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Administering State Mass Transportation Programs in Pennsylvania

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Since Pennsylvania has taken an early lead in assisting local public transportation systems, its experience in this area should be of interest to other states. This paper presents the findings of a review of the transit-related activities carried on by the Pennsylvania Department of Transportation, looking at both institutional arrangements and administrative processes. It points out a number of policy issues concerning the range of functional responsibilities, planning and programming processes, intermodal considerations, funding sources, and intergovernmental relations that may be facing other states in the development of transit programs.

From the early part of this century (when state highway departments were formed) until the mid-1960s, almost all the energy and resources of state government transportation programs were focused on building highways. However, the past decade has witnessed a significant broadening of state concern about transportation. For example, some 28 states have now organized departments of transportation with responsibilities in many areas, usually including programs intended to deal with local (primarily urban) mass transportation needs. While there is great variation as to the kinds of programs and the level of effort maintained by these state transportation departments, the increasing state involvement in mass transportation can be viewed as resulting from the confluence of two general trends over the past 10 to 15 years.

First, the evolution of the intergovernmental system in recent years has been characterized by increasing prominence of the states in many program areas, partially in response to the development of direct federal-to-local categorical grant programs. Second, since the early 1960s it has become increasingly evident that reliance on the private automobile and highways is not satisfactory in terms of congestion, levels of service, availability to all who need transportation, direct and indirect economic, social, environmental, and psychological impacts, and, more recently, energy considerations. This has led to commitment at all levels to the concept of balanced transportation systems and emphasis on the revitalization of mass transit modes.

The state departments of transportation now in existence are in various stages of development, and the experience of some has undoubtedly influenced the directions in which others proceed. While each is necessarily unique, since the political and institutional contexts and particular circumstances leading to its creation were unique, comparisons among them are useful both for assessing relative progress and for identifying promising strategies that might be adopted by other states. A number of reports on this topic have been prepared, including discussions of common problems and the alternative approaches of many states (1, 2, 3, 4, 5, 6), reports focused on a single state's programs (7, 8), and studies of state activities regarding a specific transportation mode (9).

This paper is based on a study of the transit-related activities of Pennsylvania's Department of Transportation (PennDOT). The purpose of the study was in part to identify current problems and issues in this area. Through a brief review of Pennsylvania's experience to date in the area of mass transportation, this paper will point out some aspects of PennDOT's functioning that are likely to reflect the kinds of policy issues facing administrators in other states.

ORIENTATION AND RANGE OF FUNCTIONS

Among the states, Pennsylvania has taken a relatively strong and early lead in assisting urban mass transportation systems. The state initiated programs for both capital grants and operating subsidies to local operators in 1967; it spends more money on transit and has been supporting transit for a longer time than other states. In 1969, programming for these functions was transferred from the Department of Community Affairs to the newly created Department of Transportation, along with highways and other transportation functions. Within PennDOT, the transit-related activities have been expanded and diversified. In addition to the capital grants and operating subsidy programs, PennDOT is responsible for

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multimodal planning, operates a senior citizens' fare-subsidy program, promulgates standards for transit operations, indirectly provides for training, and has a research and development function.

While one of the underlying reasons for establishing departments of transportation has been to better coordinate decision making among the various modes and so to move toward balanced transportation systems, most state departments of transportation have strong modal, as opposed to functional, orientations. PennDOT's organizational structure combines these two approaches, since long-range planning, programming, and budgeting are performed by bureaus with multimodal concerns, while most design and operating tasks are assigned to mode-oriented bureaus.

PennDOT's overall operation is largely dominated by highway activities in terms of both manpower and financial resources. It is hoped that a desirable balance between state investments in highways and those in transit will be attained through the comprehensive perspective taken in the long-range planning and programming processes. Given a multimodal framework for setting overall priorities, the prime rationale for the separate structuring of highway-oriented bureaus is PennDOT's responsibility for building and operating a 71 000-km (44 000-mile) highway network. However, the involvement of almost all (99 percent) of PennDOT's approximately 20 000 employees with highway-related functions tends to perpetuate the dominance of highway interests. The predominance of the highway function is also reflected by the fact that of PennDOT's total financial resources ($1.2 billion in fiscal year 1974-75) 92 percent was spent on highways (10).

Urban mass transit has traditionally been a local (although increasingly public) function, and PennDOT does not directly operate transit systems. Nor does PennDOT engage in the construction of transit facilities, although this may be considered as an alternative in the future, given the reserve of construction management know-how available within the department. One possibility, which is not probable in the near future but has been the subject of some discussion within the department, is the creation of transit districts as counterparts to the highway engineering districts for purposes of construction, direct operation, or technical support to operating agencies. The department has been providing some technical assistance to local operators, and the possibility of adding transit management specialists to the staff to increase this support is being considered.

A rapidly developing area of involvement is that of rural transportation services. PennDOT's transit programs have been urban oriented, but there is a growing awareness of transportation needs in the state's rural areas, particularly its Appalachian counties. The Pennsylvania Department of Agriculture has been sponsoring demonstration programs of rural public transportation operations, and in May 1974 a report on rural transportation recommended that "all residents of Pennsylvania be assured of access to transportation opportunities" (11, Vol. 1, p. 8) and proposed that a Bureau of Rural Transportation be established in an existing department to coordinate all existing and future rural transportation programs.

PennDOT has the responsibility for developing specifications for rural public mass transit service and also for establishing demand-estimating procedures. Planning and operations are to be the responsibility of regional agencies or authorities. Responsibility for rural transit is divided at the state level, since the Department of Agriculture is still funding demonstration programs and retaining its role as advocate. This raises the issue of whether the primary responsibility for this function should be located in a department concerned with all forms of transportation or one that is concerned with the provision of a variety of services to the rural population.

MASS TRANSIT PLANNING

Within PennDOT, responsibility for planning mass transportation is shared by the Bureau of Advance Planning and the Bureau of Mass Transit Systems (BMTS). The Bureau of Advance Planning is responsible for administering all the department's planning activities in the 16 urban areas that have established continuing, comprehensive, and cooperative (3C) planning processes, including the preparation and adoption of transit development programs and short-range capital improvement programs for urban transit. The BMTS has primary technical responsibility for preparing immediate action plans and transit development programs for urban areas that do not have the 3C planning process, i.e., most of the state's urban areas with populations of less than 50 000. It also participates in both short-range and long-range transit planning for the larger urban areas.

The advisability of dividing the responsibility for short-range transit planning is open to question. One rationale for the lead role played by the Bureau of Advance Planning in urban areas with populations greater than 50 000 is based on the desire to concentrate the responsibility for planning in an office with multimodal concerns. However, the assignment to the Bureau of Advance Planning of activities required to preserve transit operations and planning for short-run improvements in existing service is not wholly defensible. Shifting these functions for all urban areas to one bureau would consolidate responsibility for short-range transit planning and would serve to strengthen the state's technical expertise in this area, especially if BMTS can begin to perform some of this work itself. In addition, moving short-range planning out of a bureau that has been somewhat encumbered by the procedural requirements of the 3C process might result in the pursuit of more flexible approaches. A multimodal emphasis would be retained through the Bureau of Advance Planning's responsibility for all long-range planning.

REGULATORY ROLES

Although most of the state's transportation-related activities were transferred to PennDOT when it was created, the regulatory functions remained with the Pennsylvania Public Utilities Commission (PUC). This arrangement may lead to conflict over the regulation of urban mass transit operations since the Bus and Taxicab Regulations that were adopted by the PUC in 1946 cover all aspects of the operation of public motor carriers by private enterprise, including safety regulations, tariff requirements for rates, routes, and time schedules. Because the commission has both quasi-legislative and quasi-judicial powers, its legal power to regulate in terms of public service and safety is almost absolute with respect to private transit operators. The advantage of having the PUC retain these regulatory functions is that it is a neutral agency with no contractual relationships with local operators.

In developing its transit assistance program, PennDOT has established operating guidelines (12) for local transit agencies; compliance with these guidelines, as discussed below, forms a basis for the allocation of purchase-of-service funds. There are several sections of the guidelines that have regulatory implications, so the possibility of conflict with the PUC's Bus and Taxicab Regulations exists when dealing with private-enterprise mass transit

carriers. Of the 15 transit properties that are currently participating in PennDOT's purchase-of-service agreements, 5 are owned by private companies.

The operating guidelines define in great detail the level-of-service criteria for all mass transportation carriers that are to receive state assistance. The PUC regulations, on the other hand, do not define a level of service for the privately operated transit systems under their jurisdiction, but they do provide for the revocation or cancellation of the operating right of a carrier or suspension of service. Specific reference is made in the PennDOT guidelines to the procedure for adding or abolishing routes. They make no reference to obtaining a concurrent approval of the PUC, although the PUC regulations are very specific with respect to the addition or deletion of scheduled routes.

Another source of possible regulatory conflict is the rate of fare set by the transit properties. The guidelines establish rate levels for the carriers and also allude to the possibility that the BMTS will retain a unilateral responsibility for determining the reasonableness of fare levels. Again, for privately owned carriers, the PUC regulations are very specific about the procedures for filing and posting of tariffs.

By law the PUC has jurisdiction over private properties, and it is the position of the BMTS that operators who wish to make service changes in order to comply with BMTS guidelines would be expected to obtain prior approval from the PUC. This would indicate that on certain matters some private transit agencies must deal with two different state agencies and administrative procedures, which seems an unnecessary duplication of effort. In addition, there may be differences in philosophical perspective between PennDOT and the PUC that, in specific cases, could place the local operator in an ambiguous position. To put this problem in perspective, however, it should be noted that most of the operating agencies participating in PennDOT's program do not now come under the jurisdiction of the PUC and that, as more private operations are taken over by public bodies, the likelihood of such conflicts will decrease.

On another score, though, there still may be reason to shift the regulatory function to PennDOT. Successful rejuvenation of public transportation will require flexible, active approaches to economic regulation, with separate and concentrated attention given to the safety aspects of operation. In some respects, regulatory codes intended to protect the profitability of one kind of service operation frustrate the desire to experiment with alternative methods of meeting a public need. The PUC regulation against the provision of demand-activated service where there is neither a common origin nor a common destination is a case in point regarding rural transportation needs at present (11, Vol. 2, p. 105). Since PennDOT is actively and directly supporting local efforts to improve transit operations, it might prove advantageous to combine responsibility for the economic regulation of transit systems with these developmental functions within the state departments of transportation, as New York has done.

TRANSIT ASSISTANCE PROGRAMS

In addition to assistance in planning, technical studies and demonstrations, and promotional efforts, PennDOT is providing financial support to transit operators through capital grants, purchase-of-service agreements, and a senior citizens program. The capital grants program is funded with bonds issued by the Transportation Assistance Authority and is authorized to finance up to 16.7 percent of capital acquisition projects for which federal funding is available and up to 50 percent for projects in which there is no federal participation. In the purchase-of-service program, which is financed by the general fund, PennDOT can subsidize up to two-thirds of operating deficits. The senior citizens program is designed to reimburse local operators for providing free service to senior citizens and is funded with revenue from the state lottery.

Effectiveness of State Assistance

Assessing the effectiveness of the capital grants and other operating assistance is made difficult by the fact that there are other factors at work that influence transit service and use. Clearly, the program has been most successful in preserving existing transit systems and ensuring a continuation of service in the state's urban areas. An intrinsic evaluation would almost certainly show that levels of service are higher where new equipment has been put into use, and service might be expected to continue to improve in terms of coverage, headways, speed, reliability, scheduling flexibility, marketing efforts, and the provision of specialized service as operating agencies attempt to comply with PennDOT's Operating Guidelines and Standards. Some 200 commuter rail cars have been purchased since the inception of the capital grants program, and the acquisition of new buses has cut the statewide average age of the fleet in half since 1971. Furthermore, PennDOT statistics show that scheduled vehicle-hours and scheduled trip distances each increased about 4 percent from 1973 to 1974 for the transit agencies in urbanized areas that report to PennDOT (13).

Effectiveness in terms of maintaining or increasing ridership is even more difficult to determine. The acquisition of new buses in both Allentown and Reading was followed by substantial increases in ridership, but that was not the case in Harrisburg. Statewide, ridership as measured by revenue passengers increased by 11 percent from 1972 to 1974, following a 6 percent decrease from 1971 to 1972 (13). The 2-year increase may largely be a response to the temporary shortage and continuing high price of gasoline, but the increase in ridership in Pennsylvania was considerably greater than the average nationwide increase (less than 7 percent) for all companies reporting to the American Public Transit Association for the same period (13, 14).

	Pennsylvania		United States	
Year	Revenue Passengers (millions)	Change From Previous Year (%)	Revenue Passengers (millions)	Change From Previous Year (%)
1971	382		5497	
1972	358	-6.2	5253	-4.4
1973	380	6.0	5294	0.7
1974	400	5.0	5606	5.9

This would suggest that the state's program has had some positive effect on ridership beyond the influence of general environmental factors. Total ridership increased much more than did the number of revenue passengers in Pennsylvania, largely because of increased use of transit by senior citizens.

In another respect, there is some evidence to indicate that the state's capital grant program has encouraged and assisted local operating systems to obtain federal grants from the Urban Mass Transportation Administration (UMTA). For the period 1964 to 1973, UMTA capital grant funds awarded per transit rider (work-trip transit commuters as tabulated by the 1970 census) were greater for all Pennsylvania metropolitan areas combined than for those of neighboring and other highly urbanized states, including New York, New Jersey, Delaware, Ohio,

Michigan, and Illinois. This suggests that operating agencies in Pennsylvania have been more aggressive and successful in seeking federal funds to upgrade facilities than those in comparable states, presumably due partly to the influence of the state's programs.

Allocation of Awards

It is within the administrative discretion of the BMTS to vary the amounts of purchase-of-service awards up to the legislated ceiling of 66.7 percent of operating deficits and within the total amount appropriated for the program for a given year. The bureau has developed a system for evaluating the performance of transit operators in complying with the standards it has established and, by using data collected annually from the operators, it can give each operating system an objective rating in terms of level of service and ridership (16). These ratings, tempered by judgmental considerations, form the basis for the allocation of purchase-of-service awards in a way intended to foster the program's objectives.

While the Operating Guidelines and Standards are oriented toward efficiency in terms of both increasing ridership and revenue and reducing operating costs per unit, a core issue raised by the implementation of the guidelines and standards is whether they might work to encourage inefficiencies. The problem, foreseen by the developers of the rating mechanism (15, p. 11), is that many of the kinds of improvements sought by the guidelines and standards will lead directly to increased operating costs. Since these increased costs will not necessarily be balanced by increasing ridership and revenues, operating deficits in the future can be expected to increase, especially given the further objective of stabilizing or reducing fares. This may turn out to be a short-run problem if riders respond favorably to improvements in service, as PennDOT expects.

On the other hand, the guidelines and the rating mechanism are both flexible and, if substantial increases in ridership do not materialize, they could be revised to fit the situation more realistically. Operating standards could be made less ambitious and, while ridership trends are included in the additive point system, they might be given greater emphasis in order to more effectively ensure that improvements are made where they are most wanted by the transit-riding public. On a more general level, this issue relates directly to the philosophical underpinnings of operating subsidies; perhaps increased subsidization of improved service is justified by the social benefits that result from increased mobility, but to some extent these benefits are also based on the assumption that the use of transit will increase.

Funding Needs and Sources

The state's funding of its mass transit programs has been increasing in recent years—funding for mass transportation assistance in the operating budget has grown from roughly $11 million in fiscal year 1971 to $74 million in fiscal year 1976—but there are of course problems relating to future funding levels and the courses of these funds. The 1975-76 budget projects increasing this funding to $90 million for fiscal year 1979 and to $98 million for fiscal year 1980 (16, Vol. 2, p. 724), while unofficial estimates by BMTS personnel put the need for operating subsidies at $125 million by fiscal year 1979. While both these projected amounts are largely matters of speculation, it is clear that widening gaps between operating needs and money available from the state's general fund can be expected.

While the transit programs are in need of increased funding, a diversion of funds from highway-related revenues is not considered to be feasible by PennDOT officials. Moneys accruing to the Motor License Fund are committed to pay interest on past bond issues, to maintain the 71 000-km state highway system, and to finance only the most attractive new highway projects—those built largely with federal funds. Thus, the Motor License Fund is not viewed as an additional source of revenue for the transit program without major increases in user taxes or a disruptive breakdown of state highway transportation. Nevertheless, the constitutional prohibition against using highway funds for other purposes is a serious barrier to the creative allocation of state transportation funds.

The use of separate funding sources reinforces the tendency to program and budget for the modes separately without considering trade-offs or joint effects. Highway capital improvement funds, for example, are allocated according to need among the 67 counties in the state, without regard to where transit investments are being made. This raises the issue of whether the allocation of state transportation funds should be unified and illustrates the kind of question that would be addressed in a multimodal programming process. For example, should the flow of state funds to urban transit systems be reflected in a reduced allocation of highway funds to these areas?

The rising costs of maintenance and debt service and the improbability that highway-user revenues will increase have forced PennDOT for the first time to approach its programming function in terms of the allocation of scarce resources. This certainly does not augur well for the financing of mass transit projects from highway revenues in the near future, as evidenced by the transportation policy statement in the governor's budget for fiscal year 1976. The budget schedules new construction at a reduced rate, provides for no new capital authorizations for highways, and puts the highest priority on the maintenance of existing roads; yet less money will be spent on maintenance than in the previous year (16, Vol. 1, p. 42).

On the other hand, concern for allocating these reduced resources effectively and equitably underscores the need for PennDOT to take a truly multimodal approach in its programming. A program budget approach, for example, might set improvement of transportation in an urban area as an objective function and evaluate alternative mixes of investments accordingly. Questions from local government officials at a hearing on highway allocations in April 1975, however, made it clear that PennDOT had not taken into account the effect of rail abandonments or curtailment of service on highway needs or of investments in transit to meet urban travel needs on setting priorities among highway projects.

Fortunately, the need for increased state subsidy of local transit systems in the next few years has been greatly eased by the passage of the National Mass Transportation Assistance Act of 1974, which for the first time makes federal funds available to subsidize up to 50 percent of operating deficits (17). Funds authorized by this act, and apportioned by formula, for urbanized areas in Pennsylvania are shown below, along with the projected subsidy needs (unofficial BMTS data) and the amounts to be budgeted by the commonwealth; the latter two are more than balanced by these formula allocations. The introduction of federal operating subsidies is very timely for Pennsylvania in terms of meeting increasing subsidy needs while permitting the state's funding to continue at its present level through the balance of the decade. Beyond this, if ridership and revenue fail to increase with improved levels of service and higher costs, it might be appropriate to look to the local level for increased par-

ticipation in subsidizing local transit operations, for example through the creation of metropolitan transit districts with taxing powers (15, p. 16).

Category	Millions of Dollars				
	1976	1977	1978	1979	1980
Subsidy needs	97.0	105.0	115.0	125.0	–
Projected budget amounts	74.2	78.4	83.0	89.7	98.5
Deficiency	22.8	26.6	32.0	35.3	–
Federal formula allocation	30.3	39.3	46.9	51.4	54.5

INTERGOVERNMENTAL PROGRAMMING

State mass transit programs are an important part of transit activity at all levels of government. Relationships between state and local governments are of principal concern because these programs involve state-level planning, programming, and budgeting to support a service that is actually delivered at the local level. Relationships between state and federal government are crucial too, since the state funding was in part a response to the federal program and since the state program is heavily dependent on the federal program for success. State transit policies must be sensitive to changes in the federal program.

The National Mass Transportation Assistance Act of 1974 represents a dramatic change in the federal transit program, and this has many important implications for state-level involvement with transit (18). The act expands UMTA's discretionary capital grant program and provides for a new formula grant program to distribute to urbanized areas funds that can be used for either capital projects (up to 80 percent federal participation) or operating subsidies (up to 50 percent of operating deficits). Governors are given a central role in carrying out some of the provisions of this act, and responsibility for these funds will fall to state transportation agencies in most cases.

The act makes an important distinction between urbanized areas according to population, with the formula funds being distributed annually directly to those with population greater than 200 000; in Pennsylvania this includes Philadelphia, Pittsburgh, and four other metropolitan areas. For areas with populations between 50 000 and 200 000, of which there are seven in Pennsylvania, the governor is the designated recipient. These funds could be distributed annually by the state on a discretionary basis among the seven smaller metropolitan areas, with each area receiving, during the 6-year life of the act, the amount it would have received had the funds been distributed annually according to the formula. However, in Pennsylvania it was decided to forego this authority and to have these funds allocated directly to the local areas on an annual basis.

In order to maintain eligibility for the program, each urbanized area is required to submit to the state for review and comment an annual program of projects that is then forwarded to UMTA. When these programs are approved, the urban areas may submit individual project requests to UMTA for funding. Thus, PennDOT will have a central role in determining how these federal transit funds are used in the state's urbanized areas by analyzing each area's program of projects and commenting on their consistency with state transportation policies and programs.

Besides providing a role for the states in carrying out the federal program, the 1974 act involves the states in transit activities in many other ways. Pennsylvania will have fewer problems in this regard than some other states, since it has a history of involvement with transit, but some provisions may constrain the state's decision making to a degree. Both the federal capital grants and the operating subsidies programs require matching funds from nonfederal sources. For states in which state and local transit funding has been minimal in the past, this means that new programs will have to be instituted or that federal money will have to be forfeited. In Pennsylvania, on the other hand, the state's established ongoing transit assistance programs should permit its urbanized areas to take full advantage of the new and expanded federal program. PennDOT's planning and technical assistance activities will also expedite this process, especially in aiding the smaller areas to develop sound plans and programs in support of grant applications. For the first time a limited amount of UMTA capital grant money is available for discretionary capital grants to nonurbanized areas (population less than 50 000).

A major requirement of the new act stipulates that federal operating assistance grants be awarded only when the state or local funding is at a level equal to that maintained over the past two years. This is intended to ensure that federal subsidies are supplemental to (rather than substituted for) previous state or local subsidization, an effort that is philosophically in tune with PennDOT's own policy of encouraging operating agencies to make service improvements. However, it should be noted that this will in fact require that PennDOT's purchase-of-service funding be maintained at its previous level or replaced to some extent by local funding sources, which will force a commitment by the state legislature over the next six years.

By requiring that the previous level of nonfederal support be maintained, the provision may limit PennDOT's flexibility in allocating purchase-of-service funds among specific urbanized areas. Areas whose operating deficits have been subsidized by PennDOT in the past and do not increase substantially in the future will not be eligible for federal operating subsidies. Theoretically, if a state had instituted an operating subsidy program, service levels had improved as desired, and ridership gains were offsetting increased operating costs, its urban areas would have to forego the federal operating subsidies. In practice, this should not create a serious problem in Pennsylvania since the bulk of the state's funding has gone to Philadelphia and Pittsburgh, two areas in which there is great need for additional federal support. However, these issues do suggest that it might be preferable for the federal requirement to offer the option that the level of support maintained by the state be measured on a statewide basis.

Other provisions of the act have intermodal implications that will be of concern to PennDOT. First, the requirement that the urbanized areas must develop traffic management plans to facilitate the efficient use of transit vehicles is of direct relevance to PennDOT because the department owns and operates many kilometers of highways in urban areas. Second, the need for intermodal programming of funds may be greater in light of UMTA's hierarchy of fund use, which requires that states consider using highway money from urban system funds or interstate system switchover funds for mass transit capital improvements, although it is unclear to what extent this provision can be enforced. There has been one such switchover in the Philadelphia area, with $200 million worth of transit projects substituted for an expressway, but this involved money from general revenue funds rather than from the Highway Trust Fund. As noted in the governor's budget, it is incumbent upon PennDOT to encourage consideration of such switchovers by local jurisdictions in the future (16, Vol. 2, p. 723).

SUMMARY AND CONCLUSIONS

Pennsylvania has been relatively progressive in the area of mass transportation programming and has over the past 7 years expanded and modified its efforts to improve effectiveness. The state has made a substantial commitment to support urban mass transit and has initiated programs that go well beyond a basic buy in to federal programs. An analysis of these activities, however, points up several issues relating to the organization of the state mass transportation program, the priority attached to the state's commitment to transit, and the state's role in the larger intergovernmental system involved with transit.

Although one of the primary purposes for the creation of state transportation departments is to incorporate the transportation-related activities of the state into one administrative department, a complete consolidation is rarely obtained. In Pennsylvania the regulation of private transit operators is conducted by the Public Utilities Commission, and responsibility for an expanded state-level rural transportation function has been divided between PennDOT and the state Department of Agriculture. There are arguments both for and against assigning these two functions to PennDOT.

More importantly, the incorporation of different modal activities in one department, and even the creation of bureaus with multimodal concerns, do not assure an integrated process of planning and programming. While there is no longer an excess of highway funds in relation to highway needs in Pennsylvania, the dedication of funds specifically to that purpose in effect limits the attention the state can give to transit concerns. Although PennDOT is involved with almost all modes of transportation, to a great extent it deals with each separately; it has yet to become a truly integrated multimodal transportation agency. The need to program transit improvements in conjunction with highway projects may be greater now in light of UMTA's requirement that states consider the use of highway switchover funds for transit projects.

The effectiveness of the capital grants and operating subsidies provided by PennDOT is difficult to measure at this time; they have undoubtedly helped to preserve existing transit systems and to ensure the continuation of service in most of the state's urban areas. In addition, service levels appear to have improved, especially where new equipment has been put into service, and the linking of operating subsidy allocations to performance in complying with the department's operating standards should serve as an incentive for further service improvements. The long decline in transit ridership has been halted in Pennsylvania, and in the last two years ridership has increased statewide. While the exact cause of this reversal is not totally clear, PennDOT's activities can be presumed to have contributed to it. As local agencies continue to report annual operating and financial information in the future, it should be possible to monitor the program's effectiveness more closely.

Finally, it must be concluded that mass transit is truly an area of cooperative intergovernmental programming. Pennsylvania's programs and activities are all intended to stimulate, assist, and support the improvement of transit service provided at the local level. State transit policies must also be sensitive to changes in the federal program in order to provide the most useful package of aid to localities and ensure their eligibility for the federal funds. Pennsylvania, however, is providing assistance at a much higher level than that required to complement the federal program; while federal funds for capital improvements by far outweigh the state's capital grant funds, transit operators in Pennsylvania are receiving and will continue to receive more operating assistance from PennDOT than from UMTA.

