward various conservation actions. In an extensive review of this literature (1), Neveu found only a handful of studies that reported actual behavior during the crisis; most were retrospective views reported up to three months after the crisis ended. Neveu summarized comparisons of both aggregate and disaggregate data as follows:

1. The availability of gasoline generally controlled use; increases in price per se had little effect on curtailing demand. Thus, gasoline price increases (particularly small periodic increases) used as a lever to reduce demand are unlikely to be particularly successful.
2. Changes in travel behavior were minimal. Most people reduced discretionary travel, combined trips, and drove slower. Carpooling increased only slightly (5 percent), as did transit use. No discernable shifts occurred in automobile ownership, residential location, or other major actions.
3. Low-income travelers, who make few discretionary trips to begin with, were more inclined to shift modes, particularly on work trips. Even here, however, the relative impact was small.
4. Sales of both large and small automobiles plummeted as consumers adopted a wait-and-see attitude.
5. Patterns of travel returned to normal shortly after the crisis.
6. Many people were inclined to view the crisis as an event contrived to increase gasoline price.

Thus, reaction to the crisis consisted of minimal actions, usually individual or family based, to ride out the storm. The data further suggest that consumer responses to future crises will be slow, measured, and, in general, sluggish.

To update this information, a poll was conducted during the fall of 1977 (12). A total of 500 households were selected in multistage fashion from New York; the probability of selection was proportional to population. The households were telephoned and administered a short opinion poll on the general subject of energy conservation in the transportation sector.

The results of this poll are somewhat surprising when viewed against similar findings of other studies. As the responses below show, New Yorkers are aware of the existence of a significant energy problem in the United States.

Does the United States have an energy problem?

Response	Percent
Yes	84
In the next 15 years	7
No	9

These numbers are significantly higher than those discovered from other studies and reflect the sensitivity of New Yorkers to gasoline price and availability, as well as New York's greater reliance on foreign energy imports.

Where should energy in New York State be saved?

Area	Response (%)	Current Share (%)
Home	18	22
Industry	22	10
Business	13	12
Transportation	17	26
Other	30	30

The answers to this question were divided, but respondents generally felt that industry should bear a significantly larger portion of the effort than its present share of energy consumption.

New Yorkers said that the energy problem in the United States has been caused by a combination of external and internal factors.

What are the causes of the energy problem?

Response	Percent
Consumer and industry waste	82
Slow development of new sources	79
World is using up energy sources	78
United States is using more than we have	71
Other countries control our oil	71
Prices not high enough	17

New Yorkers are inclined to point to increased consumption of energy resources worldwide and significant control of petroleum in the hands of other countries as primary factors that influence the energy situation. But they also blame both consumers and government for significant waste, and chide the country for slow development of new sources of energy. They strongly disagree, however, that low prices have been the primary cause of such waste.

When asked specifically where transportation energy can be conserved, the attitudes of New Yorkers begin to harden.

How can transportation energy be saved?

Response	Percent
Encourage intracity transit	60
Encourage intercity bus and train	22
Encourage reduction in gasoline use	15
Other	3

Only 15 percent of New Yorkers seem to recognize (or are willing to admit) that the primary user of transportation energy is the automobile and, therefore, only through concentration on this particular use can significant savings be achieved.

When asked for specific support for actions to reduce gasoline consumption, New Yorkers show strong support for incentive and low-key actions, such as enforcement of the 88-km/h (55-mph) speed limit, encouragement of people to carpool and to plan trips better, and improvement of the flow of traffic on city streets. Considerably less support was solicited for various rebate or taxing plans on automobiles, and weak support was shown for gasoline rationing or taxes.

Support	Action
Strong—80-90%	Enforce 88-km/h speed limit
	Carpool incentives
	Trip-planning incentives
	Improve city street traffic flow
Medium—40-50%	Rebates
	Taxes on large automobiles
Weak—20-30%	Rationing
	Gasoline taxes
	Build more superhighways

The general picture is one of a public concerned but recalcitrant when confronted with specifics. It is perhaps reasonable to suppose that the public naturally shies away from actions that will have significant impact on transportation energy conservation (e.g., actions intended to reduce gasoline consumption through rationing). The study again seems to underline the importance of taking unobtrusive actions, such as improvements in the vehicle fleet efficiency, combined with significant incentives, as the most effective mechanisms for reducing transportation energy use.

CONSERVATION MEASURES

The above analysis suggests that incentives are better than disincentives from the public's viewpoint and that certain actions (particularly those aimed at improving the efficiency of automobiles) would result in significant transportation energy conservation. But what of other actions oriented toward modal shifts or increased vehicle load factors?

Because of the way in which transportation energy is distributed by modes (Table 1), even very large improvements in the use of certain modes (through diversion from the automobile) would not have a significant impact, relative to that for improvement in automobile efficiency. A number of recent studies have summarized, in comparative form, the effectiveness of numerous actions to conserve transportation energy. The most comprehensive of these studies have been the reviews by Hiatt and Rubin (13), Alan M. Voorhees

Table 6. Conservation measures.

Strategy	Percentage Savings from 1973	
	1980	1990
Passenger vehicle efficiency		
Modest improvement	8	15
Advanced technology	9	24
Maximum off-shelf	10	22
Advanced technology and small automobiles	13	32
Radial tires	0.5	0
Other retrofits	0.5	0
Work carpool		
47 percent participation	1.9	1.5
70 percent participation	4.9	3.8
Other efficiency measures		
88-km/h speed limit	1.2	0.9
Bus vehicle efficiency	0.1	0.1
Air passenger efficiency	2.3	3.7
Truck vehicle efficiency	3.3	8.7
Mode shifts		
Urban automobile to bus	0.7	0.8
Urban automobile to bicycle	0.5	0.7
Intercity automobile to bus	0.2	0.2
Intercity automobile to rail	-	-
Air to automobile	0.2	0.4
Air to bus	0.2	0.4
Air to rail	0.2	0.3

Note: 1 km/h = 0.62 mph.