PennDOT is playing an important role in carrying out the new and expanded federal mass transit program and at the same time may find itself somewhat constrained by the federal program in terms of its own activities. Much more important, however, is the fact that in general local transit operators in Pennsylvania are in a much better position to partake of the new provisions of the federal program by virtue of PennDOT's on-line programs. The state's established financial assistance, planning activities, and reporting system greatly facilitate complying with UMTA's requirements for participation in the federal program. States without much experience with mass transit programming will have to take some initiative in aiding their localities to take advantage of the federal program. Clearly, transportation needs vary among the states; the Pennsylvania model, or parts of it, may well be appropriate for other urbanized states with an interest in mass transit.

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Abridgment

Innovations in Management of Research and Development

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Effective management of research and development requires effective analysis and evaluation of its programs and projects. At the project level, for example, it is not enough that an effort meet the requirements set forth in the project's work statement; it must also advance or implement an organization's policy. Implementing policy and changing it when necessary is what an effective organization is all about, and its program structure should reflect this. This paper demonstrates an approach to evaluating research and development activities that attempts to achieve this ideal.

A synthesis of management science techniques, including Ackoff's theory of human communication (1, 2, 3) as adapted by Martin (4), and Forrester's theory of systems dynamics (5, 6, 7), was developed to evaluate the significance of projects and programs and their potential contributions, as well as subjective performance factors that may influence the outcome of each individual project or program. A Policy Interaction Potential (PIP) Index was devised to evaluate both the projects and the program containing them in terms of three functions—information, instruction, and policy. These functions were assigned weights that assist in decision making. The informational components carry the least significance and the policy components the most. A simple equation was devised to produce numbers that provide management with information concerning the extent to which its research and development effort is supportive of its policies.

A lot of money is spent on research and development (8)—in 1975 about $34.3 billion (2.3 percent of our gross national product). A more detailed picture of the national research and development effort in 1975 shows that, in terms of funding sources, the federal government provided 53 percent ($18.2 billion), while industry contributed 44 percent ($15 billion). Industry performed 70 percent of the work ($23.9 billion) and the federal government 15 percent ($5.2 billion). For state research and development expenditures, the latest figures available are for 1973, when $340.3 million was spent, more than 63 percent by the federal government.

About 20 percent of our gross national product consists either directly or indirectly of transportation of one kind or another. The U.S. Department of Transportation (DOT) share of this for research and development in fiscal year 1976 is more than $416 million. The total DOT figure represents about a 6 percent increase over that for fiscal year 1975 (9).

The PIP Index was applied to programs and projects at three different levels—international, federal, and state. On the international level, DOT's International Cooperation Program (ICP) was used, at the federal level we used DOT's Federal Highway Administration (FHWA) Federally Coordinated Program of Research and Development in Highway Transportation (FCP), and at the state level we use the Maryland Department of Transportation's Annual Work Program (AWP) under the Systems Planning and Development Division.

DOT has cooperative arrangements with more than 25 countries and international organizations. This gives the department access to foreign research and development activities, and the results of these activities are applied to the solution of U.S. transportation problems. Cooperation takes the forms of information and personnel exchanges, complementary research, and task and cost sharing.

FHWA's FCP sets up research and development activity centered on the most critical problems in seven major categories (10). In this paper, we will analyze category 3—Environmental Considerations in Highway Design, Location, Construction, and Operation. The FCP also coordinates the work of state agencies, private industry, research organizations, universities, and federal agencies.

The Maryland Department of Transportation's AWP is funded by federal, state, and local revenues. In fiscal year 1976, $225 000 was expended for research and development. These studies support a multimodal transportation planning and programming process (11).

EVOLUTION OF THE PIP INDEX

Research and development planning and control techniques

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Figure 1. Project PIP Index for DOT's International Cooperation Program in Poland.

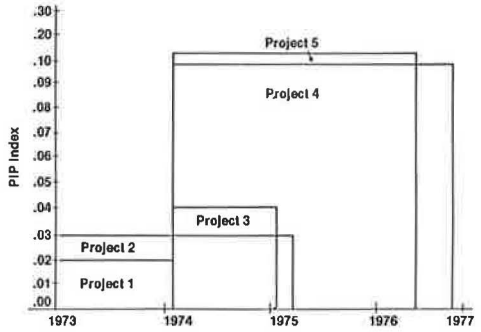
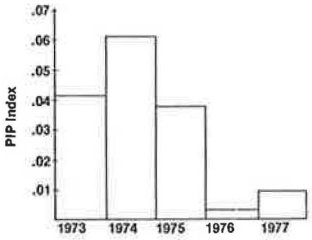


Figure 2. Project PIP Index for FHWA's Project 3B.



were used as a basis for setting up the PIP Index. Our major focus, however, was on Forrester's industrial/systems dynamics, since it has direct input into the PIP Index.

Systems dynamics was developed by J. W. Forrester (5, 6, 7) as a model of organization. Edward Roberts (12, 13) adapted this concept for a dynamic planning and control system for research and development. Roberts was critical of other planning and control techniques because he felt they lacked the basic element of a control system—the human variable, the scientist or researcher. It is the individual who evaluates the progress of a research and development activity; if the individual is not motivated, he or she will be nonproductive and completion time will be affected. Roberts, however, neglected to provide adequate measurement criteria for individual behavior.

This omission was remedied by Ackoff (1, 2, 3), who proposed a theory of human communication by defining "purposeful state," which is based on an individual's perception of his alternative courses of action, probabilities of outcomes, and alterations in the initial conception of a purposeful state. Martin (4) adapted Ackoff's theory and proposed three levels of communication. He called the first level, which refers to information, "inbits"—a message that provides knowledge of new courses of action. He called the second level, which refers to instruction, "hubits"—a message that changes an individual's evaluation of the outcome of alternative courses of action. The third level, which refers to motivation or policy, he called "mobits"—a message that changes an individual's value of the worth of the outcomes of certain actions. This represents a hierarchy from inbits at the most elementary level to mobits at the most sophisticated level. This classification was applied to research and development programs and projects.

The PIP Index is divided into Project PIP and Program PIP. These indices involve a functional relationship and are calculated as follows:

$$\text{Program PIP} = f_I(0.01) + f_H(0.10) + f_M(1.00) \quad (1)$$

$$\text{Project PIP} = [DT_I(0.01) + DT_H(0.10) + DT_M(1.00)]/PC \quad (2)$$

The Program PIP Index is a function of the total number of inbits, hubits, and mobits, multiplied by their respective weights—inbits = 0.01, hubits = 0.10, and mobits = 1.00. The Project PIP Index is a function of the project task costs multiplied by the respective weights in relation to the resources of the whole project.

IMPLEMENTATION OF THE PIP INDEX

The PIP indices were applied to DOT's ICP, FHWA's FCP, and the Maryland Department of Transportation's AWP. The Program PIP Index evaluation of DOT's ICP indicates the relative importance of programs in various countries. Four example countries are shown below in terms of the three functions.

Country	Inbits	Hubits	Mobits	Total
Iran	—	—	3.00	3.00
Israel	0.04	0.10	1.00	1.14
Poland	0.04	0.10	—	0.14
U.S.S.R.	0.06	0.10	1.00	1.16

The program in Iran is the most sensitive to policy (index score = 3.00), followed by the Soviet Union, Israel, and Poland.

Figure 1 shows the Project PIP Index scored cumulatively in Poland. Since project intensity is expected to increase in a cumulative fashion, Figure 1 contains the cumulative values of individual project scores. While the Program PIP Index for Poland was an unimpressive 0.14, there was an encouraging increase as projects were added. Project 1 began with an index of 0.02 in 1973, and, by the beginning of project 5 in 1974, the index had increased to 0.14. This tends to support our expectations that projects will become more sensitive to policy over time.

Application of the Project PIP Index to FHWA's Project 3B (see Figure 2) shows a peak value of 0.06 in 1974; from then on the project had diminishing policy utility. In fact, FHWA has decided to phase out this project. In an improvement over the earlier analysis of Polish projects, better data on task costs permitted the development of an annual indicator for a specific project rather than a cumulative evaluation of projects within a country.

Applying the Program PIP Index to Maryland's AWP shows a Program PIP of 1.46, which indicates heavy emphasis on informational (0.06) and instructional (0.40) components.

Project Number	Inbits	Hubits	Mobits	Total
6000	0.01	—	—	0.01
6001	0.01	0.10	—	0.11
6003	0.01	—	—	0.01
6004	—	0.10	1.00	1.10
All projects	0.06	0.40	1.00	1.46

This indicates that Maryland's Department of Transportation should try to incorporate more policy components in order to implement policy.

CONCLUSION

Two questions may arise: How difficult is PIP to apply? What benefits does PIP bring?

The application of PIP is easy. As illustrated here, it is a procedure that can be applied to existing as well as proposed projects and programs.

Among its benefits, PIP can give management a good idea of the policy value of its programs and projects just by the use of some numbers. For example, when management sees a high mobit count for a project, it can be certain that many policy-sensitive components are in-

volved. When it is used as an ongoing check, PIP can indicate changes and types of changes involved in terms of informational, instructional, and policy components. PIP is versatile. It can be applied to a program, to a project, or to tasks within a project. It can provide management with an overall program assessment as well as detailed project evaluation. PIP is inexpensive. Its application can be routinely set up and become part of a manager's job. A special form could be developed that required program and project information in each of the three areas, with quarterly monitoring to see whether any change has occurred. Moreover, since management is primarily interested in implementing policy, analysis of elements in projects and programs is essential and PIP can do this.

The PIP concept, of course, needs further exploration. It is offered here in a preliminary way as an easy, inexpensive, time-saving tool to help management obtain the best results from its research and development effort. Figures for inefficient research and development in terms of lack of applicability of results are not available, since no one readily admits that his research and development effort is not as productive as desired. There are, however, numerous completed studies that are reviewed and placed on shelves, never to be implemented. Moreover, although these transportation research and development programs may be atypical, they are sufficiently diversified so that successful application of the PIP indices in evaluating them is evidence of the potential application for evaluating other programs and projects.

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State Departments of Transportation: A Perspective

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Since 1959 state governments have been reorganizing their transportation function. This paper provides a current perspective on the movement to state departments of transportation. Public wishes and federal mandates first shaped the evolving state role in transportation into one centered almost exclusively on highways. By the late 1960s, the monumental scale in highway building, particularly of the Interstate system, appears to have precipitated an erosion of the values placed on highways, especially at the national level. State values and priorities are highly individualistic, however, so the movement to state departments of transportation has been an uneven one. Since some 28 states have now formed transportation departments, this is an opportune time for a comparative analysis of states according to whether they have departments of transportation. Our statistical and quasi-experimental analyses indicate that states with departments of transportation differ significantly from those without, in terms of both socioeconomic development and modal emphases. The future of the movement appears uncertain and may well depend on future federal policies.

A majority of the states have now established departments of transportation, but the movement that began with Hawaii in 1959 appears to have peaked in about 1973 with six new departments of transportation created that year and tapered off to five in 1974 and one in 1975. As of March 1975, there were 28 state departments of transportation and 15 more were being considered. Our purpose is to provide a current review and analysis of the state department of transportation movement and, we hope, an improved perspective on a major effort at reorganizing state governments. Our approach is first to develop a broad context; federal influences are highlighted as being central to this context. Secondary data sources are then used in a comparative analysis of states that have formed departments of transportation and states that have not.

BACKGROUND

In studying the department of transportation option, states have examined their total range of transportation activities, conceptualized an organizational form to match these functions, and rationalized this with political realities (1, 2). The department of transportation movement has attracted numerous observers from academia. For example, Ashford (3) commented on the role of state government in transportation and argued persuasively that states should move to departments of transportation. Larson (4) reviewed the historic roles of the state in transportation and pointed out functional areas in which a broader perspective is needed. RuBino (5) examined state departments of transportation in existence through 1970. He identified two general types of organization—hierarchical and equal potential—and implied that state transportation agencies have not developed the strong executive structure appropriate to the state transportation function. Tomazinis (6) examined the role of states in urban mass transportation, focusing on whether the states are prepared to deal with urban transit, since their experience is dominated by highways and has a rural bias. Bennett and DeWitt (7) identified the reasons that states have moved toward departments of transportation, concluding that the reasons are persuasive and the move will probably continue.

Even as this change in state government is in process and its merits or demerits are being debated, the context is changing. At the national level, for example, the Federal-Aid Highway Act of 1973 contains provisions best implemented through a department of transportation, i.e., substitution of transit for interstate segments. But more important—indeed, the basis for the federal action—is the changing state of society. There appears to be genuine public concern for having a broad-minded approach to transportation. While no one fully understands how, or whether, a state department of transportation can provide a wider range of options, there is a strong sense that out of organizational change may come improvement.

By 1900 several forces were directing state and federal attention toward highway transportation to the virtual exclusion of other modes. Railroads, city dwellers, bicycle clubs, automobile clubs, mail carriers, and school boards all added to the clamor for good roads. Indeed, there was national concurrence with the statement made at the 1894 Minnesota Good Roads Conven-

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tion, "To sum up, a perfect highway is a thing of beauty and a joy forever" (8, p. 7).

Both state and federal governments translated this public support into action. By 1929 all 48 states had highway departments and had funded them through a very efficient tax collector, the gas pump. The Federal-Aid Road Act of 1916 created a federal/state road-building partnership that was primarily aimed at meeting rural needs. The Federal-Aid Highway Act of 1934 created a funding process that institutionalized highway engineering and highway planning. This act also set penalities to prevent state governments from spending gas tax money except for highways. The Federal-Aid Highway Act of 1956 established a federal highway trust fund and 90 percent federal funding for a system of Interstate and National Defense Highways.

With the passage of the 1956 act, which launched "the greatest public works project in the history of the world" (9, p. 18), state and federal support for highways reached a lavish high-water mark. And it is important to note that scarcely any questioning or contrary voices were heard from the American public during this half-century. In fact, a Gallup poll taken in May 1956 showed that 76 percent of the American public agreed that there was a need for express highways between cities.

But single-minded attention to optimizing vehicular flow led to inevitable clashes between highway builders and those concerned with other urban activities. These clashes provided the first evidence that an era of uncritical public acceptance of highways and automobiles was ending and that governmental devotion to highways must likewise end.

With the Federal-Aid Highway Act of 1962, Congress attempted to make highway planning continuous (not project by project), comprehensive (not isolated from nontransportation objectives), and cooperative (between federal, state, and local communities)—the 3Cs—but the results were at best mixed. The institutional strength of state highway departments, supported by a continuing public clamor for more and better roads, the absence of an effective mechanism for the articulation of broad community values and goals, and the mechanical complexity of the 3C planning process all conspired to subvert the lofty ideals voiced in the legislation and in the policy documents prepared by the Bureau of Public Roads (10). Comprehensive transportation plans were most often massive freeway plans justified by average daily traffic counts projected into an apparently unchanging future.

Major institutional change came with the creation of the U.S. Department of Transportation (DOT) in 1967. DOT moved to promote balance in planning. It championed landmark legislation, e.g., the Rail Passenger Service Act and the Urban Mass Transit Assistance Act of 1970. It also inevitably accelerated the state department of transportation movement. Prior to 1967, there were only two state departments of transportation, Hawaii (1959) and New Jersey (1966); now there are 28.

Our purpose in the following section is to provide a comparative analysis between states that have created departments of transportation and those that have not. It is worth noting that transportation is not the only area of state government in transition. Examples of a new vitality in state government since 1960 and a new willingness to address complex issues can be found in state planning, budgeting, welfare, education, and all functional areas (11).

COMPARATIVE ANALYSIS

This analysis addresses factors independent of the institution of departments of transportation, such as socioeconomic characteristics of the states, and possible consequences of creation of a department of transportation, such as shifts in modal funding allocations. Our intent is to answer, as fully as possible, the following questions.

1. Do states with departments of transportation differ from states without departments of transportation in terms of socioeconomic development, state government characteristics, relative importance of highways, and state highway institutions?
2. Does creation of a department of transportation appear to alter modal emphases? Do highways suffer? Does urban public transit benefit?
3. Can we gauge the likelihood that the remaining states will create departments of transportation in terms of their similarities to and differences from states that now have departments of transportation?

The scope of these questions and the limited experience with departments of transportation preclude total resolution, but we have attempted to organize the extensive available data in terms of a simple system framework. We first postulated that socioeconomic factors are basic to a state's behavior and would directly influence the state's government structures and processes as well as the state's transportation perspective. Highway influences and characteristics of state highway departments were next considered. Finally, we attempted to gauge the outputs of the transportation system.

On the basis of preliminary scanning, the 48 contiguous states were divided into three groups:

1. No DOT: the 21 states that have not created a department of transportation: Alabama, Arkansas, Colorado, Indiana, Louisiana, Minnesota, Mississippi, Missouri, Montana, Nebraska, Nevada, New Hampshire, New Mexico, North Dakota, Oklahoma, South Carolina, Texas, Utah, Washington, West Virginia, and Wyoming.
2. Late DOT: the 16 states that instituted departments of transportation between 1972 and 1975 and have thus had relatively little time in which to demonstrate changes in transportation policies and performance: Arizona, California, Georgia, Idaho, Illinois, Iowa, Kansas, Kentucky, Maine, Michigan, Ohio, Oregon, South Dakota, Tennessee, Vermont, and Virginia.
3. Early DOT: the 11 states that instituted departments of transportation between 1966 and 1971, demonstrated high initiative in this movement, and have had some time to demonstrate performance: Connecticut, Delaware, Florida, Maryland, Massachusetts, New Jersey, New York, North Carolina, Pennsylvania, Rhode Island, and Wisconsin.

All of the following analyses are based on this classification. The general hypothesis being tested is whether these groups differ in any orderly fashion. Many other ways to classify states in terms of their transportation agencies or other features are, of course, possible. For example, a intriguing possibility would be to disaggregate the states in terms of the type of department of transportation organization (e.g., modal versus functional), but such a classification would be difficult since there are various combined forms of departments of transportation and continuous restructuring within the departments of transportation.

Selected socioeconomic factors for the states were assessed first (Table 1). The three groups, no DOT, late DOT, and early DOT, were clearly different, with the latter two being more highly developed in terms of industrialization, population density, urbanization, wealth, and technical capabilities (as indicated by patent

activity). While the late DOT states had higher values than the no DOT states for all six factors, these differences were not generally large enough or consistent enough to be reflected in the levels of statistical significance. Apparently the states that still do not have departments of transportation are not greatly unlike those that have recently instituted departments of transportation.

We next examined a limited selection of some characteristics of state governments (12). There were no remarkable differences among the three groups of states in terms of levels of expenditure, number of elected officials, or total technical expertise in the agency. While the successful institution of a department of transportation is greatly dependent on the characteristics of the state government, the essential characteristics are apparently not reflected in the basic statistical parameters we used. However, states that have historically been more innovative in terms of instituting a series of policy changes (13, p. 883) were by and large quicker to establish departments of transportation.

The state's reliance on highways (in terms of use of motor and special fuels per capita, vehicle registrations and federal highway aid per capita, and absence of controversy over Interstate highway segments) is considerably stronger in states that do not have departments of transportation, intermediate in those that have recently established them, and least in those that established them relatively early. This supports the logical deduction that creation of a department of transportation is more feasible in states that depend less on highways for their transportation needs. Again, as with the socioeconomic factors, the differences between the no DOT and the late DOT states were considerably fewer than those between the no DOT and the early DOT states.

We thought that differences in the extent of highway influence might be reflected in the state highway departments, but this was not the case for the present groupings. Differences among the three groups were relatively small on state highway revenue as a percentage of total state revenue, highway department payroll and number of engineers as a percentage of the state agency's totals, extent of diversions of highway funds, and accumulated tenure of highway department directors and chief engineers. On the basis of this information, one would not infer that the relative strength of the state highway department acts as a significant block to creation of a department of transportation. However, internal political factors are not accounted for in this analysis.

In considering the performance measures (Table 2), we shift attention from factors that may have contributed to the presence or absence of a department of transportation to the factors that may reflect its actions. Historically, the states that now have departments of transportation seem to have devoted at least as much effort to highways as did states that do not now have departments of transportation. The investment in planning was greater in states with a department of transportation, work on the Interstate system progresses as fast, and, although the early DOT states lagged slightly in commitment of non-Interstate highway funds, they more than made up for it by spending more money than that required to obtain matching federal funds. There was a slower rate of obligation of Interstate appropriations by the early DOT states in 1973 than in 1968, counterbalanced by a relative increase in the rate of obligation of non-Interstate appropriations. More notable is the slower rate of completion of Interstate highways, both urban and rural, by the early DOT states in 1973. On balance, it appears that departments of transportation have been less active in support of the Interstate highway program than their highway department counterparts.

At this point such a conclusion assumes that the institution of the department of transportation is what made the difference. Obviously, this is not the only possible interpretation. Historical forces acting during this period may not have affected all states equally. The increase in federal matching support for non-Interstate programs has different implications for a state that is investing heavily in urban transit and a state that has great need for rural roads. According to a recent survey of chief executive officers of state highway departments and FHWA directors in each of the states, there are also perceived differences in support for public highways, environmental consciousness, and demands for urban transit between more and less economically developed states (17).

Effort directed to transportation modes other than highways varies considerably and systematically, with states that have departments of transportation showing higher effort (Table 3). States with departments of transportation spend more (and intend to do so in the future) on urban public transit and on airports. In sum, states with departments of transportation display a keener attention to nonhighway modes in both past and planned expenditures.

Our findings to this point indicate major differences among the three groups in terms of socioeconomic development and performance in regard to both highways and other modes of transportation. To attempt to separate the effects of socioeconomic factors from those associated with the presence of a department of transportation, it is appropriate first to consider some methodological points. In essence, what we have is a research design in which the groups being compared are not equivalent before the experimental treatment (creation of a department of transportation) takes place. Thus, we must deal with the ambiguity of whether observed differences are due to the treatment or to other changes taking place, e.g., political switches or shifts in public attitude within the states (21, 22).

Intuitively, one might consider that a matching procedure would resolve this ambiguity. That is, if one picked subgroups of the early DOT states and of the late DOT or no DOT states that were similar in certain characteristics at time 1, then any differences between the two subgroups at time 2 would be attributable to the institution of a department of transportation. However, as Campbell and Stanley (22) explain, this is not a secure approach since it is subject to a statistical artifact of regression to the mean. A standardized change-score analysis (23) appears to be appropriate to account for differences among the three groups of states before the institution of departments of transportation. Such an analysis indicates that the early DOT states showed a greater decline in the rate of obligation of Interstate appropriations in 1973 ($t = -1.91$, $p < 0.04$) and in the percentage of rural ($t = -2.72$, $p < 0.01$) and urban ($t = -1.80$, $p < 0.04$) Interstate highways completed as of 1973. However, their higher expenditure for airports (total and per capita) was not significantly different from that of the no DOT and late DOT states.

We are able to refine the results through multiple time-series analyses (24). Basically this procedure notes the behavior of the data series up to the point of the intervention, then seeks to determine whether the series behavior changes shortly after the intervention. We looked for changes in slope for such measures as rate of obligation of Interstate appropriations and percentage of completion of rural and urban Interstate highway systems. We performed such analyses for the group of 11 early DOT states, for the 37 late DOT or

Table 1. A comparison of socioeconomic factors.

Factor	No DOT	Late DOT	Early DOT
Manufactures, value added per capita, $	860	1170	1530
Population	2 530 100	4 731 300	5 895 100
Urban population, percent	59.4	60.0	73.1
Income per capita, $	2583	2764	3151
Patents per capita	0.012	0.016	0.037
Population per square kilometer	16.8	30.7	160.3

Notes: 1 km^2 = 0.4 mile^2.
Differences among the three groups are all significant at the level of p = 0.01. Differences between the no DOT and late DOT groups are not significant except for manufactures, value added per capita (p = 0.08), and population per square kilometer (p = 0.06).
All data shown are for 1966 except manufactures, value added per capita (1976), and patents per capita (1968).

Table 2. A comparison of some performance measures concerning state highways.

Factor	No DOT	Late DOT	Early DOT
Interstate highway funds obligated (14)[a]			
1968	336	346	316
1973	285	285	222
Non-Interstate highway funds obligated (14)[a]			
1968	329	332	276
1974	277	260	263
State funding above minimum matching requirements (1954-1970), % of total expenditures (15)			
Interstate highways	6.9	8.7	12.1
Non-Interstate highways	26.6	34.6	44.9
Designated urban Interstate highways completed, %[b]			
1965	47.5	55.6	48.5
1973	80.1	82.5	72.1
Designated rural Interstate highways completed, %[b]			
1965	39.5	46.6	44.6
1973	80.8	84.0	71.1
Total state highway planning expenditures (16)			
1966	1 165 000	1 876 000	2 190 000
1974	1 694 000	2 558 000	3 354 000

Note: Differences among the three groups are significant at the p = 0.05 level for total state highway planning expenditures in 1966 and in 1974 and at the p = 0.01 level for Interstate highway funds obligated in 1973, non-Interstate highway funds obligated in 1968, and state funding above minimum matching requirements for non-Interstate highways. Differences between no DOT and late DOT are significant at the p = 0.08 level for total state highway planning expenditures in 1966 and in 1974.

[a]Figures shown reflect the amount of appropriated federal funds obligated by the states. An index of 200 indicates the obligation of all funds from the previous year; an index of 300 indicates obligation of all funds for the current year; a figure above 300 indicates the percentage of funds obligated for the coming year.
[b]Data supplied by the Interstate Report Branch, Federal Highway Administration.

Table 3. A comparison of some indicators of performance concerning various transportation modes.

Factor	No DOT	Early DOT	Late DOT
State transportation costs devoted to nonhighway modes (18), %			
1971	16.2	14.9	30.8
1989	23.8	27.1	45.7
State transportation costs devoted to urban public transit (18), %			
1971	5.8	9.8	22.0
1989	9.7	18.5	35.4
Expenditures of UMTA funds (19), $	2 218 000	14 374 000	21 936 000
State expenditures for airports, $			
1967	489 000	1 266 500	3 951 000
1973	697 000	2 829 800	14 609 000
Projected needs for 1974-1990, assuming no categorical funding restrictions (20), $			
Urban public transit	206 000 000	568 560 000	1 392 560 000
Airports	250 000 000	320 000 000	387 500 000

Note: Several differences among the three groups are significant: state transportation costs devoted to nonhighway modes in 1971 (p = 0.05) and in 1989 (p = 0.01), state transportation costs devoted to urban public transit in 1971 and 1989 (p = 0.01), state expenditures for airports in 1967 (p = 0.05) and in 1973 (p = 0.01), and projected needs for 1974-1990 for urban public transit (p = 0.01). The difference between no DOT and early DOT is significant for state transportation costs devoted to urban public transit (p = 0.05).

no DOT states, for three trios of early DOT states grouped by year of instituting the department of transportation, and for individual early DOT states.

The results were ambiguous. The group of 11 early DOT states showed a relative dip in both obligations of Interstate funds and rates of completing Interstate systems compared with the 37 other states. Two of three trios of early DOT states showed statistically significant reduction in the obligation of Interstate highway funds shortly after their departments of transportation were instituted. However, for the individual states, the shifts in these highway performance measures did not follow institution of a department of transportation in a neat fashion; e.g., the substantial drop in Rhode Island's rate of obligation of Interstate highway funds appeared to begin the year before its department of transportation was created.

The early DOT states do exhibit some enhancement of nonhighway mode activities and some decline in certain highway programs, particularly Interstate, between the mid-1960s and early 1970s compared with the other states. But we cannot attribute these relative shifts in programmatic support to the actions of new departments of transportation. Another plausible explanation is that certain forces, possibly altered social values and political priorities in regard to transportation needs, that emerged in some states enhanced the likelihood both of creation of a department of transportation and of shifts in support from highways to other modes.

SUMMARY

The state department of transportation movement springs from a rich context. Historically, state governments were guided and directed by the federal government in creating highway departments, in funding them from highway-user revenues, and in providing a rural program emphasis. Under detailed federal tutelage and with massive public support, a highway-oriented transportation role emerged for state governments. A change in national emphasis led to the establishment of the U.S. Department of Transportation and the passage of numerous federal laws oriented toward broader transportation concerns. There has been a concomitant lowering of the national priority for highways. But the states are unique in their transportation needs and priorities, and the issues here deserve careful study.

We return to the three questions posed earlier.

1. Do states with departments of transportation differ from those without? In terms of socioeconomic development, they definitely do. In terms of the statistical characteristics of state government, they do not do so prominently. In terms of relative importance of highways, they definitely do. In terms of the characteristics of state highway departments, they do not differ to any substantial degree.
2. Does creation of a department of transportation alter modal emphases? We cannot say that creation of a department of transportation causes the changes noted, but we can remark on the differences between the early DOT states and the others, including a greater increase in airport funding in states that have departments of transportation in operation. Do highways suffer? Some decrease in Interstate highway activity appears to have

taken place in states that established departments of transportation between 1966 and 1971. Does urban public transit benefit? After taking levels of state socioeconomic development into consideration, we conclude it does not; the urban states tend to have the departments of transportation.

3. Can we gauge the likelihood that the remaining states will create departments of transportation in terms of their similarities to and differences from the states that now have departments of transportation? Will the differences noted be reflected only in the timing of the creation of departments of transportation or will they not be instituted at all? It is possible to speculate directly on the logical candidate states for establishment of departments of transportation. Leaving aside Alaska, the following listing reflects an ordering in terms of economic development and reliance on highways and hence an assessment of the degree of similarity between a given state and the present states that have departments of transportation: (a) states both relatively high in economic development and low in projected highway needs as a percentage of transportation needs for 1989: Washington, Indiana, Colorado, Missouri, Texas; (b) states relatively high in economic development and moderate in projected highway needs: Minnesota, Nevada; (c) states relatively low in projected highway needs: Alabama, Louisiana; (d) states with mixed characteristics: New Hampshire, South Carolina; and (e) states relatively low in economic development and high in projected highway needs: Arkansas, Mississippi, Montana, Nebraska, New Mexico, North Dakota, Oklahoma, Utah, West Virginia, Wyoming.

It appears that the rate at which states are forming departments of transportation is decreasing and, hence, it is not unlikely that many of the states in the latter categories of the listing above will elect not to create departments of transportation within the immediate future, unless they are further prompted by changes in federal policies.

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Managing Highway Safety

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A study team examined current management practices in state and local highway safety agencies and private organizations, as well as the role played by the governor's highway safety representative. Model solutions, based on samples of excellence found in the first phase of the study, were developed for state agencies, local units, and state surrogate units that would serve communities that do not have a local agency. The study team also recommended a more active role for the federal government in developing funding sources, revising program requirements to better serve the management models, and increasing political visibility of the highway safety issue.

This paper reports on a study to analyze the current management of state and local highway safety programs and to define ways in which the management practices of these programs can be strengthened. This study was designed to assist managers of state and local highway safety programs to meet the requirements of the Highway Safety Act of 1966.

The objectives of the study were to

1. Identify the current management practices and environmental circumstances of the national highway safety program as it is being implemented by the states and local governments and to identify the related roles of private agencies and
2. Develop a series of model solutions (organizational and programmatic recommendations) for broad application to management practices of state and local highway safety programs on the basis of observed instances of excellence in management practices of those programs studied. The model solutions were intended to be pragmatic approaches that can be adopted, for the most part, under current circumstances.

The scope of this study does not include a technical analysis of how effective the highway safety program or any of its activities are in reducing traffic fatalities and accidents. The emphasis is on providing a management analysis of state and local highway safety programs to discover approaches that will make the highway safety agencies or units more effective vehicles for program management. The recommendations for the federal government address U.S. Department of Transportation actions that might support the achievement of the model solutions at the state and local levels and the involvement of the private sector.

The project team proceeded on the working hypothesis that improving the management practices of the governor's highway safety representative (GHSR) will produce a reduction in traffic fatalities and accidents as a result of the application of more effective countermeasures, improved coordination, and conservation of resources. Model solutions represent the study team's organizational and programmatic recommendations for strengthening the management practices in state and local highway safety programs.

GOVERNMENT ACTIVITY IN HIGHWAY SAFETY

The 50 states and their political subdivisions have had long-standing highway safety programs. These state and local programs have differed considerably in state and local support, consistency of highway safety standards, and degree of substantive emphasis. In 1966 the federal government established a national highway safety program to provide an increased measure of financial support for highway safety at the state and local levels and to introduce national standards so that there would be a more consistent approach to highway safety in the states. State highway safety agencies (SHSAs), under the direction of the GHSR, were required in each state to coordinate planning and program management. These SHSAs constituted a new organizational approach in state government for the purpose of focusing decentralized activity on a specific objective.

Highway Safety Program in State Governments

By comparison with other governmental programs, highway safety does not currently enjoy high political visibil-

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ity or support because it is not generally a politically sensitive or emotion-provoking issue. This lack of political visibility has, in turn, created a milieu in which agencies that deal with highway safety must constantly strive to prove the efficacy and desirability of their program proposals. Similarly, the lack of commitment at the state level has often caused states to view the national highway safety program as a federal government program, distinct and separate from state activities.

In spite of this rather difficult environment, some SHSAs have been able to muster political support on the basis of

1. The implications of losing federal highway safety program funds and a portion of federal highway construction funds if requirements for planning, coordination, and compliance with federal standards are not met;
2. Historical involvement and concern of the political jurisdiction at the executive, legislative, and operating levels;
3. Initial or current support of key political and private leaders for highway safety; and
4. Location of the SHSA at the political level in the state government.

Highway safety operating responsibilities are distributed among a number of line departments in the state government. This division of operating responsibilities and expertise complicates the establishment of an effective program-oriented management unit for state highway safety programs.

Since the various line departments are called upon to administer the elements of a state highway safety program, the role of the SHSAs has sometimes been abased to one of grants administrator for federal highway safety funds under sections 402 and 403. In some states, the role of the SHSA has been significantly broadened to one of considerable leadership in state highway safety activities. Some of the key variables in determining the degree of leadership displayed by the SHSAs in coordinating and encouraging the various line departments include

1. The placement of the SHSA at the policy level and identification with the governor, with implied or actual access to the governor;
2. The personal leadership qualities of the GHSR and his level of concentration on the SHSA (i.e., does he work full time or part time on highway safety?); and
3. The amount of state funds, in addition to federal funds, committed for central highway safety unit activities.

There appears to be a substantial lack of concurrence among professionals associated with highway safety about which strategies and approaches are the most effective in reducing fatalities and accidents. The establishment of clear definitions of successful approaches suffers from a lack of evaluation data and the complex nature of the problem itself, e.g., multiple causation of accidents, social problems, and public apathy. This lack of evaluation data creates long-range planning problems because it is often difficult to establish a correlation between a state or local project and any reduction in accidents or fatalities.

The SHSAs have evolved largely as project-oriented planning units. This apparently stems from the format of the Comprehensive Highway Safety Plan and the Annual Work Plan, which are geared toward the acquisition of federal funds and implementation of the federal uniform standards and not necessarily toward comprehensive statewide highway safety planning. Their reports are therefore not, for the most part, used as policy tools by decision makers and are largely underused for program purposes.

Most of the planning activity at the state level still remains with the line departments, which concentrate on individual functional areas at the expense of comprehensive planning.

Evaluation suffers from a lack of recognition and credibility as a tool for policy development and decision making, partly due to the lack of incentives for its use. However, state budget officers and state legislators are increasingly paying attention to evaluation findings. There is a slowly emerging effort to establish more sophisticated methods of evaluation in a few states; however, this effort is impeded by a lack of resources and basic research on practical and simplified measures of effectiveness.

Environment at the Local Level

There is considerable diversity in local highway safety activities. Centralized local units are the exception rather than the norm. Most local activity is decentralized among local line departments, special districts, and the courts.

The national highway safety program does not appear to have generated significant local management activity in highway safety. It has had an effect in the area of providing specific project funds to sustain and enhance existing local highway safety units.

Private organizations, such as safety councils, often form the key centralized planning and program development agencies in a given locality. This usually occurs when there is an absence of governmental activity, but countywide private organizations are found to be a supplementary resource to complement and enhance local government activities.

With few exceptions (notably the Traffic Improvement Association of Oakland County, Michigan), local highway safety management units have a narrow program focus (e.g., a single function such as police-traffic services or public information) and an extremely limited professional capability.

Perhaps the most significant reason that there is a lack of emphasis on highway safety at the local level is that the problem is relatively small in any given community. In relation to other problems, such as crime, taxes, and the environment, highway safety cannot command the requisite outlay of funds to sustain an intensive local program.

Model State and Local Management Solutions

The management responses to environmental questions in the six states surveyed by the study team provided the basis for model management solutions and recommendations.

State Level

At the state level, the principal program management recommendations for strengthening state highway safety programs focus on the GHSR and the SHSA.

The SHSA should be established as a leadership element in the state government. Leadership encompasses developing strategy for

1. Attaining favorable political visibility for the highway safety program and the unit itself,
2. Promoting legislation for highway safety activity and standards,

3. Influencing line department budgets and programs,
4. Initiating local-level highway safety efforts, and
5. Fostering increased and better coordinated private activity in highway safety.

The governor and legislature should ensure that the SHSA establishes a state-level planning process and is responsible for its coordination and that state line departments coordinate their programs and budget requests with the SHSA.

The state highway safety agency should

1. Interrelate SHSA activities with the state line departments and localities and with the private sector;
2. Foster sound project development in the line departments, based on accident reduction objectives;
3. Develop a program planning process through interdepartmental and intergovernmental task forces and foster line departments' multiyear planning;
4. Promote an increased concentration on evaluations;
5. Foster the development of planning capabilities at the local level;
6. Use its own and state line department field staffs for assisting localities; and
7. Prepare an annual legislative agenda that incorporates line department, SHSA, and governors' require-

Figure 1. Model organization for usual state structure.

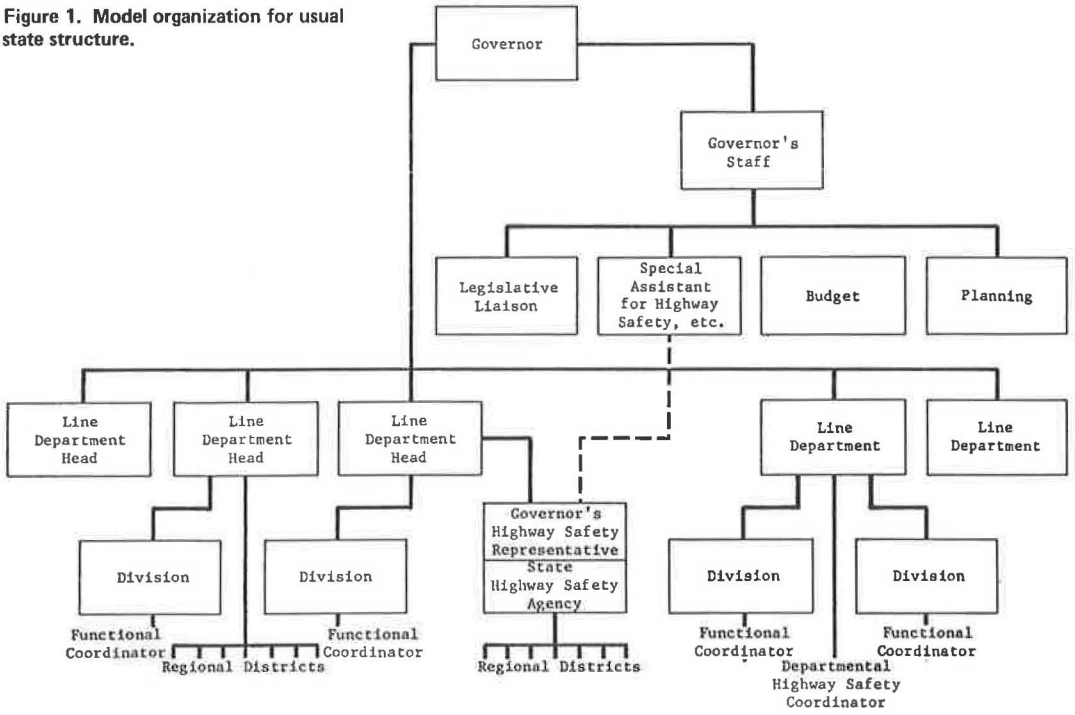


Figure 2. Model organization for superagency or umbrella state structure.

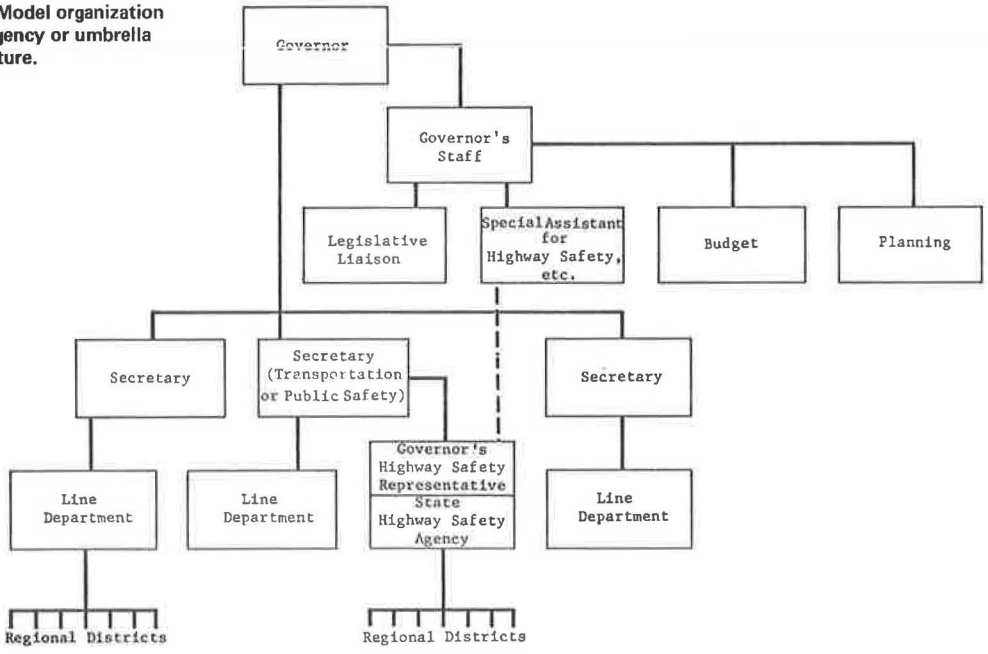


Figure 3. County line department model for local highway safety unit.

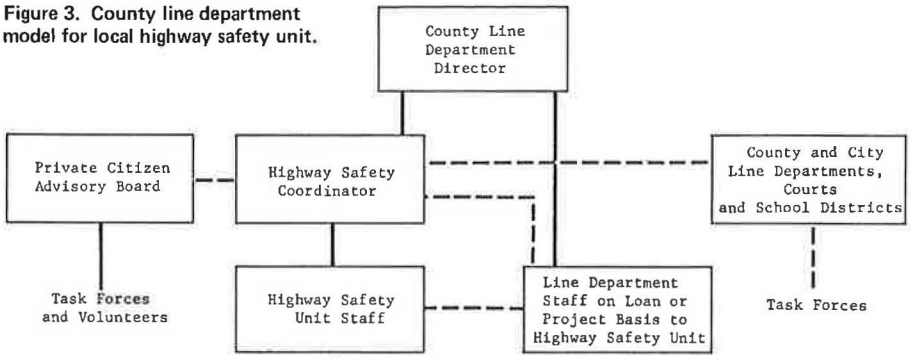


Figure 4. County commission model for local highway safety unit.

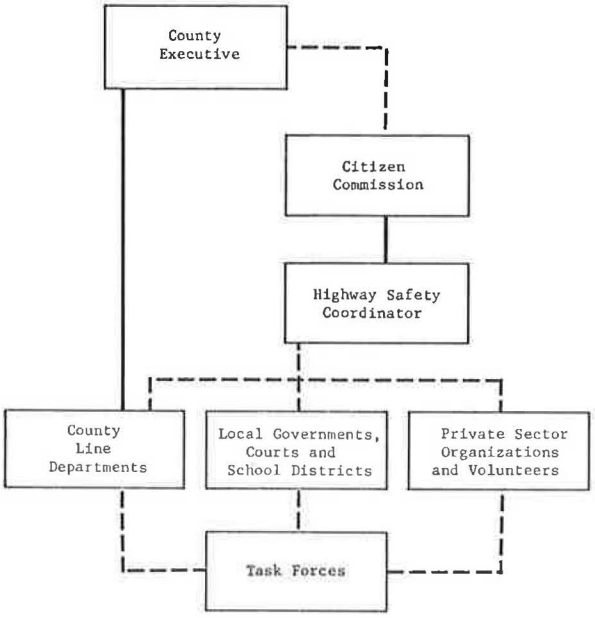
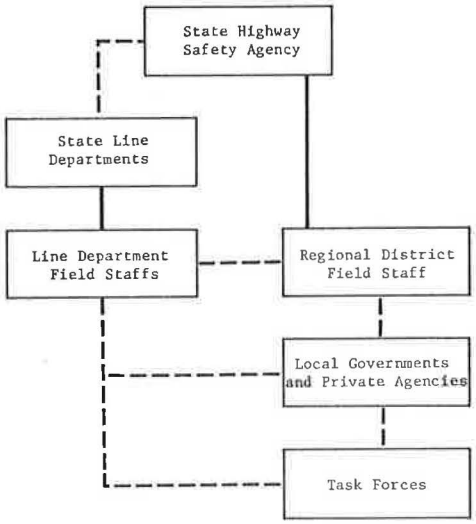


Figure 5. State surrogate model for local highway safety programs.



ments, and review budgetary requests of line departments in cooperation with the budget office.

The state highway safety agency should be headed by the GHSR, who is appointed for a term concurrent with the governor's. His or her principal deputy should be a coordinator who is a career civil service professional and who gives technical direction to the SHSA staff.

The SHSA should be placed organizationally in the office of the secretary of a major line department. The SHSA should act under the aegis of two coordinating committees—the Governor's Highway Safety Policy Advisory Committee, to deal with the private sector and with high government officials, and the state line department or local government operations coordinating committee. The state highway safety unit should conduct regional or county activities with resident staff in the regions. Figures 1 and 2 depict model organizational arrangements.

Local Government

Two principal models are suggested to deal with the diversity in local highway safety program activity—the local government highway safety unit model, which offers recommendations on how an established unit can strengthen its management practices, and the state surrogate model, which is directed at localities that do not have a highway safety unit.

The local highway safety unit may be either a private agency or a unit of government; it should have a full-time highway safety coordinator. The efforts of this unit should concentrate on initiating projects with local line departments, courts, and special districts that have the potential to continue their operations after the pilot period; fostering interdepartmental task forces for planning purposes; and coordinating activities with the SHSA. Models for the organizational structure of these activities are shown in Figures 3 and 4.

The state surrogate model requires that the field staff of the state highway safety unit serve as de facto local highway safety coordinators. In this capacity, the field staff would provide such services as

1. Organizing local highway safety projects by working with local officials, line departments, courts, and special districts on an areawide basis;
2. Promoting the establishment of local highway safety units and a local highway safety planning process, using community organization techniques;
3. Promoting the formation of groups from the private sector and their involvement in local projects; and
4. Identifying state resources and promoting their application to assist localities.

Highway safety agency field staff should have offices in the regional districts they serve. Figure 5 presents the

state surrogate model structure.

PRIVATE ACTIVITY IN HIGHWAY SAFETY

Involvement of the private sector occurs at the national, state, and local levels. It takes the forms of staffed private agencies performing functions related to highway safety, volunteer associations and civic groups that concentrate on specific issues or projects, highly sophisticated university training and research centers, and private industry. Activity in the private sector has changed in the nature of its organizational makeup, but it does not appear to have diminished in intensity in recent years.

At the national level, the major organizations related to highway safety are active in public information and the promotion of highway safety legislation, and are increasing their field staffs for technical assistance. In addition, there are continuing attempts among the major groups in the private sector to join in cooperative efforts.

Competing demands for private funds have diminished the access of older, more established highway safety organizations to the traditional funders of highway safety activities in the private sector. There have been attempts to organize statewide highway safety organizations for the purposes of communication and coordination, but these attempts have not proved very fruitful. Voluntary organizations and university institutes are emerging as forceful groups and therefore represent a potentially significant element in the promotion of highway safety. There is generally little coordination between private-sector activities and state government activities.

Most private-sector activity at the community level centers on the actual conduct of highway safety projects, such as school pedestrian safety. Local highway safety commissions are a major source of input from private citizens; several states have established such commissions.

The private sector should attempt to establish a constructive interface with the SHSA and local highway safety officials. At the statewide level, private groups could coordinate with and assist the SHSA by, for example, establishing a statewide private-sector coordinating organization (possibly as an outgrowth of the state organization), and considering the formation of a private corporation to provide direct services to localities. The SHSA should promote these private initiatives and provide staff support for them at least through their preliminary states of development.

ROLE OF THE FEDERAL GOVERNMENT IN DEVELOPING THE MODEL SOLUTIONS

The role of the federal government was not directly examined in this study. The recommendations that follow are oriented toward federal activities and sponsorship of model solutions.

The federal government, through the National Highway Traffic Safety Administration (NHTSA) and the Federal Highway Administration, could contribute to the management of state highway safety programs principally by

1. Revising the Comprehensive Highway Safety Plan and Annual Work Program requirements so that they are consistent with the GHSR's state planning and management role as identified in the model solutions;
2. Requiring that comprehensive state plans encompass all state highway safety activities and not just the uniform standards;
3. Requiring discretionary funding from Congress to promote innovations at the state level;
4. Promoting the development of and incentives for the application of evaluation methodologies and measures of effectiveness that are within the capacities of state agencies; and
5. Requesting a place on the agenda of the National Governors' Conference and the National Conference of Mayors and making annual reports to these groups to raise the chief executives' awareness of highway safety.

To focus attention on the role of the private sector in assisting state and local governments, NHTSA should reactivate the coordinating committee that is composed of the major private-sector interests involved with highway safety. This committee would have as its primary purpose the periodic identification of joint areas of interest between the private sector and the U.S. Department of Transportation.

ACKNOWLEDGMENT

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Educational Requirements for Administering Highway Safety Programs

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This paper reviews the historical background of programs for training personnel in the administration of highway safety programs. It notes that federal legislation causes graduates of safety programs to move from one area to another among highway safety, occupational safety, transportation, law enforcement, and so on. There are problems in filling these positions, especially with the current minimal funding for personnel development. An example of one state's approach to administering programs to develop personnel for highway safety programming is presented to show the administrative principles used as well as the extensive planning necessary to pursue and maintain a personnel development program to cover identified educational and training needs.

The purpose of this paper is to discuss educational and training requirements for highway safety program administration. We believe that the ability to administer either single facets or entire program elements depends on the quality of the professional preparation of the personnel available for assignment to any particular program activity or responsibility. With some modifications, we will use the definitions developed by the National Safety Council (1) for specific terms that appear in this paper.

The term "highway safety personnel" denotes all persons working full time or part time in an administrative, supervisory, research, professional, specialist, or technical capacity in employment that requires specific knowledge of the principles and practices necessary to implement the highway safety standards established by the National Highway Traffic Safety Administration (NHTSA).

Administrators, managers, and supervisors are those who are responsible for managing, directing, and coordinating either specific activities of a major function or a total program that encompasses many functions. Included in this category are persons who may be termed generalists who have responsibilities that encompass the broad range of highway safety activities. In evaluating programs and counseling on improvement of activities, these people need a broad perspective and understanding of the many functional areas that make up a total highway safety program at the local, state, or federal level.

Professional personnel includes those persons engaged in jobs that require at least a college degree, such as traffic engineers, driver education teachers, or automotive engineers.

Specialists or technical personnel are those persons, such as motor vehicle inspectors, law enforcement officers, accident investigators, emergency medical specialists, and traffic-court personnel, who require some specialized training but not as much as that required by professional personnel.