Table 7. Upstate New York projected energy savings.

Policy	Changes in Parameters	1980 Change Over 1975 Base[a] (%)
1975 baseline		0
1980 baseline		-3.3
Encourage carpooling	10 percent increase in automobile occupancy for work and school	-5.0
	25 percent increase in automobile occupancy for work and school	-7.0
	10 percent increase in automobile occupancy for shopping	-4.1
	25 percent increase in automobile occupancy for shopping	-5.2
Chauffeur service in urban areas	25 percent increase in automobile occupancy for serve passenger, change mode, and ride trips, small urban areas only	-3.7
	25 percent increase in automobile occupancy for serve passenger, change mode, and ride trips, urban areas only	-4.2
Combine trips—trip chaining	Weekend shopping—25 percent decrease in trip length for shopping, eating meals, personal business	-4.8
	Weekday stop off—50 percent decrease in trip length and trip rate for shopping and personal business	-13.2
	Shopping center—10 percent increase in automobile occupancy for shopping, eating meals, personal business, serve passenger, social and recreational, and 2 percent increase for home; 30 percent and 15 percent decrease in trip rate; 25 percent and 5 percent increase in trip length	-16.0

Note: 1 L = 0.26 gal.
[a] 1975 baseline = 4.8 billion L.

Associates (14), the National Cooperative Highway Research Program (15), and Interplan Associates (16). All of these studies have reached essentially the same conclusion: Improvements in the internal operating efficiency of automobiles are by far the most cost-effective and significant actions that can be taken to save transportation energy.

The results of the Rubin study are summarized in Table 6 (13). The action "maximum off-shelf improvements in passenger vehicle efficiency", for instance, would appear to yield, over a 1973 baseline, about 10 percent savings in 1980 energy and about 22 percent savings in 1990. Results are about the same as those achieved and described earlier by New York State Department of Transportation and by DOE. Actions to improve carpool participation, although somewhat effective, would require significant participation levels in order to bring about a significant improvement in transportation energy savings. This is because, as described earlier, a significant part of automotive fuel use is expended on nonwork travel. By comparison, the enforcement of the 88-km/h (55-mph) speed limit would save about 1 percent of transportation energy, but improvements in bus efficiency would have a very small effect. Improvements in the efficiency of planes and trucks would be somewhat more effective, and their effectiveness would be more important in later years as a greater percentage of transportation energy shifts to those modes.

Mode shifts of passenger travel would appear to not be a particularly important means of transportation energy conservation, primarily because current use of bus, bicycle, and rail modes is very small. Therefore, even a significant increase, say a doubling of use, would have very little (perhaps even negative) (17) impact on total energy consumption and might not even be achievable within the 15-year time frame, given the present capacity of vehicle manufacturers to produce rail cars and buses. Diversion of air traffic to more efficient modes would also appear to have minor effectiveness.

Actions such as community-based chauffeur services or trip chaining would appear to be effective in certain environments, as demonstrated in Table 7 (9). In particular, a significant decrease in average trip length and trip rate for shopping and personal business trips might be achievable by combining them with other weekday travel, e.g., trips to work. If a 50 percent decrease could be effected (a very large percentage), the impact on transportation energy savings would be substantial. The numbers in Table 7 refer to percentages of gasoline consumption and not to all transportation energy. This review, of course, does not consider various combinations of actions that might be taken in the form of packages, and taken together might save upwards of 20 percent of transportation energy. Such packages can be constructed for a variety of purposes, such as transportation system management and the Clean Air Act Amendments of 1977, as well as on the basis of good common-sense transportation planning actions. The Voorhees report (14) describes such packages in some detail.

SUMMARY

The energy situation in New York can be characterized as follows:

1. New York's energy supply is concentrated in petroleum; less reliance is on coal and natural gas.
2. New York's foreign-oil dependence is great (72 percent overall); major gasoline and jet fuel suppliers are Africa and the Middle East.
3. Demand is spread evenly through all sectors; transportation, which is entirely petroleum dependent, constitutes 26 percent of demand.
4. Transportation use is concentrated in automobiles, 65 percent; air, 16 percent; and trucking, 10 percent.
5. The greatest share of automobile fuel goes to work travel.
6. Automobile energy use is projected to decline if average automobile efficiency increases by federal standards. Without such increases, trade-offs between energy conservation and growth in mobility are required.
7. The public favors voluntary and incentive actions to conserve transportation energy.
8. Conservation actions that focus on the private automobile are likely to be the most effective.

The New York State Department of Transportation is currently heavily involved in the analysis of transportation energy and is likely to remain so beyond the immediate future. Numerous other studies and reviews could be undertaken at this time; however, the effort to date represents a significant investment of time and effort on the part of the department in this very important subject area. The department intends to use this information for distribution to the various actors engaged in transportation planning and development in New York and elsewhere. The eventual result will be that actions to conserve transportation energy are taken by all responsible parties at all appropriate levels of government. Only through such actions can the general picture of increasing energy consumption in the transportation sector be reversed, and then New York and the nation can move toward energy independence and flexibility.

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