HISTORICAL BACKGROUND

Little concern has been expressed about education and training programs for highway safety personnel from the initial development of motor vehicles until 10 years ago. This is not to say that there have not been outstanding educational programs for traffic engineers, traffic law enforcement personnel, driver education teachers, or the other 130 different job types or 36 composite occupations in highway safety described in a 1968 study (2) nor that a number of organizations or agencies have not devoted staff time and financial resources to the development of education and training programs. However, there has not been a national commitment on the part of both the federal government and the private sector for quality education and training programs for highway safety personnel. Even today that coordinated commitment is missing.

The 1924 National Conference on Highway Safety barely touched on education and training needs. In 1937 the Automotive Safety Foundation was established by the automobile industry and related groups. One of the basic charges to the foundation was education and training. Their record over the years speaks for itself through scholarship grants, research grants, publications, and many other types of support for education and training programs for highway safety personnel.

In 1938 the Traffic Education and Training Committee was established. Today this committee is part of the Traffic Conference of the National Safety Council. From

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the beginning this committee has recommended support for quality education and training programs for highway safety personnel (1). Representatives from approximately 40 organizations serve as members of this committee, which has been responding for nearly 40 years to its initial charge of recommending needed education and training programs to improve highway safety. It has neither the financial resources nor the official responsibility to implement and carry out its recommendations.

A number of organizations or programs have helped to educate and train highway safety personnel. The most notable have been:

1937—Traffic Institute, Northwestern University, which primarily trains law enforcement personnel and traffic engineers.

1937—Yale Bureau of Traffic Engineering, which prepared traffic engineers; since 1968 it has been located at Pennsylvania State University.

1937—Center for Safety Education, New York University, which offers graduate programs in safety.

1945—National Commission on Safety Education, National Education Association, which was active in numerous areas of school safety education until its termination in 1971, when the Automotive Safety Foundation withdrew its funds. One organization staffed by the commission, the American Driver and Traffic Safety Education Association, carries on many of the commission's traffic safety activities and remains as a department of the National Education Association (NEA).

The Highway Safety Act of 1966 established an Office of Safety Manpower Development in the National Highway Safety Bureau, now the NHTSA. Since it has limited resources and personnel, this office has not exerted leadership for the education and training programs that are urgently needed in the United States today.

FEDERAL LEGISLATION

During the past 10 years more than 70 laws have been passed by the U.S. Congress that relate to safety and that have implications for qualified available personnel, including the Highway Safety Act of 1966, the Law Enforcement Assistance Act of 1968, and the Occupational Safety and Health Act of 1970. If fully implemented at the regional, state, and local levels, these laws would create a personnel need in the vicinity of 4 000 000 people.

When the personnel needs of approximately 67 other laws are added to this, it is obvious that, if the enacted legislation were fully implemented, highway safety personnel could be trained for highway safety but be employed by other agencies concerned with a much wider variety of safety activity. A well-qualified police officer with a background in traffic safety, given additional training, could move into the area of occupational safety and health as a director of industrial safety for an industry in which traffic safety is just one of his responsibilities, or into the law enforcement area in a state or federal government agency as a staff person responsible for law enforcement assistance programs. Although the financial support provided by legislation is greatly needed, the legislation creates a demand for personnel in each area of safety that may actually drain off well-qualified highway safety personnel to other positions.

PRESENT NEEDS

In addition to the personnel needs previously listed, young people in elementary and secondary schools today have little opportunity to learn about the career opportunities currently available in the highway safety field. One of the problems is that many of the position titles in the 36 composite occupations, which include more than 130 individual job descriptions (3), are not readily available to elementary and secondary school teachers or guidance counselors.

The Occupational Outlook Handbook (4), published by the U.S. Department of Labor's Bureau of Labor Statistics every other year, contains job descriptions and employment outlook information for white-collar, blue-collar, and service occupations. The publication is designed as a basic reference source for vocational counselors and personnel planners, as well as for people seeking career information. Of the more than 800 occupations listed, only a few could possibly be classified as related to highway safety: police officers, state police officers, intercity bus drivers, local transit bus drivers, local truck drivers, long-distance truck drivers, parking attendants, taxi drivers, automobile mechanics, motorcycle mechanics, and truck and bus mechanics.

Highway safety positions are not specifically listed in the Occupational Outlook Handbook, nor are transportation safety positions listed. Guidance counselors and teachers are at a disadvantage in recommending highway safety positions as career opportunities to their students. With the lack of career guidance information in this field, a steady flow of new personnel to fill developing jobs or as replacements for retiring personnel is not forthcoming. However, some driver education textbooks are beginning to include units on career opportunities in highway safety and transportation safety (5).

Much more research also needs to be done by the individual states to determine specific highway safety personnel needs. Education and training requirements can then be planned to meet these existing needs. The Booz, Allen, and Hamilton study (2) laid a groundwork at the state level. The National Association of Counties conducted a second study of highway safety personnel needs in 1970-71. The survey identified highway safety personnel required at the local, city, and county levels.

What the separate states need to do now is to identify personnel needs at specific locations and to develop plans for educational and training programs to meet these needs. Missouri's activity in developing education and training programs to prepare qualified highway safety personnel is not a singular approach. It incorporates many of the facets of earlier traffic safety efforts and recommendations promulgated by agencies and organizations previously cited in this paper.

MISSOURI'S SAFETY CENTER

In 1965 and 1966 leaders in Missouri realized that one college or university in the state should specialize in safety. In 1966 the Missouri Commission on Higher Education, in collaboration with the Governor's Traffic Safety Coordinating Committee, requested that Central Missouri State University (CMSU) develop the Missouri Safety Center. On July 1, 1967, the Missouri Safety Center became operational. The center had four specific charges: instruction at the undergraduate and graduate levels, research, publications, and special services.

As CMSU began to assemble staff for the Missouri Safety Center, operational guidelines were developed. The guidelines, adapted from an NEA publication (6), have been adjusted periodically to stay abreast of expanding activities. On September 1, 1971, because of the rapid growth in the number of students, courses, and programs, the School of Public Services was established. It included the Departments of Criminal Justice Administration, Safety, and Industrial Safety and Hygiene, and

the Missouri Safety Center. Units of the center include: the National Center for the Administration of Criminal Justice, Publications, Special Services, Project Management, and the National Public Services Research Institute.

The Missouri Safety Center is an organization formed by CMSU and dedicated to highway accident prevention and other safety fields. It draws the institution's resources together in a common effort, providing a liaison unit that serves college personnel, state and local officials, business, industry, professional interests, and the public at large. It uses a staff of specialists and the services of personnel from many academic departments to provide organized leadership and a unified program in accident prevention.

The following guidelines provide direction for the center.

1. The center is an instrument of all the departments and schools of the university.
2. The center uses the university's total resources on an interdisciplinary basis.
3. The center uses a staff of specialists and the services of professional personnel from various academic departments and administrative offices to provide academic programs, conferences, short courses, research activities, publications, and public information programs for the entire state of Missouri.
4. The center does not duplicate efforts conducted elsewhere in the university.
5. Those associated with the center program are employed and recognized on the same basis as their counterparts elsewhere in the university. Dual or joint appointments of academic and research staff for the center enable each staff member to preserve his identity with his particular discipline and at the same time to contribute from his discipline to the projects and activities of the center.
6. The dimensions of the center's program will develop in the directions and to the extent that the university believes will help it to fulfill its role as the safety center for the state of Missouri and as a national safety center. Areas of interest include school safety, traffic safety, Traffic Management Institute programs, law enforcement, industrial safety, sanitary science, industrial hygiene, traffic engineering, fire science, aviation safety, transportation, public administration, agricultural safety, and other safety areas to meet the needs of the state.
7. The university provides the basic financial support for establishing and operating the center, with supplemental support from legislative appropriations, foundation and government grants, and other sources. A specific budget is allocated from general university funds for the center to conduct its programs and activities.
8. Responsibility for policy decisions on the center's organization, procedures, programs, and budget is vested in the university president.
9. Administration of the center's program is the responsibility of its director (under the supervision of the vice president for academic affairs) whose rank and function are such as to provide managerial authority. The director of the center is in charge of its day-to-day operations, the activities of the staff, and management of its program. He or she remains in close communication with the vice president for academic affairs on matters involving changes and extension of the center's programs and particularly on those that may involve university policy.

As of June 1, 1975, the School of Public Services was authorized to offer undergraduate degrees in criminal justice administration, corrections, driver and safety education, fire science, industrial safety, industrial security, safety, and sanitary science, as well as graduate degrees in administration, agricultural safety, aviation safety, corrections, criminal justice administration, industrial hygiene, industrial safety, industrial security, safety, safety education, and transportation safety. Graduates of the School of Public Services are highly sought after and are accepting positions throughout the United States and in other countries.

In the fall of 1974, the Office of Manpower Planning, Department of Social Services, and the Division of Highway Safety, Department of Public Safety, engaged the Missouri Safety Center to conduct a survey of personnel needs for highway safety specialists within Missouri.

The survey included highway safety personnel positions at the state, county, and city levels of government, as well as positions in the private sector. The data were collected through use of a survey questionnaire that was developed and field tested before being administered in person by the research staff in all major cities and a cross section of smaller towns and villages throughout the state.

The survey questionnaire contained items believed to be vital in determining present and future needs for highway safety specialist personnel, including job title, job description, entry requirements, recruitment resources and selection procedures, education and training provided immediately after employment, resources for such training, education requirements for maintenance of competency, usual career pattern, location of the job title in the organizational structure, salary range and other financial benefits, age and tenure of persons currently employed, and the number of persons filling or needed to fill the position under the job title at present and for each of the next five years. General information on educational and training problems related to each job title was also requested.

The information obtained through this survey of highway safety personnel needs will be vital to the state of Missouri in achieving the goal of having available adequate numbers of qualified personnel to plan, develop, implement, coordinate, and evaluate traffic safety programs in each area of highway safety standards.

After 8 years of operation, the Missouri Safety Center has trained more than 42 000 persons in short courses, seminars, and workshops, including law enforcement workshops for local law enforcement officers, safety education officers' seminar for local law enforcement and fire officers, Traffic Management Institute, school transportation workshops for supervisors of pupil transportation, motorcycle workshops for college professors and driver education teachers, traffic engineering seminars, and so on.

LONG-RANGE NEEDS

There are a number of long-range needs that should be considered by all agencies, colleges and universities, professional associations, and individuals concerned with the education and training of highway safety personnel. These needs are not necessarily ranked according to priority but are submitted for consideration as we see them.

1. A state highway safety education and training committee should be established within an existing highway safety program advisory committee; it would work in cooperation with the governor's representative for highway safety and his staff person responsible for personnel development programs. The committee would assist in determining education and training needs of the

state, interesting education and training agencies and institutions in conducting programs, and interesting agencies involved in highway safety at both state and local levels in having their personnel attend training courses, conferences, and seminars.

2. The state's personnel and training needs, existing programs, and available resources for training and education activities at both the state and local levels should be analyzed periodically, and the additional programs and resources required should be determined. This assessment should include the existing personnel performing highway safety activities; the additional personnel needed; the length and scope of all existing training programs; the numbers of technicians, specialists, and professionals enrolled in training programs per year, as well as the number of students in preparatory programs for highway safety careers; the capacity of training and education facilities of educational institutions, governmental agencies, and private agencies; and the numbers of instructors by subject and their qualifications.

3. The federal government needs to plan an equal-partner role with state and local governments and agencies in the private sector in a meaningful effort to deal with deficiencies in the development of highway safety personnel.

4. NHTSA's highway safety personnel should recognize the training capabilities available in establishing educational institutions. Failure to recognize available programs will be detrimental to these qualified institutions, those who need to be trained, and NHTSA's budget for personnel development.

5. The private sector needs to reinstate its extensive funding and programming of highway safety personnel development.

6. Educational institutions should provide the following types of programs when they are qualified to do so: (a) education for doctoral and postdoctoral research; (b) doctoral programs for professionals, i.e., driver education teachers and supervisors, engineers, university highway safety program directors; (c) graduate and undergraduate degree programs for career highway safety personnel, both at the preentry and in-service stages; (d) junior college programs for subprofessional and technical levels, preentry education of career highway safety personnel, and in-service career advancement of specialists and technicians; (e) training programs ranging from conferences to longer courses for highway safety specialists, technicians, supervisors, administrators, and instructors; and (f) assistance to government agencies that conduct entry-level, in-service, and advanced training programs.

7. Scholarships and other types of financial assistance for students should be greatly increased by the colleges and universities, with support from the private sector and government agencies.

8. Well-designed and informative career guidance materials need to be developed to explain career opportunities in highway safety programs; they should be made available to elementary and secondary school teachers and guidance counselors.

9. Recruitment of the best qualified young people into the highway safety field should be a goal of all personnel concerned with highway safety.

10. Federal, state, and local highway safety offices and the private-sector groups involved in highway safety should provide financial support and provide internships for college and university students for a specified period of time (7).

11. The numerous recommendations of the National Safety Council (1) should be carefully reviewed and implemented.

SUMMARY

For more than 70 years, educational and training programs for highway safety personnel have been growing in an uncoordinated way. Around 1937 the private sector supported a handful of education and training programs in several leading colleges and universities. During that period government agencies provided little or no direction or financial support for education and training programs for highway safety personnel. Since 1966 financial support and staffing by the federal government for such programs have been inadequate, while the private sector withdrew financial support almost entirely.

Both the federal government and the private sector have recognized the need to expand their concern from highway safety alone to safety in all modes of transportation. With the development of departments of transportation in various states and cities, and with the new thrust of the Transportation Research Board to all areas of transportation, attention should be directed to the educational and training needs of all personnel involved in transportation.

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State of the Art of Environmental Impact Statements in Transportation

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The purpose of this study is to show how environmental issues are currently dealt with in environmental impact statements for transportation facilities and how the incorporation of environmental concerns into the transportation planning process is accomplished. The treatment of environmental issues in 40 statements is reviewed and summarized in this paper. Serious deficiencies are pointed out regarding the types of alternatives presented and the means by which the primary impacts of these alternatives are predicted. Most statements were too narrow in scope to show the total impact of a given project, especially if it was part of a proposed network. The consideration and evaluation of secondary (indirect) impacts need to be improved. Incorporation of citizens' opinion and environmental considerations early in the planning process would help to avoid irreconcilable differences at later stages. Any procedures that lessen adversary relationships among planners, environmentalists, designers, and citizens are encouraged.

In recent years conservationists, ecologists, and concerned citizens have aroused public interest in the worsening condition of the human environment. The National Environmental Policy Act of 1969 (NEPA) is a direct outgrowth of the significance Congress has attached to the environmental impacts of government actions and policies.

In order to determine how well transportation impact statements conform to NEPA requirements, 40 impact statements were read and analyzed. This study indicates how completely and with what technical competence the various reports conform to the purpose of NEPA. In many instances alternative means of attaining greater uniformity are suggested and improved technical methods are described.

UNIFORMITY AND COMPLETENESS WITH RESPECT TO NEPA

The guidelines of the Council on Environmental Quality (CEQ) (1) and various agency memoranda have augmented the topics that are to be discussed in an impact statement. Instead of the original five points addressed by NEPA, eight general items are now required:

1. A description of the proposed project,
2. The relationship of the action to land use plans,
3. The probable impact of the proposed action on the environment,
4. Alternatives to the proposed action,
5. Probable adverse environmental effects that cannot be avoided if the project is implemented,
6. Local and short-term uses of the environment versus maintenance and enhancement of long-term productivity,
7. Irreversible and irretrievable commitments of resources if the proposed action is implemented, and
8. Comments by other agencies and the public.

The second item, land use plans, was added with the 1973 guidelines, which became effective January 28, 1974. The statements reviewed were written before the effective date, so the relationship of the action to land use plans will have been included in other portions of the statements, if at all.

Description of the Proposed Project

The descriptive section of the impact statements reviewed was more nearly in compliance with NEPA than the other sections. No special expertise is required to write this portion of a statement since the descriptive material is usually available to the writer and does not have to be interpreted. Maps, photographs, and technical data (such as right-of-way and construction specifications) were normally contained in this section.

Surprisingly, none of the possible benefits or other impacts were mentioned here. This section should contain brief introductory remarks about the significant benefits that the project should bring and about the most significant environmental issues involved.

Relationship of the Action to Land Use Plans

This section was not required in statements issued before 1974; however, the impact on land use plans should

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have been dealt with somewhere in the statement.

More than half of the statements reviewed did discuss land use impacts. The extent to which a change in land use was discussed depended on the land's present use. The use of parkland for right-of-way generated the greatest amount of rationalization. Section 138, title 23, of the United States Codes (commonly known as section 4f) prohibits the use of publicly owned property such as parkland, wildlife refuges, or recreational areas for transportation right-of-way unless two conditions are met: (a) there is no feasible and prudent alternative to the use of such land and (b) all possible care is taken to minimize harm to such land if it is used in this manner.

The main effect of this restriction on the statements reviewed was that parkland was avoided if possible. When it could not be avoided, comments on the first requirement, that of finding no feasible or prudent alternatives, appeared to be deficient; for example, the costs involved in relocating the proposed right-of-way were skimmed over in some of the reports (2). Also, if statements on the section 4f requirements were written in conjunction with the impact statements, this could cause a conflict in interest. An agency that would favor a given alternative in the impact statement would surely favor the same alternative in the section 4f statement.

Many statements also argued that transportation facilities would be an economic asset to a community because of the land use changes that would occur near the facility. The change in land use could obviously result in an alteration of the local environment, especially if the change were a big one, e.g., from agricultural to commercial. Therefore, one would expect to see a discussion of expected land use impacts in transportation impact statements.

Probable Impact of Proposed Project on the Environment

Direct and indirect positive and negative impacts resulting from the implementation of a project should be discussed fully but without needless detail in the impact statements. In addition, the range of impacts should be complete and issues should not be hidden in inaccessible pages of material but made obvious, since the purpose of a statement is to inform the immediate decision makers, the Congress, and the public of all the ramifications of a project, both good and bad. If the impacts are categorized in the statement, i.e., presented in outline form, the reader can quickly determine the completeness of the set of impacts; however, this was not often done. It was also observed that the omission of a discussion of impacts was a more serious deficiency than an abridged discussion.

Direct impacts are often the easiest to measure, predict, and comprehend, while the measurement and prediction of indirect impacts are often quite uncertain. For this reason the direct impacts should be presented clearly at an early stage and the effect of indirect impacts on project selection and design should be evaluated during the planning process, which should be sensitive to the values held by the citizenry with regard to the indirect impacts.

Pollution Impacts

Normally, the most obvious environmental concerns associated with a transportation project are the various forms of pollution. One would expect most impact statements to address themselves to this problem in some manner, and the results of this review substantiated that hypothesis. In general, the direct impacts of pollution were discussed to the exclusion of secondary impacts. For example, carbon dioxide, hydrocarbons, nitric oxides, sulfur dioxide, and particulates were mentioned as principal atmospheric contaminants in terms of emission loads but their ultimate environmental consequences were not indicated. The most frequently mentioned water pollution problem was erosion. Many statements approached problems of erosion by placing construction constraints on the contractor. Explanations of what these impacts entailed (e.g., gully erosion, stream siltation) in spite of preventive measures were sidestepped.

Standards were used to assess the secondary impacts of noise in many statements. For the most part, highway-oriented statements appeared to follow guidelines set out by FHWA in Policy and Procedure Memorandum 90-2. It is questionable whether arbitrary nationwide standards are helpful in evaluating the secondary impacts of noise; the importance of these secondary impacts depends on what the alternatives are. A more reasonable approach would be to raise the noise issues in public sessions and the mass media and to deal with them frankly.

Ecological Impacts

The ecological impact of a project is of primary importance in an environmental impact statement. Preservation of the existing interactions between organisms and their environment is a national goal because these interactions form part of the human environment. Projects involving rural areas, wildernesses, and parklands require the greatest amount of care because the ecological status of such regions is most susceptible to change as a result of construction of transportation facilities. This does not imply that the balance or equilibrium will be upset in all cases but that present conditions will be changed.

Half of the statements we examined admitted that implementation of the project would result in some type of ecological impact. Some more detailed statements, especially if section 4f lands were involved, identified and discussed impacts linked to endangered species, nesting and breeding areas, migratory paths, existing flora and fauna, and other ecological data. Even those few environmental impact statements that recognized specific ecological problems seemed to fail to use such information in planning early enough to affect the development of alternatives (3, 4, 5). Generally, however, the effects on local ecosystems were discussed rather than the aformentioned specific impacts, probably because such discussions do not require results from field surveys for prediction but can often rely on rationalizations by the authors. This is not meant to imply that logic has no place in the analysis but that it should be accompanied by evidence.

Monetary Impacts

Both policymakers and the public should have some idea of the monetary impact of a proposed project. These impacts should be analyzed along with other types of impacts in a systematic manner. Unless one alternative is decidedly better in all areas, trade-offs will have to be made so that the most desirable choice can be carried out. Such topics as capital relocation, displacement costs, and changes in taxes, property values, and employment were handled with varying amounts of expertise. One statement went through an itemized list of ways that the displaced would be recognized and helped by the agency (6). However, only five households and five businesses were displaced by the project, leaving the reader skeptical of whether standard bureaucratic procedures were being followed at a substantial cost instead of using a

responsive planning process to accomplish the same ends.

Future impact statements need to present monetary impacts in a well-organized manner. Better cost-accounting procedures must be followed so that cost estimates are credible. Monetary estimates of benefits of the proposed project and its alternatives should be presented along with costs. The inclusion of cost-benefit analysis is not a requirement of NEPA and was not observed in any of the statements surveyed. However, a good cost-benefit analysis of project alternatives, using the given monetary data, would expose to public view a comparison of the resultant net monetary benefits of these alternatives. In any event, some type of monetary analysis should be incorporated in all impact statements.

Social Impacts

Social interactions form part of the human environment. Any change in social equilibrium that may result from implementation of transportation projects should be covered in impact statements. More than half of the statements did look at some types of social effects, but most were far from comprehensive. The types of social impacts most commonly addressed were neighborhood cohesion and identity, school access, access to recreational facilities, community services, and zoning.

An acceptable method of evaluating an explicit social impact usually involved acknowledging the existence of the impact and stating how that impact would be ameliorated. For example, it was not unusual for statement writers to admit that a given highway project would act as a barrier to school access. A common, albeit expensive, solution was to propose the construction of a walkway.

The assessment of social impacts of a highly nebulous nature, such as neighborhood cohesion or future zoning changes, was quite often overlooked. Impacts on future zoning were thought to be associated with expected growth in only two statements (7, 8). Since physical and economic growth, generally advocated as being a consequence of proposed projects, will inevitably be accomplished by zoning changes and zoning will to some extent influence resultant land use, one would expect more discussion of zoning impacts than was observed.

Operation Impacts

Operation impacts are those directly related to the operation of a transportation facility. These include safety and intermodal and intramodal compatibility.

A common assumption was that a good measure of the safety benefits associated with a proposed project would be evident in a before-and-after comparison of accident rates. None of the reports considered the increased volume generated by the improved facility itself. Taking into account the expected accident rates for this new traffic would permit a more realistic estimation of the number of accidents expected. Also, a comparison of accident figures if other feasible modes were present should be made. None of the highway statements considered the safety of alternative modes. Only seven statements mentioned any relationship between proposed projects and other modes of travel in their respective local areas.

A transportation facility forms part of a cooperative network that can include several modes of travel. If small sections of a highway or public transit facility are considered separately, effects on the network may be overlooked. For this reason a relevant portion of a facility, one that could stand alone, should be evaluated in one step.

Effects on local roads and streets also need to be indicated, even if the statement concerns a project of the same mode. Temporary disruptions during construction and more permanent obstructions due to limited access facilities were typical impacts noted in the statements. However, none of the statements considered the impacts on traffic in local street systems.

Aesthetic Impacts

Aesthetic impacts are possibly the most elusive and subjective aspects of an environmental impact statement. They refer to the artistic quality or natural beauty of the area and to the appearance and architectural quality of the facility. For the sake of brevity, the historical and archeological sites are also discussed in this section.

It should be noted that the appearance of the facility to the user and to the nonuser is not necessarily the same. An elevated section of highway or rail can offer panoramic views but may itself form a visual barrier. High fills impede horizontal views, while overhead spans cast ominous shadows and may be an aesthetic liability.

Nearly half of the statements looked at natural and aesthetic impacts. Detrimental impacts appeared to far outweight beneficial changes imposed by the various projects. Some concern was given to minimizing the resultant impact, but in most instances the expected negative impact was just described.

A historical site can form a significant portion of the aesthetic appeal of an area. The change in access to a site and the displacement of a site were considered primary causes of any impact. The magnitude of the impact was related to the relative significance of a particular site. Sites listed in the National Register of Historic Places or in state historic registers were accorded the most deferential attention.

Alternatives to the Proposed Action

All reports mentioned possible alternatives, but some were more sincere in their efforts to satisfy the requirements of NEPA than others. The omission, unequal treatment, and small scope of alternatives were the major deficiencies noted.

Different alignments or routes involving the same type of design were often presented as alternatives. One shortcoming of this approach is that environmental differences between routes tend to be insignificant. A large number of alternatives can be presented without looking into the true choices available to a community.

Unequal treatment of alternatives was evident whenever one mode was arbitrarily preferred over others. Although various modes may be outside the jurisdiction of a given agency, feasible alternatives that use such modes should be included without prejudice in an impact statement.

Impact statements covering only small segments of large projects tended to be shy of reasonable alternatives. In each case a prior commitment to an overall project precluded the possibility that any alternative to the proposed action would be realistic. The same problem occurred when the corridor under study was arbitrarily narrow.

Effects That Cannot Be Avoided if the Project Is Implemented

This portion of most statements was presented as a summary of the negative impacts of the proposed alternatives. Deficiencies in the general part of the statement were usually carried through to this section of the statements. Some reports described the impacts of various alternatives, but most gave a brief account only of the detrimental effects of the recommended alternative.

One of the main purposes of an impact statement is to ensure that environmental considerations enter into the planning process. Presentation of designs and procedures to be used that will reduce environmentally debilitating aspects of a project is not only desirable but also obligatory if the statement is to be effective.

It appeared that this important section was too often a set of pat answers, not a set of sensitive and well-reasoned approaches to avoid adverse environmental effects; considering its importance, not enough attention was given to this section.

Maintenance and Enhancement of Long-Term Productivity

According to the CEQ guidelines (1), future options that have been eliminated and trade-offs between short-term and long-term environmental gains or losses should be analyzed in this portion of the impact statement. In most reports, the analysis was limited to a brief explanation of how the proposed project fit into the future plans of the agency. Environmental aspects were often overlooked in favor of compliance with some type of general plan. Trade-offs were referred to but not detailed (9).

Most of the reports did not indicate what future options may have been eliminated. While these economic constraints on future options imposed by construction of the project rightly belong to the system planning activity, a brief discussion of the alternatives considered at that level should be included for completeness.

Irreversible and Irretrievable Commitments of Resources

Brief statements concerning the amount of material, land, and labor to be used in planning and construction were the usual approaches to this required section of impact statements. The CEQ guidelines require a broad interpretation of what is meant by a resource. General environmental change, in effect, involves the loss or commitment of environmental resources, and it would be appropriate to discuss that change in this section of an impact statement.

It would also be appropriate to discuss in general terms the opportunity costs associated with the use of economic resources; that is, what possible enterprises will have to be foregone if a given project is implemented. In short, this section should not only include economic resources (land, labor, and capital) but also the environmental resources that could not be recovered due to planning, construction, and operation of a transportation facility.

Comments on the Statements

The most voluminous portion of many impact statements was composed of the comments from sister agencies and concerned citizens. Comments from government sources far outnumbered those from the private sector. Some of these governmental replies were form letters in which no opinions about the proposed project were offered. There should be no need to reproduce such material since it tended to hide the informative comments in the sheer volume of replies.

It was apparent that more work in the area of citizen involvement will be needed if the controversy surrounding future projects is to be resolved. The lack of alternatives and unjust displacement were two concerns most evident in citizens' comments. Agencies will have to be willing to approach transportation projects with a broader outlook and be more sensitive to the needs of those displaced if such complaints are to be answered.

METHODS USED TO PREDICT ENVIRONMENTAL IMPACTS

The future environmental impact of a transportation project is at best uncertain. Different tools of analysis have been used to attempt to predict the environmental outcome of a given plan; some have been more successful than others. Methods ranged from highly technical computer applications to more conventional means, such as the comparison with standards or the opinions of experts.

The means by which a given alternative was determined to be environmentally superior to others under consideration varied greatly. The most arbitary and probably least environmentally conscious method noted was the selection of a given alternative before any environmental studies were made. If a statement concerned only a portion of a project, this type of approach was quite likely. Since a partial commitment had already been made, the alternative that advocated fulfilling this commitment was inevitable. Less arbitrary but still environmentally negligent methods involved the selection of an alternative on the basis of engineering economics alone. Referring to (but not presenting) a benefit-cost analysis or least cost analysis independent of environmental considerations rendered the impact statement impotent. Assurances that various steps would be taken to minimize impacts if a given alternative was implemented did not mean that the chosen alternative in itself minimized either economic or environmental impacts.

Mathematical models to predict the magnitude of impacts were used quite sparingly, with the possible exception of the travel forecasts. Besides travel forecasts, models were evident only in the fields of air and noise pollution.

Gaussian dispersion models were used to predict the levels of carbon dioxide that resulted from predicted travel near transportation facilities under various atmospheric conditions. The greatest impacts were usually predicted when low wind speeds and the presence of a temperature inversion impeded dispersion of pollutants. Noise-level calculations usually followed models set forth by NCHRP (10). For both air and noise, predicted levels of pollution were compared with standards for evaluating the actual impact.

Travel forecasts were, as a rule, expressed as truths for 1985 or 1990. Surprisingly, the models themselves or their underlying assumptions were never shown, even in an appendix. A good surmise is that the travel forecasts were obtained by using the standard urban transportation planning system. Given that the profession has long been aware of the pitfalls of the standard travel forecasting methods, it comes as no small surprise that the credibility of travel forecasts was never questioned or that the generally informed public was not afforded the opportunity to examine the premises of these forecasts.

Standards of various sorts were quite popular for evaluation of impacts, especially if any pollutants were involved. Pollution standards referred to in impact statements were usually set on a national basis. Comparison with a given standard should take into account the present pollution situation surrounding the transportation project. If the current ambience is relatively pollution free, an increase in the level of pollutants that does not exceed national standards may still produce severe environmental impacts. The existence of standards does not relieve agencies from their responsibility of attempting to assess impacts even though standards will not be violated.

The opinions of prominent individuals were also invoked for predicting impacts. Experts such as sociol-

ogists, economists, ecologists, and engineers were asked to shed light on difficult problems. Elected officials, appointed government personnel, clergymen, and other people who had standing in the community were also used to help assess impacts in areas of their authority. Interested groups also offered thoughts on various impacts, but their ideas were usually confined to the section on comments.

The judicial use of reasoning is probably the most powerful tool in the hands of the people writing impact statements. Logical conclusions have to be made about all the data presented in a statement, whether it is derived from displays, models, opinions, or other sources. Reasoning is subjective but quite potent. Environmental sincerity is mandatory if biased results are to be minimized. It is this use of reasoning that can make an impact statement a worthwhile aid in the planning process. The reasoning used in the statements reviewed was generally inferior. An improvement in the quality of reasoning in future statements would enable those statements to more effectively determine a course of action to be taken.

METHODS USED TO PRESENT THE IMPACT OF ALTERNATIVES

No strikingly new or innovative methods of presenting impacts of alternatives were observed; most reports used fairly standard approaches to the presentation of material.

Various types of visual displays were quite popular. Maps (land use maps or aerial photos) indicated the location of a project and usually how it fitted in with the existing network. Some indicated topographical features, e.g., rivers and lakes, so that proximity to environmentally sensitive areas could be surmised. Land use maps helped to clarify where impacts to schools, homes, businesses, and recreational sites would occur in developed areas. Impact statements that devoted a lot of effort to diverse routes for essentially the same alternatives made extensive use of maps for comparisons.

Structural descriptions consisting of cross-sectional drawings were included in statements to indicate how much right-of-way would be consumed by the proposed project. In addition, sketches of intersections and other major structures were sometimes included. These drawings did add information but, since alternative designs were not included, comparisons could not be made. The addition of these alternative designs would be helpful, especially if drawings of this type were to be incorporated into statements.

Computer mapping techniques were used extensively in the Rhode Island statement (9). The authors of the statement offered their opinion about the probable impact of each alternative, but the influence of this analysis on the proposed course of action was not evident because this was a draft statement.

The general impression one gets after reviewing many statements is that they are boring. If these reports are meant to be read by the public, it is doubtful that much information will be conveyed. Many reports need to be more concise and lucid. The major environmental issues have to be made obvious to the reader, not hidden in massive documents. By presenting data in a clearly understandable form, impact statements can be of useful service to both decision makers and the public.

INCORPORATION OF PUBLIC OPINION IN THE DECISION-MAKING PROCESS

Incorporation of the opinions and viewpoints of planning experts is automatic; however, the incorporation of the views of the general public is a difficult task. Without evidence to the contrary, the lead agency should not be suspicious of the intentions of the public and vice versa. The existence of such mistrust between agencies and concerned citizens was both subtle and direct.

Whenever a section of an impact statement concerning public interaction was titled Problems and Objections or something similar, some type of mistrust was implied. It appeared that the public was being treated as a type of impediment to the implementation of a project that could be effectively neutralized by the mere admission in an impact statement that objections were raised at public hearings. The viewpoint of the public was heard but was not incorporated in the decision-making process. More direct evidence of mistrust occurred in attached comments.

Most comments were answered in some form or another. When public input was restricted to comments alone, however, there was really no attempt to use this input when decisions were made. The comments were external to the statement and therefore formed no portion of the chain of logic used to formulate the decisions explained in the statement.

Comments were useful in that they tended to indicate how valid an impact statement appeared to the public and other agencies, but this should not be the only place public input is used in a statement.

CONCLUSIONS

Major environmental issues should be fully disclosed in a comprehensible manner. A complete set of alternatives must be prepared to ensure that all feasible means of minimizing environmental harm can be studied. If the study is to be useful, these alternatives have to be fundamentally different from each other, so that the differences in impacts can be distinguished. Alternatives suggested by citizens should be considered, especially if they are significantly different from those already proposed. The basic differences between alternatives should be clearly pointed out. In this way decision makers and citizens can more easily identify the trade-offs associated with any given alternative.

Impact predictions need to be realistic and credible. A total disclosure of the method used to predict an impact and the errors associated with that prediction needs to be presented as a part of the statement or as an appendix. Impacts that are believed to be of major consequence by any interested parties should be analyzed without prejudice. This would be, in effect, a response to input from citizens or peer agencies and thus would help encourage such input.

Citizens' views, especially on environmental matters, need to be incorporated early in the planning process so that they can effectively change the outcome of a project. The term citizens does not imply the elite of the community (the elected officials and other influential citizens); it refers to the citizenry at large, with people from all walks of life represented. When the general citizenry is involved in planning, irreconcilable differences at public hearings are avoided or at least minimized.

The treatment of secondary impacts could definitely be improved. Although secondary impacts are not necessarily quantifiable, they can at least be described. It is, after all, the secondary impacts that are of vital concern. The reliance on standards is not reassuring. The responsibility for environmental damage is delegated to those people who set the standards instead of where it belongs—to the planners and builders of a given project.

Statement summaries need to be concise and informa-

tive. Alternatives and their associated major impacts and benefits should be described briefly, leaving greater detail in the remainder of the statement. The general consensus of planners and citizens as to what course of action would be best to follow should be provided in a final statement. If no consensus has been reached, it is apparent that more negotiations need to be pursued before a final statement is written.

On the basis of our reviews of the environmental impact statements, it appears that they have had no discernible effect on the selection of alternatives. Even so, they may have had at least two positive consequences. The first is that the actual construction of projects may have become more environmentally sensitive than it would have been in their absence. The second positive consequence is that the citizenry now has something concrete to challenge.

In order to make the environmental impact statements more effective, the values expressed in NEPA should be internalized by the planning profession, as the environmental impact assessment should be in the planning process. This is an obvious conclusion. Equally obviously, it has not been accomplished. From our reviews, we not only observed the lack of importance of statements to the decisions but also sensed an adversary relationship between engineers and environmentalists and noticed one bureaucracy regularly supporting another. Either the values implied by NEPA are not worth internalizing, or they may be of secondary importance, or we do not know how to go about instilling new worthwhile values and expressing them in our daily work.

We believe that a far more productive way to accomplish environmentally and socially sensitive planning is not by instituting a uniform set of values and guidelines to be internalized and learned but to place emphasis on the development and distribution of good theories for transportation system analyses. To this end it is proposed that much greater attention be paid to the education and reeducation of men and women who have internalized the thought and underpinnings of transportation science and not the manipulation of turn-key methods, programs, and red tape. The objective should be to train engineers and planners who can think for themselves and engineer and plan solutions to problems, each of which is always in many ways unique, with the help of the theories and methods of transportation science and its administration.

We realize that this is in some contrast to the current federal guidelines for the conduct and even the outcome of transportation studies. We believe that transportation planners are currently so regulated in their work that these rules and regulations are more a deterrent than a help to finding imaginative and fitting alternatives. One would also expect the productivity of engineers and planners to decline in an atmosphere in which tasks, problems, and methods of solution are all given. On the other hand, a greater amount of freedom in planning would be likely to increase their productivity, as well as the number of imaginative and successful planning exercises.

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Urban Regional Environmental Impact Studies: Some Recent Experience

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Assessment of the impact of large-scale regional plans on regional environmental quality is increasingly being recognized as a useful effort. This paper reviews two such studies and draws conclusions from them. The authors suggest that regional assessments cannot be undertaken within the normal context of a planning agency but must generally be treated as a special project. Although such treatment may make these assessments seem costly, they should yield substantial returns to the region in the form of improved information for effective planning and control of environmental quality.

As greater experience has been gained in dealing with the environment, there has been a greater realization that it is not enough to consider only the localized impact of single projects. Such facilities as a highway or a sewage treatment plant are actually parts of a larger system. As part of this larger system, the individual project will have an impact on the entire region in which the system is located. There is a need to explore the impact of the system as a whole.

Studies of the environmental impact of regional plans may be undertaken for socioeconomic and land-activity plans, transportation systems, sewer and water plans, recreation and open space, and natural resources, as well as comprehensive plans that may incorporate several or all of these individual components. Such plans have impact through the sets of projects that result from plan implementation. Closely related to studies of regional plans are the studies of single very large projects that, because of their size, have regional impact. New communities and major sports facilities are perhaps typical of these major projects.

The purpose of this paper is to present some recent experience with analysis of the regional environmental impact of such plans and projects. A brief discussion of the legal and regulatory incentives for such studies is followed by a review of two studies in which we were involved—the Baltimore Regional Environmental Impact Study and the environmental assessment of the Tallahassee Urban Area Transportation Study. From these examples of regional assessments, some lessons have been learned about the costs of such studies and the return to be gained from them.

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REQUIREMENTS FOR REGIONAL STUDIES

The basic requirement for federal environmental impact assessment is, of course, the National Environmental Policy Act of 1969 (NEPA). Under this act, for all proposed legislation and other major actions significantly affecting the quality of the human environment an environmental impact statement (EIS) must be prepared. The purposes of this requirement are to ensure that all federal agencies ascertain that their policies and programs are designed to protect and enhance environmental quality, while avoiding or minimizing adverse environmental effects, and to evaluate the short- and long-range implications of the proposed action. In addition to the environmental assessment, the net economic, technical, and other benefits of the action must be assessed.

The Council on Environmental Quality (CEQ) is responsible for implementing the NEPA requirements and for performing the final review of environmental impact statements. To assist in this function, CEQ has issued guidelines (1). Although they do not specifically require regional assessments for major federal actions, the guidelines state (section 1500.6):

> In considering what constitutes major action significantly affecting the environment, agencies should bear in mind that the effect of many federal decisions about a project or complex of projects can be individually limited but cumulatively considerable. This can occur when one or more agencies over a period of years puts into a project individually minor but collectively major resources, when one decision involving a limited amount of money is a precedent for action in much larger cases or represents a decision in principle about a future major course of action, or when several government agencies individually make decisions about partial aspects of a major action. In all such cases, an environmental statement should be prepared if it is reasonable to anticipate a cumulatively significant impact on the environment from federal action.

This suggests that the actions of several federal agencies occurring simultaneously or over time would have a cumulative effect on the environment and that this effect

would require an EIS on a regional scale.

NEPA has been interpreted by several federal government agencies to require consideration of the regional impact of their actions. Notable among these are the Department of Housing and Urban Development's comprehensive planning grants and the Environmental Protection Agency's areawide wastewater treatment plans under section 208 of the Federal Water Pollution Control Act of 1972. EISs or similar reviews are required to accompany each of these plans, and HUD and EPA recently agreed to coordinate planning under these two programs so that joint EISs may be appropriate. Similarly, the Air Quality Maintenance Plans, designed to control air quality in a region, will require consideration of secondary impacts of the plan. It is further anticipated that legislation may be passed to coordinate procedures for all these plans.

While transportation planning under the urban transportation planning process does not specifically require an EIS of the plan, portions of the transport plan are assessed for each project. In addition, an annual review of the plan with respect to consistency with air-quality implementation plans is required under section 109j of the Federal-Aid Highway Act of 1970. Thus, a series of federal-level requirements for areawide assessments currently exist.

Against this background of federal regulation, an increasing number of states have adopted environmental policy and protection acts. These acts typically include a provision similar to that of NEPA's requirement of a formal statement of the anticipated impacts of major actions. Actual authority to implement and enforce a review may be placed at the state or the local level. Unlike NEPA, these state laws frequently define which actions may require formal review. The focus is on the geographic extent of effect—developments of regional impact. Private projects, such as major subdivisions, are frequently also included.

Because of this explicit recognition that a single large project can have an effect throughout the region, the environmental assessment of such a project assumes many of the characteristics of a system plan assessment, although the range of alternatives considered may not be as far-reaching. Since a major project plays a considerable role in determining the effectiveness of a plan in the context of regional planning efforts, it may be desirable to support a full-scale regional environmental assessment when such a project is being considered.

In addition to these legislative actions, there has been litigation that has encouraged regional assessment. Two actual cases of regional overview assessments evolved from court actions to apply NEPA on a regional or system scale.

In Baltimore, the planned Interstate highway system in the city was still incomplete by late fall of 1972. This plan, designated the 3-A system, was partially under construction, but portions were delayed due to citizen suits related to EISs on segments of the system. A citizen suit was filed in 1972 against the U.S. Department of Transportation (DOT) (Movement Against Destruction versus Volpe) charging that the 3-A system as a whole represented a significant federal action and that a regional environmental impact statement should be filed in addition to separate statements for each facility.

As a result of a hearing, the court found on June 22, 1973, that "the applicable law does not require that an environmental impact statement be prepared by the 3-A system as such" and that "components of the 3-A system are not necessarily so interdependent as to require the construction of all the 3-A system or none of it." The court continued:

> It may be wise for the city, state, and federal authorities to prepare in the near future a statement which considers those environmental impacts that should be determined with respect to the entire configuration, or major portions thereof. Such a statement would be included in one or more of the EISs which will have to be prepared in the future for other sections of the highways in the 3-A system and which will, of course, also include and consider those environmental impacts that should properly be determined section by section or road by road.

As the legal contest was proceeding, the U.S. Environmental Protection Agency (EPA) was stressing the need for a regional environmental analysis for the 3-A system. In September 1972, after a series of discussions, a consensus agreement between EPA and FHWA was reached. This agreement provided in part that for all remaining segments of the 3-A system under environmental review, neither approval of plans, specifications, and estimates nor further right-of-way approval would be granted by FHWA until a regional impact statement was prepared and circulated to FHWA, EPA, DOT, and the Maryland Department of Health and Mental Hygiene's Bureau of Air Quality Control and that the regional impact statement would address the regional issues identified by EPA in its various reviews that could not be addressed on a project basis. The Baltimore Regional Environmental Impact Study (BREIS) was initiated in response to these actions.

The environmental assessment of the Tallahassee Urban Area Transportation Study (TUATS) also arose from citizen action. The regional transportation plan, which had not been officially adopted, was challenged by citizen groups. A court suit was threatened and, as a result, local authorities undertook to develop a new plan. Since several individual projects—particularly the widening of Thomasville Road—were especially controversial, there was a need to examine the environmental impacts of the entire system.

The scope of TUATS was not defined by external requirements as much as BREIS was. Emphasis on particular environmental issues was based on a preliminary survey of the area to identify problems and key public interests. In addition, in contrast to BREIS, TUATS was conducted as part of the planning process, prior to formal adoption of a plan alternative. A brief overview of the Baltimore and Tallahassee studies will illustrate the process and products of regional assessment. We believe these two studies are unique in the depth and detail of the analyses undertaken.

BALTIMORE STUDY

Concern in this study was focused particularly on the Interstate highway system proposed for construction in the city of Baltimore and the General Development Plan (GDP) for road improvements in the region. Impacts on air, noise, water, solid waste, ecology, socioeconomics, traffic, and energy were assessed for alternative transportation and land use policies.

The problem was to examine the short-term (1980) effects, both with and without the Interstate highways, and the long-term (1995) effects, also with and without the highways. The process was conducted by a multidisciplinary team of consultants in association with federal, state, and local agencies. Unlike most past studies, which assumed a specific pattern of development would exist that would require certain transportation facilities, the BREIS recognized that building transportation routes creates demands and opportunities for development. For each transportation policy developed, land activity was varied accordingly. In this way the alternatives that were examined could be viewed in their entirety.

The alternatives ranged from building the complete interstate system to building only portions of it and in-

Table 1. Transportation alternatives of the Baltimore Regional Environmental Impact Study.

Alternative	Year	Highway Assumption		Rapid Transit Assumption
		3-A Interstate	Other Highways	
1	1970	Existing	Existing	None
2	1978	Existing and programmed	Existing and programmed	Phase I
3	1980	Complete	Existing and programmed	Phase I
4	1980	Partial	Existing and programmed	Phase I
5	1980	Existing and under construction	Existing and programmed	Phase I
6	1995	Complete	General Development Plan	General Development Plan
7	1995	Existing and under construction	General Development Plan	General Development Plan
8	1995	Complete	Existing and under construction	General Development Plan
9	1995	Existing and under construction	Existing and under construction	General Development Plan

Figure 1. Baltimore regional 1995 with full transportation system completed (alternative 6).

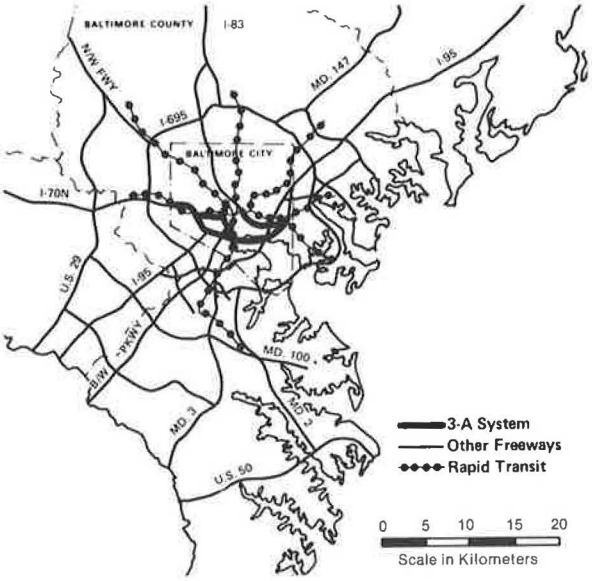


Figure 2. Effects of the proposed alternatives on population.

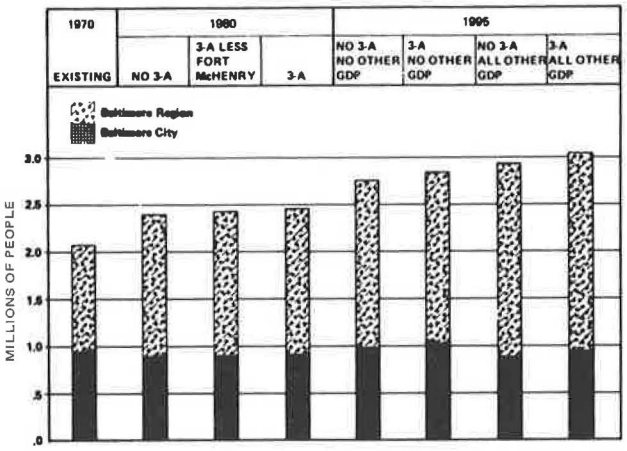
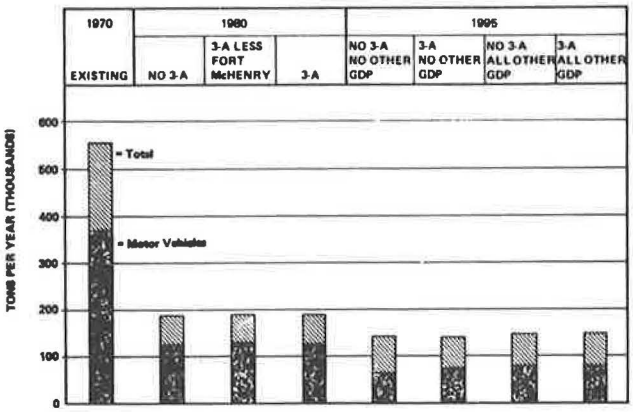


Figure 3. Effects of the proposed alternatives on carbon monoxide emissions.



cluded a no-build alternative. A regional rapid transit system was assumed for all alternatives. At the time the study was conducted, no transportation control plan for air pollution had been officially adopted for the region; therefore, no transportation control strategies were assumed in the study. The summary of alternatives is shown in Table 1. Figure 1 shows the full transportation system, including the 3-A system, as planned for 1995.

It should be noted that the scope of BREIS did not include all the elements that should be considered in the decision-making process; therefore, there are no recommendations on overall regional development policy. The data in Figures 2 and 3 show the expected effects on the region's population and air pollutant emissions. They are arranged in increasing order of estimated capital cost for the alternatives, thus permitting an approximation of a cost-effectiveness evaluation.

Population and Employment

In the short-term (1980) projections, if the full 3-A system were built there would be approximately 3 percent more people in the city and 1 percent more in the region than if the system were not built. Building the 3-A system was also predicted to result in about 15 000 more jobs in the city and 4000 more in the region than if it were not built.

In the long-term (1995) projections, if the 3-A system were built and all other GDP highway improvements were made, the regional population would be about 10 percent higher than if no highways were built or improved. The city would have about 72 000 fewer persons in this comparison. Regional employment figures would be about 6 percent higher and the city's employment would be 5 percent higher if the full highway program were implemented.

Economic Indicators

In the short-term estimates, the city payroll would be higher by about $110 million annually (all figures are expressed in 1969 dollars) and regional payrolls would be higher by $23 million annually if the 3-A system were built. Retail purchasing power would increase by $42 million annually in the city and by $16 million in the region. Retail sales in the city would increase by $85 million annually and by $16 million in the region. In the long term, building the 3-A system and other GDP improvements would maximize economic growth in the region. Payrolls and retail sales would be higher by $1.74

Table 2. Comparison of alternatives in the Tallahassee Urban Area Transportation Study assessment.

Alternative	Travel on Severely Congested Links (km)	Total System Costs (millions of dollars)		1995 Annual Vehicle Operating Costs[a] (millions of dollars)	1995 Annual Travel Time Costs[b] (millions of dollars)	Traffic Disruption of Parks and Open Space	Number of Communities Subject to Increased Through Traffic
		Construction	Right-of-Way				
Recommended plan	56 000	94	50	156	67	None	6
Arterial plan	350 000	109	–	170	77	McClay Gardens	11
Freeway plan	379 000	108	–	174	80	McClay Gardens	11
Existing and committed system	1 355 000	–	–	180	172	Tom Brown, McClay Gardens	13

Note: 1 km = 0.6 mile.

[a]Based on 24 cents per vehicle-kilometer. [b]Based on $1.80 per vehicle-hour.

billion and $750 million annually than with the no-build alternative.

Travel Simulation and Traffic Analysis

In the short-term analysis, travel time and congestion levels would tend to be higher than in 1970, whether or not the 3-A system is built. The overall vehicle-kilometers of travel will increase, but there will be only slight differences on a regional basis. Transit use will be slightly higher if the 3-A system is built, but all 1980 alternatives will have lower transit use than 1970.

If the full highway system were built by 1995, the result would be 16 percent more vehicle-kilometers of travel than if the system were not built. On a 24-hour basis, the mean trip speed would be 40 km/h (25 mph) for the region if the full system were built and 27.8 km/h (17 mph) under the no-build alternative. There would be approximately 10 percent more trips made with the full 3-A system and GDP improvements than if the system were not built. The no-build alternative would result in 4000 fewer daily transit trips than the full highway program; the proportion of transit trips would be higher however.

Air Quality

After 1980 there would apparently be no violation of the air-quality standards for carbon monoxide. However, there will continue to be a violation of the guideline level for hydrocarbons, primarily because of the growth in pollution from stationary rather than mobile sources and, as a consequence, predicted violation of the standards for photochemical oxidants for some period of time between now and 1995. These findings hinge, however, on effective implementation of federal motor vehicle emission controls for new vehicles and may be adjusted on the basis of revised data.

Water and Solid Waste

The difference in effects of the transportation alternatives on water and solid waste will be minor in the short-term (1980) and long-term (1995) plans. The impacts on suburban growth and development of completing the GDP highway improvements are most significant with respect to increased flooding risk in the Gwynns Falls, Magothy, and Severn River basins. The 3-A system itself would have little direct impact on this problem. Wastewater flows will be approximately 8 percent greater if the 3-A system and GDP highways are completed than if there is no building. Solid waste production will be approximately 10 percent higher if the full highway system is constructed.

Noise

In the short term, an increase for the region of approximately 4 percent in the residential noise dosage per capita above the standard would be produced by building the 3-A system rather than adopting the no-build alternative. In the city, the increase would be about 2 percent if the 3-A system were built. In the long term, building the full 3-A system and GDP improvements would produce approximately 10 percent less residential noise dosage per capita above the standard than the no-build alternative for the region as a whole. For the city, this figure would be approximately 3 percent greater if the full 3-A and GDP highways are built. In general, residential noise dosages in the Baltimore area would be relatively lower for any of the alternatives than they are under existing conditions.

Environmentally Sensitive Areas

Analysis of environmentally sensitive areas is dependent on population distribution. In the short term (1980), the 3-A system would not have a marked regional environmental impact. In the long term (1995), construction of the 3-A system and other GDP improvements would increase the population by about 10 percent and the environmental impact by 28 percent over the no-build alternative.

The results of this study have been incorporated into environmental assessments and EISs of individual links in the system.

TALLAHASSEE STUDY

The Tallahassee urban area is much smaller than Baltimore. The entire region has a population of approximately 130 000 people, with an increase to 230 000 anticipated by 1995. Due primarily to geological conditions and the fact that large land areas are held as national forest or held by pulp and paper interests, the city has grown toward the north, and development promises to continue within corridors in the northeast and northwest quadrants.

There are two notable differences between the TUATS and BREIS assessments. First, since the Tallahassee region is quite dependent on the automobile, the alternative system plans are primarily highway plans. Strong citizen interest in transit suggests that the improved services being considered would be useful, but it seems unlikely that any substantial reduction in use of automobiles will occur. Second, it was a basic assumption in development of a transportation plan that future land use would be as shown in the plan for the metropolitan area. The transportation system was formulated to support the regional land use plan.

The TUATS assessment thus effectively had a much

smaller scope than BREIS and served primarily to screen plan alternatives for adverse environmental effects that might have been neglected in development of a plan. The assessment was timed within the planning process in such a way that discovery of such effects could lead to plan changes. The factors considered in the Tallahassee environmental assessment were

- Ecological factors
  - Geology and soils
  - Canopied roads
  - Parks and open space—regional, state, and national
  - Other biotic resources
- Water factors
  - Surface water
  - Groundwater
  - Flooding and drainage
- Energy resources
- Air quality
- Noise
- Socioeconomic factors
  - Community quality
  - Community economics
  - Visual quality
- Safety
- Historic structures and areas

This list was developed to be comprehensive and to reflect the particular interests of the people in the Tallahassee area. For example, trees are of considerable importance; there is an ordinance that regulates the cutting of trees and there is great public interest in the several canopied roads in the area. These canopied roads—roads completely shaded by the Spanish-moss-hung branches of huge trees lining both sides—are a major scenic feature of Tallahassee and a part of the area's character.

The principal plan alternatives examined were to expand the capacity of existing alignments (arterial plan), bring in new capacity in the form of a new freeway facility (freeway plan), or to do nothing (existing and committed system), with no construction scheduled beyond that already adopted through the political process. In addition, intermediate plans, representing restrictions on the principal alternatives, were explored. The final recommendation was prepared by combining the better features of the first two principal alternatives so that adverse impacts were minimized.

Because of the fixed land use plan, the principal impacts projected for 1995 stemmed from construction activities and from increased traffic flows. Table 2 presents a summary of this assessment. Other assessments were made for such factors as construction impact. The recommended plan, along with the results of the environmental assessment, was presented at public meetings in five parts of the Tallahassee urban area.

COSTS OF STUDIES

The dollar cost of regional overview assessments will, of course, vary as a function of a number of factors, including the size of the urban area, state of the art of planning in the functional areas of the plan (transportation, waste management, and so on), availability of data, degree of agency involvement, number of alternatives considered, and type of land use inputs.

The Baltimore study cost somewhat in excess of $600 000, with additional costs of participation by local agencies not clearly identifiable. Much of the Baltimore work was done in conjunction with updates of the urban transportation planning program. The Tallahassee study cost approximately $50 000, again with additional agency participation. As described above, there was no land use variation in the Tallahassee study; an additional $40 000 to $50 000 might have been required to perform a full-scale assessment analogous to that for the Baltimore study.

The costs of such a study may approximate the annual budget of the planning agency that sponsors it. This fact may have two consequences. First, as special projects, regional environmental assessments will probably not be feasible without specific federal assistance. However, because various federal programs require environmental reviews, regional overview assessments might be undertaken with joint findings for several programs. Second, regional environmental assessment could be conducted as part of the ongoing planning process without being out of scale in relation to other agency activities. Both the Baltimore and Tallahassee studies were conducted in less than 1 year. Had an approach been taken to build up a diary of the planning process, incorporating full environmental concern throughout, these studies might have effectively been conducted over 2 to 3 years at a lower total cost.

RETURNS ON THE INVESTMENT

While regional assessments are somewhat costly in relation to the regular bedgets of the regional agencies that are most concerned with the results, there are a number of distinct benefits associated with these studies beyond the results for the particular plan in question. These benefits are of three distinct types.

1. A regional environmental baseline is established that will support future assessments of environmental impact in the region. This baseline is a description of conditions in the region—now and projected to the future under the assumption that the system under study is not implemented—and is a by-product of the impact analysis. This baseline is particularly useful in future studies because it has already been placed in a coherent form that is compatible with the procedures of analysis.
2. The regional assessment serves as a context for assessments of impact of the individual projects within the system. There is thus a tiered set of impact assessments from the regional overview down to the project EIS. This tiered approach maintains a perspective of individual projects and reflects the manner in which environmental impact actually occurs, with policies shaping plans and thus fostering projects that can affect the impact.
3. The overview provided by the regional assessment is an ideal point at which to start a monitoring program for environmental quality in the region. Regional environmental conditions are monitored as implementation of the system proceeds, to determine whether the impacts are substantially different from those anticipated. The baseline mentioned above and the assessed impact of the system as a whole provide points of comparison for the monitoring. Effective monitoring can lead to early recognition of situations in which assumptions or projections were in error and can thereby prompt effective mitigative measures when they are required.

CONCLUSIONS

Regional environmental assessments are of value and are likely to be more frequently undertaken. As greater experience is gained, these assessments may be conducted as part of the planning process in urban areas, perhaps serving to make the environment a greater part of the basis for choosing among plans. If it is properly conducted, the regional assessment will leave a region with

a number of planning tools of lasting value. The establishment of baseline data and coordinated capability for environmental prediction and assessment will reduce the cost of future environmental analyses. In this sense, environment might be in the position that transportation held at the start of the great round of producing transportation plans in the late 1950s and early 1960s.

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Examination of Some Implicit Assumptions of Noise-Impact Analysis Techniques

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Implicit in the existing techniques for assessing the impact of transportation noise are several assumptions that warrant explicit examination. The authors of this paper use data collected in southern Ontario to examine three assumptions, expressed as testable hypotheses, that deal with the relationship between the subjective rating of specific noise sources and the rating of the overall level of neighborhood noise, the strength of this relationship as a function of the number of disturbing noises present, and the relationship between specific noise-source ratings and the total number of disturbing noises. In testing each assumption, a major hypothesis and alternative hypotheses are proposed and supporting explanations are suggested. The principal basis of hypothesis testing is to use nonparametric correlation analysis. The results show a significant positive relationship between the rating of specific sources and the overall noise rating, a tendency in the case of certain transportation-noise sources for this relationship to become stronger as the number of disturbing noises present increases, and a significant positive relationship between the rating of specific noises and the total number of disturbing noises. The major conclusion is that the results tend to support the implicit assumptions of existing procedures for assessing the impact of transportation noise. At the same time, they indicate the need to develop techniques that more closely relate to specific noise sources and that take into account the number of disturbing noises present.

Almost all of the commonly used procedures for identifying the impact of transportation noise on the community rely on several simplified assumptions about the relationships among particular noise sources (such as an expressway), overall noise levels in a residential area, and the way people respond to both the specific and the general noise levels. The importance of these assumptions can be clarified by considering two main ways to identify the impact of transportation noises.

The simplest approach involves predicting the noise levels generated by the transportation facility and matching them against some preselected standards. The identification of these standards is usually based on previous studies that obtained data on both noise measurements and community response. In fact, there is a considerable literature on this issue; it has resulted in the identification of a variety of measures of noise that correlate well with community response, e.g., L_{eq} (1), traffic noise index (2), or noise-pollution level (3).

The second approach carries the analysis one step further, by attempting to translate the impact on the community from a measurement in terms of noise to a measurement in terms of numbers of people affected. As has been pointed out (4), this approach has several advantages over the first but demands an even clearer understanding of the relationship between noise levels and the percentage of a population affected, which presumably must also have been obtained from previous studies.

The drawbacks of these two approaches are similar. First, in the previous studies on which both approaches rely, analysts could measure only the aggregate noise in a neighborhood. They could not generally measure the noise in a community produced by a single source, nor would it be reasonable to do so, given the manner in which decibel levels combined. This means that even when the analyst has interview data on community response to noise from a particular transportation facility, it must be matched against physical measurements of noise from all sources combined. On the other hand, the interview data can be matched to the physical measurements by using ratings of the overall neighborhood noise level, but in that case one must assume that the neighborhood noise rating is highly correlated with reaction to the transportation noise. Hence, whichever procedure is followed, it is necessary to assume a strong and direct relationship between the ratings for a specific source and those for the overall neighborhood. The first assumption to be investigated in this paper is:

1. The way an individual responds to general community noise levels is directly related to the way that person reacts to the specific noise sources that make up the general noise level.

If assumption 1 is true (and we certainly hope that it is), there remains the question of whether the number of disturbing noises present has any effect on either the strength of the relationship or the ratings of individual noise sources. Measurement procedures implicitly assume that it does not, since a term dealing with the num-

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ber of distinct types of noise sources is not included. On the other hand, practice in some instances seems to assume that the greater the number of types of noise present, the less important any one particular noise will be. For example, when truck routes through cities must be selected, routes that are already noisy are chosen rather than quiet ones. The two further assumptions to be discussed are:

2. The strength of the relationship between the rating of general neighborhood noise and the rating of a specific noise source is independent of the total number of noises rated as disturbing.
3. The rating of an individual noise is independent of the total number of noises rated as disturbing.

During a study undertaken to relate community responses to a range of noise sources, we collected data to examine the validity of these three assumptions. The reader should be aware that the analysis presented here is based on comparisons of different people in different noise situations. Field research precludes exposing particular individuals to a variety of noise environments, so it is misleading to interpret these results as indicative of the way in which a particular individual's reaction will vary. The results are, however, reliable across groups of people. Each of the three assumptions we examined is treated as a hypothesis; alternative hypotheses are also examined to provide a basis for strong inference (5).

DATA COLLECTION

The data base for the analysis reported in this paper was drawn from a study of community response to ground transportation noise in the Hamilton-Toronto area of southern Ontario. Two types of data were collected: physical measures of noise at each site for a 24-hour weekday and information on household attitudes and behaviors with respect to the noise. The analysis reported in this paper is based only on the household data, which were obtained through a carefully constructed and pretested questionnaire administered to 837 respondents—approximately 30 from each of 28 sites. A comprehensive set of questions was asked to determine various aspects of residents' attitudes and behavioral responses to noise, including responses to specific noise sources rather than simply a general neighborhood rating of noise, as has been common in previous community studies (6, 7).

A distinguishing feature of the questionnaire design was the use of a bipolar rating scale for measuring the intensity of respondents' reactions to specific and general noise levels. Previously, the practice has often been to employ unipolar disturbance or annoyance scales. This procedure was not followed in the present study because it prevents the respondent from indicating a positive response to noise. In the pretest, when a unipolar disturbance scale was used, the interviewers noted that in many instances a positive response occurred, particularly in rating the general level of neighborhood noise; we therefore adopted a bipolar scale in the major data-collection phase. A nine-point scale ranging from extremely agreeable to extremely disagreeable, with a neutral midpoint, was employed. Thus the study did not proceed on a definition of noise as unwanted sound, as most previous studies have done.

The 28 sites used in this study were selected to provide a number of locations within each of seven noise-environment categories. The primary criterion for site selection was the dominant nonresidential noise source, with particular emphasis on transportation facilities. An attempt was made to include sites in which a single source acted in isolation and others in which two or more sources were combined. An additional concern was to vary the degree and type of shielding at each site. Finally, a sufficient amount of housing paralleling the noise source had to be present to allow 30 interviews to be completed within the same noise environment. The sites are categorized as follows: 8 expressway sites, with 237 respondents; 6 arterial roadway sites, 165 respondents; 4 main rail-line sites, 122 respondents; 3 secondary rail-line sites, 90 respondents; 2 sites exposed to both expressway and rail noise, with 58 respondents; 2 sites at industrial or commercial interfaces with transportation facilities, 60 respondents; and 3 quiet residential sites, 105 respondents.

A deliberate effort was made to vary the socioeconomic characteristics of the respondents among the sites, and to obtain a representative set of respondents within each site. Tabulation of the personal data showed that the sample contained a cross section of the general population with respect to the age, educational level, and income of the respondents. There was a bias toward female respondents, who made up 75 percent of the sample, and an associated bias toward housewives. Several statistical tests on the data have indicated no significant differences between housewives and other occupational groups in the response to noise, however, so this overrepresentation should not bias the results.

Sampling across this range of sites ensured the desired variance in the exposure of respondents within the sample to transportation noises while, at the same time, yielding a sufficient number of responses from each type of site to make aggregate comparisons reliable.

EXAMINATION OF ASSUMPTION 1

The first and most important of the assumptions implicit in most techniques for measuring the community impact of noise, stated as a hypothesis together with two other possible hypotheses, is that

1.A. The way an individual assesses the general neighborhood noise level is positively related to the way that person reacts to the specific noise sources that make up the general noise level.
1.B. The neighborhood noise rating is inversely related to that for specific sources.
1.C. There is no relationship between the neighborhood noise rating and the rating of specific sources.

Certainly the original hypothesis is the most plausible of the three. Hypothesis 1.B may perhaps hold for one or two particular sources, in which case one might be tempted to comment more on the importance of that source than on the hypothesis. The presumption in favor of hypothesis 1.A is so strong, in fact, that evidence in favor of 1.C might be dismissed on the basis of insufficient data. The first assumption is so intuitively appealing that it is hard to derive plausible explanations or interpretations of alternative hypotheses a priori.

The most obvious approach to use in testing these hypotheses is to investigate the correlation between the neighborhood noise rating obtained from each respondent and the rating of each noise mentioned. These data constitute valid ordinal scales but certainly have no validity as interval- or ratio-scaled data. Hence either Spearman's or Kindall's correlation coefficient is an appropriate statistic. Given the large number of data points and the relatively small number of scale points, there will be a large number of tied ranks. Hence Kendall's tau was selected as the correlation coefficient throughout the analysis (8); the results are as follows.

Noise Source	Number of Cases	Coefficient	Significance
Expressway traffic	206	0.4062	0.001
Arterial traffic	86	0.2573	0.001
Local traffic	130	0.2638	0.001
Trucks	189	0.3948	0.001
Trains	209	0.1517	0.001
Aircraft	73	0.3359	0.001
Motorcycles	194	0.0986	0.05
Children	161	0.2409	0.001
Pets	114	0.2478	0.001
Garden machinery	54	0.1587	0.05

It should be noted when interpreting these figures that the number of cases varies for each of the noise sources; the correlations are therefore based on different subsets of the total sample. This is inevitable, given that in general people in different locations are exposed to different noise sources. These figures indicate the relationship between an individual's overall rating of neighborhood noise and the rating of an individual noise source for those respondents who mentioned that they noticed the particular noise. The 10 specific noise sources listed are a subset of the 20 sources included in the questionnaire. Attention is restricted to these in the analysis since they were the only ones mentioned by more than 5 percent of the sample.

In general, the results shown above tend to support hypothesis 1.A, namely, that there is a positive relationship between the rating of individual noise sources and the rating of the general neighborhood noise. Further, they suggest that this relationship is strongest for transportation-noise sources. With the exceptions of trains and motorcycles, all transportation-noise sources correlate more strongly with the neighborhood rating than do any of the other sources.

Hypothesis 1.B is clearly rejected since none of the coefficients are negative. With the exception of perhaps three sources, hypothesis 1.C would also appear to be rejected, since seven of the coefficients are greater than 0.24 and are statistically significant at the 0.001 level. Marginal support for hypothesis 1.C comes from motorcycles, garden machinery, and trains. All three have low coefficients and the first two are the least significant of all those in the table (significant at 0.021 and 0.046 respectively). Plausible explanations can be developed for these three. Motorcycle noise, while disturbing, is in most instances a relatively infrequent occurrence and is therefore not likely on its own to be a major influence on the overall noise rating. Noise from garden machinery may again be disturbing but is normally accepted in the neighborhood because at some time most people are responsible for creating it; in addition it signifies that properties are being maintained. The low correlation in the case of trains reflects the general ambivalence about this source. On many occasions, particularly at secondary rail sites, people expressed a favorable response to train noise even though they may have rated the overall noise level as disagreeable. In other instances, the specific and general ratings were consistent. The net result is a low correlation.

The remainder of the paper will focus on the sources listed above, omitting garden machinery because of its low correlation and significance but retaining the motorcycle (despite these same factors) since it is a transportation mode.

EXAMINATION OF ASSUMPTION 2

The preceding section has supported the assumption that there is a positive relationship between the rating of an individual noise and that of overall neighborhood noise. The implicit assumption in most noise-impact analysis is that the relationship is independent of the number of different noise sources that disturb someone. That assumption can be stated here as a hypothesis, along with its most obvious alternatives.

2.A. The strength of the relationship between the rating of general neighborhood noise and that of a specific noise is independent of the total number of noises that disturb the individual.

2.B. The strength of the relationship between the two ratings increases as more disturbing noises are reported.

2.C. The strength of the relationship decreases as more disturbing noises are reported.

The first hypothesis, which is the assumption being tested, is intuitively appealing because it implies, first, that people are consistent in their assessment of a particular noise and, second, that the analyst does not need to worry about the number and types of other noises present in assessing the impact of any single noise source (for example, a new highway or transit line).

Alternative 2.B, if verified, can be explained only on the basis of the way in which people evaluate community noise. In particular, it would have to be based in some way on mutually reinforcing effects. For example, if an expressway is the only noise source disturbing people, they may weight this in a variety of ways to arrive at an overall neighborhood noise rating, so that the strength of the resulting relationship is quite low. If, however, an expressway, trucks, and children are all disturbing, the weightings for each may be more consistent among a group of people, which would result in an apparently stronger relationship. A related interpretation of alternative 2.B is that the relationship is strengthened as the number of disturbing noises increases because people who are more disturbed are more likely to hold definite opinions about specific noises and hence to give more precise ratings. In this sense, the strengthening of the relationship is a function of the decline in error variance of the ratings as the number of disturbing noises increases.

For alternative 2.C, two explanations are plausible. The first is based on the physical nature of noise, as expressed in the dBA scale, for example. The nature of the additivity of sounds means that the overall level is mostly a function of the noisiest single source. Therefore, if there is only one disturbing source, it should be more strongly related to the physical measure of total neighborhood noise, and hence to the rating of it, than if there are several disturbing sources. Alternatively, 2.C can be explained on the basis that, as the number of disturbing noises increases, there are simply more sources to contribute to the overall rating; hence the importance of each declines.

As for assumption 1, the appropriate statistics to use here are the Kendall's τ correlation coefficients, stratified this time by the number of disturbing noises; see Table 1. A more detailed breakdown for more than two disturbing noises was precluded by the need to maintain reasonable sample sizes. It was possible to calculate the coefficients even in cases in which no disturbing noises were mentioned because the bipolar scale allowed respondents to rate specific noise sources as agreeable or neutral. The substantial sample sizes associated with no disturbing noises appear to confirm the importance of using a bipolar rating scale.

A striking feature of the table is the number of nonsignificant correlations, which is partly a function of the reduction in sample sizes that resulted from the stratification of the data set. In addition, the correlations in the first column are probably low because there were fewer variations in the rating of the specific source; since it was not disturbing, only half of the scale is used.

Table 1. Correlations of specific noise source ratings with the neighborhood noise rating, by number of disturbing noises.

	No Disturbing Noises			One Disturbing Noise			Two Disturbing Noises			More Than Two Disturbing Noises		
Noise Source	Number	Coefficient	Significance	Number	Coefficient	Significance	Number	Coefficient	Significance	Number	Coefficient	Significance
Expressway traffic	57	0.0056	NS	69	0.2349	p = 0.01	50	0.3610	p = 0.001	30	0.4400	p = 0.001
Arterial traffic	28	0.1863	NS	30	-0.1188	NS	24	0.4311	p = 0.01	4	—	—
Local traffic	46	0.2757	p = 0.01	42	-0.1079	NS	22	-0.0641	NS	15	0.2909	NS
Trucks	39	-0.0107	NS	54	0.2338	p = 0.01	62	0.3772	p = 0.001	34	0.2233	p = 0.01
Trains	80	0.1735	p = 0.05	70	0.0053	NS	36	-0.1937	p = 0.05	23	0.0303	NS
Aircraft	27	0.0607	NS	18	0.0604	NS	15	0.3670	p = 0.05	13	0.3466	p = 0.05
Motorcycles	29	-0.0704	NS	62	-0.2312	p = 0.01	60	0.0428	NS	43	-0.0138	NS
Children	77	0.1684	p = 0.05	36	-0.0555	NS	27	0.2245	NS	21	-0.0448	NS
Pets	31	0.3290	p = 0.01	31	-0.0665	NS	26	-0.0626	NS	26	0.0352	NS

Table 2. Correlation of specific noise source ratings with number of disturbing noises.

	All Respondents			Respondents Who Reported Some Disturbing Noise		
Noise Source	Number	Coefficient	Significance	Number	Coefficient	Significance
Expressway traffic	210	0.596 15	p = 0.0001	152	0.379 27	p = 0.0001
Arterial traffic	89	0.545 39	p = 0.0001	60	0.215 56	p = 0.01
Local traffic	130	0.526 18	p = 0.0001	84	0.392 29	p = 0.0001
Trucks	191	0.577 29	p = 0.0001	152	0.317 64	p = 0.0001
Trains	213	0.385 34	p = 0.0001	130	0.120 24	p = 0.05
Aircraft	74	0.459 73	p = 0.0001	46	0.238 19	p = 0.01
Motorcycles	196	0.455 08	p = 0.0001	167	0.282 26	p = 0.0001
Children	162	0.398 47	p = 0.0001	85	0.405 26	p = 0.0001
Pets	116	0.469 86	p = 0.0001	84	0.332 96	p = 0.0001

Examining the coefficients by row suggests that for many of the noise sources no consistent trend occurs, which appears to support hypothesis 2.A—that the strength of the relationship between the ratings of general neighborhood noise and of specific noise sources is independent of the total number of disturbing noises mentioned. There are, however, some important exceptions to this general result, expressway traffic being the prime example. In this case, the coefficients consistently increase from a nonsignificant value (0.0056) when no disturbing noises are reported to a highly significant value (0.4400) when more than two are reported. This result seems to refute 2.A and support 2.B. A similar but less consistently maintained trend applies with respect to arterial traffic, truck, and aircraft noise.

No single conclusion can be drawn from these results. The coefficients for five of the nine noise sources seem to support 2.A, since in these cases the relationship with the overall neighborhood rating does not vary consistently with the number of disturbing noises mentioned. For the remaining four sources, the coefficients appear to support 2.B, most clearly in the case of expressway traffic. The results provide no support for hypothesis 2.C. As suggested earlier, the most plausible explanation for hypothesis 2.B is that respondents tend to be more internally consistent in their ratings of both specific and general noise levels when they are disturbed by a number of different sources. In addition, it is important to notice that support for hypothesis 2.B emerged for the four noise sources that had the strongest relationship overall with the neighborhood rating shown above.

EXAMINATION OF ASSUMPTION 3

The third assumption implicit in present noise-impact analysis techniques is that the rating of a specific noise source is independent of the total number of noises that disturb the individual. If the assumption holds, then the way people react to expressway noise, for example, should not be affected by whether they also report being disturbed by trucks and children. The assumption and its alternatives can be stated as the following hypotheses.

3.A. The way a specific noise source is evaluated by an individual is independent of the total number of noises mentioned as disturbing.

3.B. The individual is more disturbed by a particular noise as the number of disturbing noises increases.

3.C. The individual is less disturbed by a particular noise as the number of disturbing noises increases.

From the point of view of validating current approaches to noise-impact analysis, the confirmation of 3.A is appealing. Plausible explanations can be suggested, however, for 3.B; for example, some noises may combine several sources so that there is a physical causal connection between an increase in a specific noise and the number of contributing sources. A case in point is that expressway noise may be more disturbing when trucks are also disturbing, if trucks are a component of the expressway noise. A second explanation is based on the existence of a carry-over effect such that, once disturbed by a particular noise, an individual is more likely to be disturbed by other sources. A hypothetical example is that of a person who ordinarily is undisturbed by children but finds their noise disturbing once his irritation level has been raised by the noise from trucks.

The basic procedure used to test the hypotheses developed from assumption 3 was again to calculate Kendall τ coefficients as measures of the relationship between each noise source and the number of disturbing noises mentioned. Two sets of coefficients were calculated, one that included and one that excluded respondents for whom no noises were disturbing. The rationale for this was that, by the definition used in the study, if no noises were disturbing, then the source(s) mentioned must have been rated as agreeable or neutral. Hence, it could be argued that the inclusion of respondents for whom no noises were disturbing would lead to an artificial inflation of the correlation coefficients.

Table 2 shows the two sets of coefficients. (The number of respondents for each noise in this table may be greater than the total numbers in the two previous tabulations because a few people did not give an overall neighborhood rating.) As expected, the magnitude of the coefficients is less when the respondents who mentioned

no disturbing noises are excluded, except for the case of noise from children, where the coefficient was slightly higher. Despite these differences all the values are positive and significant, which is contrary to hypothesis 3.A and hence leads to the conclusion that the rating of specific noises is not independent of the total number of disturbing sources. Since the coefficients are all positive, there is support for alternative hypothesis 3.B, which implies that, as the number of disturbing noises increases, specific sources are likely to be rated as more disagreeable. The statistical significance of the correlations and the fact that they are consistent for a range of noise sources provide a strong basis for this conclusion.

Of the two explanations suggested for this relationship, the notion of a carry-over effect that leads disturbance from one source to trigger unfavorable responses to other noises seems the more likely. A recent case in Toronto seems to support this possibility. Residents close to an entertainment area complained about the noise from cars as drivers repeatedly circled the area looking for parking space. There was an additional complaint against the noise theater patrons made walking to and from their cars. It seemed on the evidence presented that the second complaint was very much a carry-over from the first and would not have arisen nearly as often had the traffic noise not first raised the annoyance levels in the neighborhood.

SUMMARY AND CONCLUSIONS

The aim of this paper has been to examine three assumptions implicit in existing approaches to noise-impact analysis. The results presented lead first to the conclusion that there is a significant positive correlation between an individual's rating of specific noise sources and his rating of the overall level of neighborhood noise.

This finding supports the implicit assumption of existing community noise-measurement procedures and to that extent is reassuring. On the other hand, the magnitude of the correlations for several of the sources was relatively low, and none exceeded 0.50. Caution should therefore be exercised when treating community response to specific noises by using physical measures based either on all sources combined or on ratings of the overall neighborhood noise level. It is fortunate that the results show the strongest relationships in the case of transportation noise since this has been the major focus of noise-impact analysis. Train noise does, however, stand out as having a relatively low correlation with the overall neighborhood rating, which indicates in this case that measures related to overall neighborhood noise levels are probably unreliable as bases for estimating the impact of the specific source.

Examination of the second implicit assumption failed to produce a clear-cut conclusion. For five of the nine sources, the relationship between the rating of the specific noise and the overall neighborhood rating appeared to be independent of the number of disturbing noises mentioned, which supports the assumption. However, for four sources the results tended to refute the assumption, since they showed a strengthening of the relationship as the number of disturbing noises increased. This creates some cause for concern, since existing techniques of noise-impact analysis typically do not take account of the number of disturbing noises present. The implication of the findings is that this may be a significant factor, particularly with respect to response to transportation noise.

Further evidence for this conclusion is found in the results of testing the third assumption. Contrary to the basic hypothesis, it emerged that the rating of a specific noise is not independent of the total number of disturbing noises but rather is significantly and positively related. This result was true for all sources tested and was most decisive in the case of road traffic noise.

These conclusions leave us in some doubt as to the adequacy of the techniques used to assess the impact of transportation noise that are based on overall measures of neighborhood noise and that make no allowance for the number of disturbing noises present. As indicated in the introduction, both factors are characteristic of a number of existing procedures. The general implication of the results of the analysis presented here is that such procedures, while not invalid, are at best crude tools for assessing community response to specific noise sources. There would certainly appear to be a need to develop more refined techniques that are less subject to the limiting assumptions examined in this paper.

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Statewide Transportation Planning: The North Carolina Experience

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North Carolina's experience in statewide transportation planning represents a new attempt to deal with comprehensive multimodal transportation planning at the statewide level through the use of sketch-planning techniques. The characteristics and relationships of the social, economic, political, and environmental systems that affect the state are described and analyzed. Four projected futures for the state are identified with corresponding development patterns. All feasible modes of transportation are considered, and transportation requirements are defined for each projection. The elements common to all or most of these requirements are screened and formulated into low-risk, short-range (5-year) action programs, grouped into four major classes: capital improvement, operating, regulatory, and promotional programs. Similar classes are used to identify mid-range (10 to 15-year) conceptual programs. These, however, provide policy direction rather than deal with specific projects and are addressed to each of the different projections separately. This paper presents an overview of this process and preliminary comments on its usefulness to statewide transportation decision making. The effort indicates that sketch planning can be effective and economical as a planning approach. As a decision-making tool, it seems that more time and better reconciliation of conflicts in the public and private sectors are needed before it is fully useful.

In recent years many states have demonstrated a desire to initiate or improve comprehensive transportation planning at the statewide level (1, 2, 3). These efforts frequently met with mounting frustrations. Nevertheless, there seems to a general agreement that this neglected area will deserve and receive increasing attention from now on.

The North Carolina experience described here represents a new attempt to deal with this difficult subject through the use of sketch-planning techniques. Sketch planning is defined as "the statement of plan alternatives at a low level of detail with emphasis on broad policy implications rather than on details on (physical) plan configuration" (4). It is important to emphasize here that sketch planning is intended to represent only a single step in the total planning process. It does not claim either to answer all the questions and needs or to substitute completely for any of the existing approaches. Determination of its potential value will have to wait for the completion of the future phases of the North Carolina effort and similar efforts, such as the current NCHRP project on sketch planning.

Statewide transportation planning is defined here as the orderly, honest, and complete analysis of the characteristics and relationships of the social, economic, environmental, and political systems that affect the state, with the objective of defining the most effective alternate solution(s) and with special emphasis on transportation. This ambitious definition is designed to reflect and emphasize two important themes. First, transportation is only one element in the total scheme of state development and should be viewed as such regardless of who is sponsoring or carrying out the planning effort. It is also valuable as a tool for accomplishing nontransportation objectives. This extends the role of transportation beyond the efficient and safe movement of people and goods as an end product and establishes its value in terms of its contribution to improved social, economic, and political development, as well as preservation of the natural environment. As such, transportation planning can and should be expected to result in nontransportation strategies and decisions. Second, statewide transportation planning involves all transportation-related activities within the boundaries of the state, including urban, rural, urban-rural, and interurban activities, as well as interstate movements and considerations.

The North Carolina effort can be better understood and evaluated when viewed from the special circumstances under which it was conceived and executed. Its details may be of special interest to other states concerned about the transition from traditional modal arrangements to the recent multimodal state departments of transportation. Although the creation of the North Carolina Department of Transportation was authorized in 1971, it was only in late 1972 that the Office of the Assistant Secretary for Planning (OASP), the unit responsible for managing the sketch-planning effort, was established as a staff unit and only in late 1973 that it had a working staff. Neither the department nor OASP had any stated mandate or mission as a multimodal

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agency. In 1973, through cooperation with the Division of Highways (one of the modal divisions in the department), OASP obtained $250 000 for multimodal transportation planning for fiscal year 1974-1975. In developing the basic elements of the work program for OASP, specific and conflicting concerns became apparent; although there were limited time and resources, there was a desire to develop a planning process that would provide policymakers with a decision-making tool at the earliest possible time, while avoiding as many of the pitfalls of existing planning methodologies as possible. The present approach was adopted and consulting services were secured in October 1974 to help develop phase 1 of the North Carolina Statewide Transportation Plan.

After 18 months of work and $275 000, this phase was completed and a new challenge was faced. The challenge is represented by some critical questions. Does the effort satisfy its intended objectives as a planning framework for North Carolina? If yes, can it be useful, and will it be used as a decision-making tool in North Carolina? This paper is concerned with the general description and evaluation of North Carolina's experience to date (4, 5).

GENERAL APPROACH

The North Carolina effort was guided principally by the desire to develop an implementation-oriented product while exploring the entire range of feasible alternatives, without being constrained exclusively by historical trends and biases. To accomplish this, specific objectives were established and translated into the following tasks:

1. Definition of existing conditions, directing special emphasis to the characteristics, attributes, and requirements of each mode; to an evaluation of transportation goals, objectives, and policies in North Carolina; and to a general description of the transportation, social, economic, and environmental systems in the state;
2. Identification of at least the two most probable development patterns in North Carolina;
3. Identification and assessment of the most feasible alternate transportation plans corresponding to the individual development patterns;
4. Description of modal programs;
5. Definition of requirements for implementation of alternate plans, including scheduling, management, financial, and legislative elements; and
6. Development of a strategy for both the completion and the continuous evaluation and updating of the plan.

These tasks reflected the general approach desired for the study. However, it was recognized later that there was a need to refine these tasks into a final strategy to make the planning effort more feasible and effective. In the general area of transportation planning, two propositions were formulated and adopted. On the one hand, realistic transportation planning was viewed as an effort whose results could only bend established trends rather than radically alter them. On the other hand, effective planning could only be achieved by responding to the uncertainties of the future and identifying the entire range of feasible future developments and transportation alternatives. This would require expanding the analysis beyond the limits of traditional forecasts and solutions. It was also hypothesized that in examining this range of forecasts it would be highly probable that some elements of the alternate solutions would be common to most or all of them. These commonalities could be used to develop a low-risk implementation program, i.e., one that would not prematurely limit the ability to choose from or respond to the potentially different futures. The final strategy adopted incorporated these notions and provided a clearer framework, which could be monitored and evaluated.

It is important to emphasize here that the definition of the North Carolina Statewide Transportation Plan was extended to include three important and interrelated elements:

1. A management system with special emphasis on an effective and clear planning process that provides for monitoring and updating the process;
2. A set of system and policy alternatives capable of resolving areas of concern; and
3. A set of action programs for implementation, including institutional, operational, regulatory, and capital improvement strategies.

A prerequisite to the formulation and evaluation of transportation plans was an understanding of North Carolina's potential futures and the conditions from which they would emerge. Documentation of existing conditions included description of the transportation, social, economic, environmental, and political systems in the state. In addition, relevant goals, objectives, and policies of the public sector with regard to each area were summarized. Many of the data required for this element were extracted from available secondary sources and from interviews with key policymakers in state and local government (6, 7).

As noted earlier, realistic plans were defined as those that could bend trends rather than radically change them. Consequently, a study of historical trends was established as the initial point of reference. A two-day work session and subsequent investigations by the study team resulted in determining which factors could contribute to the modifications of associated projections. Two such factors were identified as most significant—the availability of natural resources, primarily energy; and the nature and extent of public intervention required to effect growth management.

FRAMEWORK OF ALTERNATIVES

With regard to the energy factor, an assumption was made that technological breakthroughs would circumvent shortages of resources. The opposite assumption was also made that, either due to the absence of technological breakthroughs or as a matter of societal choice, the growth rate of use of resources may never be as high as in the past. Intervention by the public sector could occur as a result of the state government's assuming either a reactive or a directive role. On the basis of these assumptions, a framework for determining alternative futures emerged; this framework is shown below.

Government Role	High Availability of Energy	Low Availability of Energy
Reactive	Alternative 0—historical trends	Alternative 1—voluntary conservation
Directive	Alternative 2—managed growth	Alternative 3—managed conservation

Once the shaping forces of each alternative had been established and relevant documents (6, 7, 8) had been consulted, details about population growth and distribution, economic structure, income levels, demand for natural resources, government activities, and life-styles were outlined, and their implications for transportation were highlighted. A description of the general characteristics of the resulting four alternatives follows.

Alternative 0: Historical Trends. This is based on the continuance of a strong industrial economy supported by relatively cheap available energy. Government intervenes only to correct market irregularities. The automobile remains the dominant mode of transportation, reinforcing urban sprawl as the dominant form of urban expansion. Income levels and life-styles suggest the affluent suburban living of today.

Alternative 1: Managed Growth. This posits a strong government, vitally interested in making the most of the traditionally high availability of resources. Extensive state and regional plans are drafted and implemented. The values of North Carolinians are such that a dispersed growth concept is pursued that offers a full range of urban amenities via urban clustering techniques. Income levels and life-style options are the greatest of any of the futures.

Alternative 2: Voluntary Conservation. This assumes that energy shortages are a long-term reality and that the marketplace, acting within a broad but still relatively weak government framework, can voluntarily adjust its processes in a manner that assures the growth of North Carolina's economy. Income levels are slightly lower than under alternative 1. Life-styles change more significantly as the use of energy-intensive forms of transportation and urbanization is curtailed. Less reliance is placed on automobiles and airplanes; greater reliance is placed on higher urban densities and corridor development patterns.

Alternative 3: Managed Conservation. This also posits a strong government with definite state planning and management ideas, but it is a government that is sharply constrained by resource shortages. The need for steering away from energy-intensive processes results in the rise of labor-intensive economic activities (most notably service industries), a substantial swing toward public modes of transportation, and the development of optimum-sized (in an energy sense) cities. Due to careful governmental management and increased demand for labor, incomes do not drop significantly below those in alternative 1, but life-styles do evolve from an orientation toward materialistic consumption to one toward consumption of services.

The final step in defining the alternative futures was to translate them into development patterns or, more specifically, into statewide population distributions. This required that population distribution be defined in terms of the total number of people and total number of square kilometers for each of three types of areas: (a) contiguous urbanized areas—those with a density of at least 580 persons/km^2 (1500 persons/mile^2), (b) scattered urbanized areas—those with a density less than the above but greater than 80 persons/km^2 (200 persons/mile^2), and (c) rural areas—all other areas of the state.

The process by which this information was derived involved three steps. First, an index of growth potential for each urban node (defined as a town or cluster of towns with a 1970 population of 5000 or more) under each future was derived. Second, the index for each node was compared with existing population projections to determine a growth rate and population change for each node under each future. Finally, urban population distribution and density assumptions for each future were used to allocate nodal populations among the three types of areas.

The growth potential indices were established according to growth inducements and constraints stemming from five factors: economic base, political attitude toward growth, environmental constraints on growth, population size, and accessibility characteristics. In addition, it was necessary to determine what effect public intervention in growth management might have on the growth potential of each node. Public actions to modify the transportation system were emphasized in this analysis. On the basis of this information, a single indicator for the growth potential of each node was derived.

It is important to note that the growth potential indicators were not expressed in quantitative terms and hence did not set the growth rate for the analyzed nodes. Rather, the indicators provided, in a single phrase (developed city, target growth center, and so on), a qualitative description of the social, economic, environmental, political, and transportation characteristics of a node. As a result, the study team had ready access to information relevant to the analysis of the growth potential of each node that, when used in conjunction with existing state and regional growth projections, facilitated estimation of the 1990 population for each node under each future. Rural population was simply the difference between the 1990 statewide population estimates, as developed by the North Carolina Office of State Planning, and the sum of the population estimates of the urban nodes as developed in the study.

The allocation of nodal population estimates to either contiguous or scattered urban areas and estimates of the amount of urban land were then made. These were determined through population-density assumptions for each future, subjectively derived by the study team. The qualitative nature of this method precluded much confidence in the population projections of individual nodes. Consequently, nodal population and land-area estimates were summed according to the three major geographical regions of the state in order to minimize error.

One additional outgrowth of determining existing conditions, futures, and development patterns was the generation of a matrix for the accessibility of transportation for the urban nodes. This matrix provided necessary information to help establish the indices of growth potential of the nodes by indicating how the existing transportation system is influencing existing development patterns and how it might influence future development patterns.

The determination of the futures and their respective development patterns was the pivotal element of the effort in phase 1. This work established the framework and generated the information that determined the transportation plans. Transportation requirements were either a part of the futures' definitions, revealed through the formulation of the accessibility aspects of the indicators of growth potential, or they were derived from data used to define the development patterns. Since each transportation plan was designed to achieve a specific future and development pattern, these elements also served as the impact statements for such plans. Given the centrality of this element to the planning process, the credibility of its conclusions is critical to the potential usefulness of the sketch plan as a decision-making tool.

TRANSPORTATION REQUIREMENTS

The identification of existing conditions, alternative futures, and resulting development patterns established the data base and framework for identifying transportation requirements in North Carolina. The objective was to identify broad system and policy issues and alternative solutions rather than to provide detailed analyses or project-level recommendations. For the analysis, the transportation system was divided into two parts—intrastate (intercity transportation within the state) and intraregional (transportation within urban areas and their immediate surrounding areas).

The analysis of intrastate movements was restricted to links between the major cities (selected through population and geographic considerations) in the state. These links provided transportation corridors that included most cities in the state with a 1970 population of 10 000 or more.

An accessibility matrix was developed that outlined the current transportation characteristics of each corridor. The matrix included all modes, with facilities and services of each mode described in terms of availability, frequency, and travel time. The relative quality of services available to each corridor was then evaluated by using an algorithm that incorporated the data items and a set of subjectively imposed standards, such as the requirement that intercity travel time by nonautomobile modes not exceed 150 percent of automobile travel time. The transportation requirements of the alternative futures were considered next. Some of these, such as policies concerning the operation and promotion of different modal services and the use of transportation as a growth management tool, were inherent in the definitions of the alternative futures. Others emerged with the formulation of the development patterns. For example, the development of the accessibility indicator revealed the transportation improvements that would stimulate growth and achieve the development objectives of the futures with managed growth and managed conservation. The integration of these two analyses, existing conditions and future conditions, culminated in the identification of intrastate transportation requirements. This was achieved by systematically addressing specific areas and answering a series of questions, including the following:

1. Define the modal implications of each future: What are the energy constraints? How might these affect each mode in terms of general use? What is the likely extent of government intervention in regulation, funding, or operation of each mode of service?
2. Define the growth posture under each future: Where will growth be concentrated (increased urbanization of the Piedmont or clustering around growth centers)? What is the role of the government in directing growth? Which areas of the state will grow under each future? What happens to densities in urban areas under each future?
3. Review existing modal intercity service: Where are the strong modal corridors? What linkages now have poor service? Which modes are deficient? Which modes offer the best levels of service and for what types of trips?
4. Knowing the above, define the corridors, linkages, areas, and types of actions (e.g., expanding service along certain corridors) that must be emphasized for each mode under each future.

Requirements for intraregional transportation service included urban roadways, urban transit, and rural transit. The future need for intraregional roadways (i.e., arterials and collectors) was derived from assumptions regarding the roadway improvements required per unit of new land brought into urbanized use as determined in the formulation of alternate development patterns. A series of nomographs were developed as sketch-planning tools for regular (fixed-route and fixed-schedule) urban bus service, as well as guidelines for planning hybrid demand-responsive or fixed-route and fixed-schedule transit systems. These nomographs were based on established transit-planning principles and empirical analysis of existing transit operations around the nation. They specifically allowed for variations in the level of service, and thus provided the needed sensitivity to the different futures and the changes in energy supply and population density associated with them. Public transportation requirements in smaller urban areas, low-density suburban areas, and rural areas were estimated on the basis of the demand for such service under each future. This demand, in passenger-kilometers, was estimated as a product of empirically observed trip-generation rates for different population groups, the population of each group under each future, and the average trip length. It should be noted that estimates of urban roadway improvements were assumed to reflect infrastructure requirements that varied only according to the land-area changes under each future. On the other hand, urban and rural transit service estimates were made sensitive to the specific economic, energy, and development characteristics of each of the futures.

Movement of goods was investigated separately and differently from passenger movements. This was partly necessitated by the lack of both historic freight data and knowledge of the complex institutional arrangements between private shippers, operators, and government agencies. The analysis used a general approach that investigated the types and sources of freight in North Carolina, the characteristics of the different modes for freight movement, and the applicability and role of each mode to serve various futures and development patterns. Some of these characteristics included cost, speed, energy efficiency, flexibility, and accessibility.

The estimation of costs associated with each of the four futures served two purposes: to provide a basis for comparing the relative differences in state transportation expenditures between modes and alternative futures and to indicate the order of magnitude of possible statewide transportation investments. The ranges of costs for all modes of transportation between 1975 and 1990 were $11 billion to $12 billion for historic trends, $12 billion to $14 billion for managed growth, $5 billion to $11 billion for voluntary conservation, and $6 billion to $12 billion for managed conservation. The lower limits in voluntary conservation and managed conservation are artificial limits that reflect our inability to estimate some components of the transportation requirements. Nonhighway costs were estimated to range from 2 to 6 percent of the total cost in historic trends to 17 to 18 percent of that in managed growth. Higher percentages of nonhighway costs in the energy-tight futures were due more to reductions in highway commitments than to increases in nonhighway transportation investment. The apparent minor variations in the total costs associated with the different futures do not reflect the fact that they represent partly different transportation systems. As such, they do not reflect the penalty cost associated with failure of the state to support the emerging development pattern.

IMPLEMENTATION PROGRAMS

One of the final steps in the North Carolina approach was to develop short- and mid-range implementation programs. Short-range programs were defined as the group of decisions that the state could make at a relatively low risk in the face of future uncertainties. Low risk meant that adopted strategies were common to all or most futures and hence were relatively independent of the choices that the state may pursue in later years. This implied that the state could implement such programs and still retain the ability to evaluate in detail alternative futures and either choose from among them or respond to any that may be imposed.

The study identified four general classes of short-range strategies: capital improvement, operating, regulatory, and promotional programs. Capital improvement programs included the construction of transportation facilities, such as highway links between and bypasses around key cities on important routes, as well as assistance in capital funding of facilities and rolling stock. Operating programs included the direct maintenance and operation of some transportation facilities and services, such as highways and urban transit, or the provision of operating

subsidies to others, such as rail, intercity transit, rural transit, and commuter air service. Regulatory programs included the retention or revision of regulations related to speed, safety, inspection, rates, rights, taxation, and provision or discontinuation of transportation-related facilities, rolling stock, or services. Promotional programs included direct involvement or assistance in marketing and encouraging the use of efficient modes of transportation and available services, as well as endorsing specific developments such as an offshore superport or airports included in the statewide airport system plan.

Mid-range programs dealt with policy directions that would form the basis for developing additional short-range action programs during the 1980s. The groupings were similar to those of the short-range programs, but each future was treated separately. Although the programs were not project specific, they outlined future directions in a manner potentially useful to both the policymaker and the transportation analyst (5).

A public involvement program was deemed to be an essential component of the sketch-planning process. It was needed to develop responsiveness to diverse public concerns, establish informed discussion of issues, and encourage intergovernmental and interagency coordination.

Because of constraints on resources and time, the techniques used were designed to enable small numbers of events and personnel to reach large audiences and to involve key figures in state government. The techniques included producing material for the mass media, monitoring the mass media, distributing a monthly newsletter, maintaining public files on the effort, maintaining personal contact with key policymakers, conducting a public-opinion survey, developing two participatory television programs, establishing review committees from the private and public sectors, and distributing study reports. In general, the program was a worthwhile effort, but it had varying degrees of success. Consequently, while the program generated new communication channels and elicited important input from some sectors of the public, other sectors were inadequately contacted. In addition, no group that had a strong commitment to the effort was established.

Work in this area indicated two specific directions to be pursued in the planning effort. First, the study identified transportation issues and opportunities, as well as some methods for responding to them within the context of various futures. Consequently, it was recommended that the assumptions and findings of phase 1 be taken to the public and tested across the state. This should include determination of the applicability and feasibility of planning for the future and perhaps a consensus on a future that the state can accept or support. It is anticipated that such dialogue will also expand public knowledge and awareness of transportation issues and thus aid in planning and decision making in the future. Second, the study identified a need to conduct specific studies and analyses to complement the sketch-planning effort. As noted previously, the intent of statewide sketch planning is to test and analyze policies and programs on a broad scale with lesser emphasis on the specifics of project development and implementation. It is through this broad analysis that gaps in the planning process are noticed, signaling the need for increased emphasis and analysis in subsequent phases. These gaps may include unavailability of certain data, analysis techniques, or institutional arrangements that currently hinder a truly comprehensive transportation planning process.

In a general context, the planning effort indicated three overriding concerns that suggested a policy direction for future transportation decisions in North Carolina. These concerns deal with the impact of reduced energy resources on transportation needs and services; the relationships between the state's rural character, urban development patterns, transportation services, and the natural environment; and the impact of limited financial resources for transportation investments on the total transportation program in the state. These concerns are likely to move the state in the direction of making the existing and substantial transportation system more efficient rather than more expansive. In other words, transportation planning and implementation in the future may change their orientation from construction facilities to better management of these facilities and to solutions outside the traditional domain of state transportation agencies, such as operation, regulation, land use planning, growth management, and monetary as well as nonmonetary promotion of transportation services.

USEFULNESS OF THE NORTH CAROLINA EXPERIENCE

The present status of statewide transportation planning in the country can generally be described in terms of three characteristics—the organizational arrangement of the state agency or agencies directly responsible for it, the planning approaches or methodologies being used, and the degree and range of interaction within state government and among all levels of the public and private sectors. In general, the solution to these challenges has yet to be found. Available choices are represented either by operating solutions that are full of conceptual or practical weaknesses or by conceptually consistent and potentially valid solutions that will require years of development and testing before they become operational and acceptable to all parties involved (1, 3).

In North Carolina, the organizational structure of the new department of transportation is still modally the oriented, with inadequate interaction and coordination among the different modes. Multimodal policy and systems planning is a staff function that is characterized by inadequate resources and isolation from the modal operations and the decision makers. In this area, North Carolina's experience is confirming what is happening in other states and at the federal level: The provision of a less multimodal organizational structure does not by itself result in comprehensive multimodal planning and decision making. The interaction between the department of transportation and other state agencies is confined to budgetary considerations and logistical matters. Its interaction with other levels of government and the private sector does not go beyond routine and unspirited compliance with federal requirements.

As a technical approach, sketch planning in North Carolina has the potential for overcoming some of the shortcomings of other planning approaches, especially master planning. The distinction between the two approaches concerns their respective views of the future: whereas master planning typically establishes a single long-range future and a detailed blueprint for its achievement, the North Carolina sketch plan establishes a planning process that recognizes two important elements. First, several futures could emerge. Second, while there may be a long-range direction to guide short-run decisions, that direction is constantly evolving as a result of a sequence of incremental decisions, a sequence of exogenous events, and the public and private response to each. At the same time, sketch planning retains the systems perspective, comprehensive and long-range analytical approach, and goal orientation of master planning. However, sketch planning allows more effectively and at a very early stage for needed shifts or modifications in the objectives of the state. Specifically, the North Carolina

experience indicates that objectives could not remain immune to potential changes and that each alternate future was directly associated with a special set of objectives.

Sketch planning has proved its ability to incorporate increased flexibility in responding to future uncertainties while maintaining the primary objectives of long-range system planning through a low-cost, iterative process that involves technical and political parties and concentrates on policy and broad system concerns. These attributes of sketch planning make it more consistent with and responsive to the manner in which public decisions are made and make it a potentially more realistic and useful decision-making tool. For example, sketch planning is viewed as a new element that can effectively serve the contemplated and promising multimodal simulation-evaluation approach and speed its development to an operational level (1, 3).

The North Carolina experience also revealed some specific characteristics of this approach.

1. The sketch-planning approach proved its capability for broad evaluation and identification of alternative and essentially different and realistic futures. It also succeeded in dividing strategies into two distinct classes: strategies independent of the variables that determine the futures and strategies dependent on such variables. This resulted in identifying low-risk programs adaptable for immediate implementation, as well as areas that require more detailed analysis. This approach revealed definite advantages, such as low cost and fewer data requirements of the initial planning phase, an early development of action programs, a better understanding of future data needs that minimize related costs, and a lower monitoring load due to the identification of the independent strategies.
2. The North Carolina definition of comprehensive statewide transportation planning made the planning process independent of the organizational arrangements at the state level and allowed transportation to be viewed in its proper framework. It basically opened the doors to any of several agencies that had the needed funds or resources to initiate the effort regardless of the specifics of its stated mission. This constituted a response to the criticism that the North Carolina Department of Transportation did not have a mandate for comprehensive planning that dealt with alternative futures and development patterns in the state.
3. Sketch planning did not require statewide origin-destination data, which resulted in two advantages: lower cost and greater freedom from historical or present biases in forecasting techniques and model calibration.
4. The effort specifically included urban and rural transportation, among others, in its area of concern. This was deemed essential to testing and reevaluating the planning efforts in these areas, as well as to providing a consistent framework for linking all elements of the transportation and activity systems in the state.
5. It succeeded, especially in interurban movements, in considering jointly and simultaneously several modes of transportation.
6. The effort stimulated reevaluation of existing policies and concepts and expanded the range of feasible transportation alternatives to go beyond the politically and economically acceptable and to include nontransportation alternatives as well.
7. The effort delineated strategies beyond the traditional project-specific approach and established a clear tie between the transportation and activity systems.
8. It provided a promising approach to the determination of impacts of transportation decisions.

In evaluating the usefulness of the North Carolina experience, it is important to indicate that it was conceived primarily as a decision-making tool whose value would be measured mainly by its consequences in the state and not only by what it added to the general knowledge in statewide transportation planning. It was also recognized that the usefulness of any planning effort was dependent on three elements—the quality of the planning effort itself (defined in terms of its consistency, validity, honesty, and comprehensiveness, as well as in terms of its sensitivity and its ability to address effectively issues of concern to the decision makers and the public and to provide alternatives capable of resolving such concerns), acceptance of the effort by decision makers and authorization for implementation, and effective and honest implementation of the planning strategies endorsed by the decision makers, as well as the monitoring and adjustment of such strategies over time.

This indicates that it is premature to fully evaluate the quality or usefulness of the North Carolina experience in terms of the relative validity of its assumptions and findings or in terms of its impact on the decision-making process. However, some relevant conclusions have already emerged. It appears that the ultimate usefulness of sketch planning will require a basic change in the federal attitude toward multimodal statewide transportation planning and programming. At the state level, more effective integration of the existing modal programs with multimodal systems and policy planning and a reconciliation of the political and planning processes is required. Even with these constraints and some of the technical weaknesses of this new approach, the North Carolina effort can be judged as not only useful but also imminently essential. It meets its basic obligations of both raising new and fundamental questions relevant to the futures of the state and initiating the search for solutions, as well as providing alternate solutions. The next step would be a strong commitment by top management and the decision makers to the effort and to the full use of its potential.

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Transportation Management Strategies: Prospects for Small Cities

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A case study of a transportation system management program for the Santa Barbara, California, central business district is reviewed in order to indicate the breadth and scope that similar programs might take in other small urban areas. Three alternative scenarios for transportation management are outlined—maximizing nonautomobile access, minimizing automobile access, and maximizing internal circulation opportunities. The evaluation of more specific options within these categories, according both to potential levels of goal achievement and to local community preferences, is described, and components of a recommended transportation management program are outlined. Conclusions are drawn regarding the applicability of case study concepts and methods to other areas.

The increasing interest in transportation system management (TSM) strategies—maximizing the efficiency of existing transportation facilities and services—has been primarily oriented toward our larger urban areas. Air-quality problems are more severe in these areas, energy consumption is higher, freeway and transit investments are more extensive, and transportation problems and opportunities are generally greater. However, the need for higher performance from both highway and transit systems is pervasive and extends to smaller urban areas as well.

This paper outlines how comprehensive transportation management strategies might be formulated within smaller urban areas, while recognizing the problems and opportunities for implementation. It is based on a recent transportation study conducted for the Santa Barbara, California, central business district (CBD).

DEFINING TRANSPORTATION SYSTEM MANAGEMENT

According to the U.S. Department of Transportation, "automobiles, public transit, taxis, pedestrians, and bicycles should be considered as elements of one single urban transportation system. The objective of urban transportation system management is to coordinate these individual elements through operating, regulatory, and service policies so as to achieve maximum efficiency and productivity for the system as a whole" (1). These general guidelines have been carried forward by both the Federal Highway Administration (FHWA) and the Urban Mass Transportation Administration (UMTA) and are included in regulations for development of a Transportation Improvement Program (TIP) for each urbanized area (2, 3, 4, 5, 6).

A TSM element is basic to the TIP. It emphasizes a focus on transportation improvements that are efficient, using and optimizing existing transportation investments; short range, implementing lower cost, lower risk improvements over a short time frame; and balanced, developing multimodal programs that satisfy a variety of transportation, social, and service objectives. The components of urban transportation management can be categorized into four general areas.

1. Mode of travel. Management alternatives should address the variety of transportation modes.
2. Geographic orientation of travel. Alternatives can relate to access travel to major employment or shopping centers or to travel within an activity center, such as an internal circulation trip in downtown.
3. Travel operations and service levels. Alternatives could include such physical devices as street modifications, street barriers, and various channeling devices to direct vehicular traffic. Nonphysical measures could include signalization, signing, one-way streets, and transit service levels (routing, headways, speeds, and so on). Terminal facilities (for automobile, bus, and bicycle) would also fall under this category.
4. Economics of travel. Parking rates, transit fares, gasoline costs, bridge tolls, and similar economic factors all affect travel patterns.

As for any urban system, there is no one right action plan or plan element. Rather, an overall TSM plan must include a variety of elements, all working together to enhance each individual's mobility as well as the opportunities for mobility. Thus, a key matter in urban transportation management is the need for a proper balancing between incentives and disincentives. For one particular

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situation, automobile disincentives may be an appropriate course of action. However, such disincentives will not be in the public's best interest if other modal alternatives or travel opportunities are not available to overcome this restriction on mobility. Alternative means of travel must be made available if automobile disincentives are to be employed.

CASE STUDY

This paper reports on a study recently conducted for the Area Planning Council of Santa Barbara County (2). The major thrust of the study was to develop programs that would reduce dependency on the automobile for travelers to the CBD.

The continuing strength and vitality of Santa Barbara's downtown area, when meshed with the study's primary objective, highlighted a unique dilemma that the project addressed, i.e., to answer the question: How to attract more people to the downtown area and, at the same time, not increase the number of vehicles entering the CBD? The dilemma was caused by the traditional fact that, as people activity in an area increases, so do the number of vehicles attracted and generated. Potential solutions call for new positive ways to encourage more people to use the bus, bicycle, or car pools.

Therefore, the study investigated various low-cost immediate-action transportation management strategies and programs. From a transportation viewpoint, these programs involve access, terminals, and circulation. Further, they involve all modes of available transportation for the smaller city: automobile, bicycle, bus, and walking. However, at the same time, these options must be weighed against those factors that actually stimulate and generate trips: environmental conditions and land use. Together, these factors affect transportation to, from, and within the downtown area. Thus, they all must be considered when evaluating alternative transportation actions for the CBD.

The Santa Barbara metropolitan area is bordered on the south by the Pacific Ocean and on the north by the Ynez Mountains. It is a coastal community about 2 hours' driving time from central Los Angeles. Table 1 indicates the population of various segments of the region and the importance of the CBD as a major employment center in the area. The CBD core contains less than 2 percent of the south coast area's population but holds nearly 20 percent of its available employment. Further, the entire CBD contains more than 25 percent of the employment available in the south coast metropolitan area.

CBD Travel Patterns

In order to obtain a thorough understanding of CBD travel patterns and traveler characteristics, a comprehensive series of travel surveys (of parkers, pedestrians, employees, and people driving through) was conducted during the months of August and October 1974.

Table 1. 1970 population and employment levels in Santa Barbara.

Category	Population		Employment	
	Number	Percent of County	Number	Percent of County
Central business district				
Core	2 335	0.9	11 687	11.1
Total	8 164	3.1	15 406	14.6
City of Santa Barbara	70 215	26.6	29 000 (est.)	27.4
South coast area[a]	150 425	58.9	60 000 (est.)	56.8
Santa Barbara county	264 324		105 700	

[a]Includes Santa Barbara, Goleta Valley, Montecito, Carpinteria, and Summerland areas.

These surveys not only provided a satisfactory data base (nearly 10 000 interviews) but also provided information that could be used in the actual evaluation of alternative transportation programs for the CBD. In this manner, the survey results themselves became important ingredients in the determination of a recommended transportation management program. This expanded information base was obtained, in particular, through a series of attitudinal questions asked in a survey of people who work in the downtown area. Additional surveys dealt with the travel patterns and characteristics of nonworkers, pedestrians, and motorists driving through the CBD.

Some important travel facts were determined from these surveys, including

1. Shorter trip lengths. It was found that approximately 65 percent of CBD-oriented trips originated within 1.8 km (3 miles) of the downtown area. This short trip length makes it extremely difficult for transit to compete with the private automobile. A 10-min wait for a bus, for example, would completely offset any convenience offered by the bus.
2. Abundance of free available parking. In Santa Barbara, 60 percent of CBD employees parked free. Many of these employees parked on the street in adjacent residential areas. Thus, any possible cost advantage of transit is reduced considerably.
3. Significant through and internal circulation traffic. Approximately 30 percent of the vehicular traffic passing through the center of Santa Barbara's CBD had neither an origin nor a destination there. Another 15 percent involved trips that had both trip ends in the CBD. Further, it was determined that 30 percent of the cars parked in the CBD during the peak accumulation time were reparked in the CBD during the day. The result is that much (nearly half) of the traffic in the CBD represents either through traffic or vehicles reparking.
4. Short peak period. Peaking of employee work schedules was found to be significant; nearly 75 percent began and ended work during the same hours. However, the proximity of parking to access and egress routes meant that a relatively short part of each trip was in motion within the CBD. The actual peak period (during which traffic congestion does exist) is much closer to a 15- or 20-min span than to an hour.

Framework for Evaluation

Building on this base of factual information, alternative transportation management scenarios were developed for testing and evaluation. Using evaluation criteria that were developed from regional (countywide) goals and objectives, a recommended transportation management plan was developed. The regional transportation goals identified by the Area Planning Council were used to guide the study. These four goals were to

1. Develop a comprehensive transportation system that provides a choice of transportation modes for people and goods,
2. Preserve and enhance the character of the environment,
3. Prepare plans with provisions to ensure that appropriate new transportation methods can be incorporated as they become available,
4. Coordinate land use and transportation planning and capital improvement programming so that transportation needs can be met as growth occurs.

From this list of goals, a set of 14 objectives was developed by the consultant team. These objectives, de-

signed to provide more specific direction for measuring plan performance, were to

1. Maximize CBD transportation access,
2. Enhance modal opportunities in the central area,
3. Minimize the amount of traffic traveling through the downtown area with neither an origin nor a destination in the CBD,
4. Decrease dependence on motor vehicles for internal circulation trips,
5. Minimize pedestrian-vehicle conflicts,
6. Maximize ease of travel between major activities and buildings in the downtown area,
7. Minimize the inconvenience of transfers between modes,
8. Maximize visual compatibility of the transportation system with the downtown style of architecture and environment,
9. Minimize noise and air pollution,
10. Improve service to major CBD activities,
11. Maximize the flexibility of future transportation operations,
12. Maximize the efficient use of existing investments and facilities,
13. Maximize ease of implementation, and
14. Minimize costs in relation to expected benefits.

OVERVIEW OF TSM SCENARIOS

The guidelines promulgated by FHWA and UMTA (4) list a variety of improvements that could be implemented within a TIP. For planning and evaluation purposes, the various actions included under these federal guidelines were grouped into three basic scenarios.

Maximum Nonautomobile Access Opportunities

Included under this scenario were a variety of access alternatives that emphasize public transportation, bicycle facilities, walking, and supporting policies. Among the public transportation alternatives investigated were

1. Improved fixed-route bus service to expand the present bus system's level of service by reducing headways and extending route coverage.
2. Demand-responsive (dial-a-ride) bus service, with doorstep service, whereby passengers are picked up and dropped off within a very short distance of their destinations.
3. Commuter subscription service, operated similarly to demand-responsive service but catering to the CBD employee. Monthly subscription would bring door-to-door bus trips for the employee. A variation of this service would be the operation of van pools.
4. Related public transportation facilities, including the development of outlying park-and-ride lots in combination with direct express bus service and facilities that expedite transit-vehicle movement, such as exclusive lanes for buses and special bus ramp facilities.
5. Improved bicycle facilities, including both paths and terminal areas.
6. Policy alternatives, including two primary programs—the staggering of work hours and the continued expansion of transit promotion and marketing. The former concept would involve flattening the distribution of beginning and ending work hours for employees in the downtown area. The objective of such a program would be to more evenly distribute these times over the course of the morning and afternoon peak periods. Included under the latter program would be an expansion of transit marketing efforts to include economic incentives for employers and merchants in the downtown area, joint merchandising programs with the CBD parking district, or simply expanded advertising campaigns.

Minimum Automobile Access Opportunities

Included with this scenario were alternatives oriented toward increasing the average occupancy of automobiles arriving in the CBD, such as:

1. Carpool incentives—special close-in parking locations, special parking rates, merchandise coupons, or even employer bonuses for government-, employer-, merchant-sponsored programs that would encourage people to carpool.
2. Automobile-free zone—an area in which automobile traffic would be discouraged or even prohibited. This coule be a street or a zone that would be, in effect, turned over to the pedestrian. The purpose of such a program would be to restrict traffic penetration of the downtown area.
3. Restrictions on parking time—restriction of on-street parking facilities (or other facilities) to discourage or prevent long-term parkers from using them.
4. Parking rate increases—an economic disincentive for downtown parkers, oriented primarily toward the long-term parker. Such a program could be balanced with a program that provides incentives for the commuter to switch to transit.
5. Fringe parking facilities—the current Santa Barbara downtown plan incorporates a multimodal transportation terminal at the CBD fringe, in which parking is a key function. While fringe parking facilities do not invite motorists to get out of their cars for the entire trip, they do intercept motorists before they penetrate the downtown area. Normally, a supplemental shuttle-bus system is necessary to provide a convenient linkage between the core area and the parking facility.

Maximum Internal Circulation Opportunities

Internal circulation opportunities build on many of the alternatives outlined above:

1. Pedestrian precinct—similar to the automobile-free zone described above. Such a precinct typically takes the form of a full mall treatment for a street.
2. Shuttle bus—an expansion of the current downtown service to provide shorter headways and greater route coverage in the CBD.
3. Preferential transit streets—separate, exclusive lanes within existing thoroughfares or bus-only streets. Such an alternative would help to provide a travel-time advantage for the bus and thus help to overcome downtown traffic congestion.

EVALUATION OF ALTERNATIVE PLANS

The evaluation of the alternative scenarios outlined above was conducted in terms of potential achievement of the objectives identified earlier. While the overall goal is, of course, to achieve all of the objectives at a desirable level, this is not always possible. Some objectives are achieved at the expense of others (trade-offs). Because of the need to assess overall goal achievement, the performance measures used must be matched or combined to provide certain composite evaluation results. It is the comparison or aggregation of these results that leads to the development and recommendation of a transportation management plan.

Since the scope of the study did not permit a detailed

quantitative evaluation, a qualitative rating scale was used to assess each alternative. In essence, a systematic comparison of the more specific program options for each scenario, matched against each of the 14 objectives, was accomplished on the basis of a judgmental rating.

Table 2. Results of the survey of employee preferences.

Category	Number	Percent
Most desirable method to reduce automobile use in CBD (sum of first two preferences)		
More frequent bus service	2 547	22.0
Special commuter buses	2 132	18.4
Car-pool incentives	2 003	17.3
Park-and-ride lots	1 810	15.6
Closer bus service to home	1 419	12.3
Better bicycle facilities	1 105	9.5
All-day parking prohibition	411	3.6
All-day parking more expensive	145	1.3
Total	11 572	
Most desirable unconventional method to reduce impact of automobile		
Free parking for smaller cars	2 502	37.7
None	1 955	29.5
Higher parking rates for one-occupant car	1 786	26.9
Higher parking rates for large cars	395	5.9
Total	6 638	
Greatest drawback to reducing automobile use in CBD		
Shoppers will not come downtown	2 998	51.3
Hardship on employees who must use car for work	1 241	21.2
Some people need car for personal business	519	8.9
Infringement on personal convenience and comfort	360	6.2
Bus service cannot be made adequate	325	5.6
Cars are no problem	221	3.8
Employees will not work in CBD	177	3.0
Total	5 841	
Paired preference questions		
Car pool	855	27.9
Park-and-ride	999	32.6
Neither	1 213	39.5
Total	3 067	
Special commuter bus	1 229	43.8
Improved bus service	1 013	36.0
Neither	567	20.2
Total	2 809	
Most significant factor that would make you consider taking bus to work		
Comparable commuting time to present	1 048	38.2
10-min frequencies	427	15.6
Free bus service	409	14.9
Nothing	401	14.6
Bus route within 2 blocks of home	343	12.5
Adequate shelters	114	4.2
Total	2 742	

Figure 1. Evaluation matrix for alternatives and objectives.

RATING SCALE (Degree of satisfaction)
1 Very good
2 Good
3 Average
4 Poor
5 Very poor
□ Not applicable

ALTERNATIVES	A. Maximize CBD access	B. Enhance modal opportunities	C. Minimize through traffic	D. Decrease auto use for internal trips	E. Minimize pedestrian-vehicle conflicts	F. Maximize ease of circulation	G. Minimize transfers	H. Visual compatability	I. Enhance environment	J. Service to major activities	K. Flexibility of expansion	L. Efficient use of existing facilities	M. Ease of implementation	N. Cost-effectiveness
1. Special commuter bus	1	1		4	3		1	2	1	1	1	1	2	1
2. Park-n-ride lots	2	2		4	3		4	2	3	1	3	2	3	2
3. Improved fixed route bus	3	3	3	3	3	3	3	2	2	2	1	1	1	3
4. Dial-a-ride	1	1	3	2	3	3	1	2	1	1	1	1	4	3
5. Car pooling	1	2		3	3		1	2	3	1	1	1	2	1
6. Staggered work hours	3	5		5	5			3	4	2	1	1	4	3
7. Parking disincentives	4	4		1	1			2	1	3	1	1	5	1
8. Small car incentives	5	5		5	5	3		2	2	2	3	2	3	2
9. Improved shuttle bus	3	4		1	2	1	3	2	2	1	1	1	2	2
10. Auto-free zones	3		1	1	1	2		1	1	3	5	3	5	3
11. Improved bike facilities	3	3	3	3	3	3	1	2	1	3	2	2	3	3

As another phase of plan evaluation, the results of the employee survey were applied. The questions included in this survey were those used to ascertain the preferences of people who live in the area and work in downtown Santa Barbara. The combination of the technical evaluation criteria (as interpreted by the consultant team) and the preferences revealed by the surveys was used in a two-pronged approach to formulating a recommended plan.

Community Preferences

An indication of the level of acceptance of the alternatives under consideration was given by certain questions included on the employee and pedestrian surveys, the results of which are summarized in Table 2. According to the surveys, the most desirable methods to reduce automobile use in the CBD involve greater use of public transportation—special commuter buses, more frequent bus service, park-and-ride lots, and closer-to-home bus service. The paired comparison questions indicated that the special commuter bus seemed to have the most potential, since it was being preferred over route or service improvements to existing bus service. Also, provision of park-and-ride facilities was preferred to car-pool incentives.

The greatest drawback respondents saw in reducing the use of automobiles in the downtown area was the impact on retail shopping facilities; more than half of the respondents indicated that shoppers would be discouraged from coming downtown if automobile use were curtailed.

Travel time is still a very important factor to the commuter. Approximately 38 percent of the respondents indicated that the most significant factor that would make them consider taking the bus to work was a commuting time comparable to what they already have. Other key inducements that were noted included frequent service (10-min headways), free bus service, and bus stops located within two blocks of the home. In addition, approximately 15 percent indicated that nothing would make them consider taking the bus to work.

Incentives for using small cars showed relatively high acceptance; nearly 40 percent of the employees thought that free parking for smaller cars was a desirable method of reducing the impact of the automobile. Just over 25 percent thought that higher parking rates for the one-occupant automobile were also desirable. However, approximately 30 percent felt that none of the unconventional alternatives was satisfactory. The expanded use of a downtown shuttle bus for internal circulation trips was supported by approximately 38 percent of the pedestrians interviewed.

Goal-Achievement Analysis

For the purposes of evaluation, the three scenarios were separated into 11 distinct alternatives, each of which was then judgmentally evaluated by the consultant team as to its potential to achieve each of the planning objectives. The results of this evaluation are summarized in the matrix in Figure 1. Each of the alternatives was subjectively graded on a scale of 1 to 5 as to how well it would satisfy each particular objective. Even though some objectives were obviously more important than others, weights were not applied in the process (i.e., all objectives were assumed to be of equal importance); a more formal and quantitative evaluation could be performed in later phases of implementation. In addition, the 11 alternatives were evaluated individually; that is, each alternative was evaluated as a distinctly separate option.

1. Maximize CBD access. The provision of an express ride without transfer from origin to destination was felt to be the most critical factor in diverting motorists to transit or car pooling. Diversion of motorists was used as a surrogate measure of enhancing accessibility to downtown Santa Barbara and determining the overall efficiency of the CBD transportation access system.

2. Enhance modal opportunities. The most significant modal alternatives to the automobile were judged to be the commuter bus and dial-a-ride. Both of these transit services would not only generate the most significant amount of diversion from the automobile but would also offer the best alternatives to the mobility needs of area residents.

3. Minimize through traffic. Most of the alternatives would not have any significant impact on reducing through vehicular traffic. However, it was judged that designation of automobile-free zones would do the best job of discouraging such traffic. Completion of the US-101 freeway (along the CBD fringe), although it was not considered here as an alternative, would certainly induce some through traffic to remain on the freeway and would be expected to prevent some traffic not destined for the CBD from penetrating the downtown area.

4. Decrease automobile use for internal trips. The automobile is currently a significant mode of transport for the internal-circulation trip in downtown Santa Barbara. Discouragement or prevention of all-day parking in the CBD core, expanded shuttle-bus service, or automobile-free zones would provide the best ways of minimizing the use of the personal automobile for short trips.

5. Minimize pedestrian-vehicle conflicts. Pedestrian safety in the downtown area can be enhanced by reducing the potential for pedestrian-vehicle conflicts. Again, elimination of the automobile would have the most dramatic impact in improving safety. Thus, all-day parking disincentives and automobile-free zones were rated as having the potential to satisfy this objective to the highest degree.

6. Maximize ease of circulation. Not many of the alternatives could actually facilitate ease of circulation; improved shuttle-bus operations were judged to be the best means. However, on a longer range basis a highly improved alternative, such as automated personal rapid transit, would satisfy this objective to a high degree. Because of its long-range nature and corresponding cost implications, this alternative was not evaluated further in the context of this study.

7. Minimize transfers. Transferring between vehicles or modes can be a frustrating experience for the traveler and is a major factor behind low penetration of the travel market by public transportation. The one-seat ride offered by commuter buses, dial-a-ride, and car pools would minimize transfers to the greatest degree.

8. Visual compatibility. This objective was concerned with how well each alternative fits into the special visual feeling offered by the style of architecture and environment of downtown Santa Barbara. Prohibition of vehicular traffic in the downtown core through the use of automobile-free zones would be the most satisfactory alternative.

9. Enhance the environment. This objective is concerned with the enhancement of air quality and reduction in noise. Diversion of motorists to transit or low-energy modes would best help achieve this objective; therefore, the most satisfactory alternatives would be commuter buses, dial-a-ride service, improved bicycle and pedestrian facilities, and parking disincentives.

10. Service to major CBD activities. Service to major CBD activities is primarily a function of access convenience and ability to provide doorstep service. The inherent flexibility of the automobile and some bus alternatives help them perform best. Fixed-route bus service, for instance, does not possess the flexibility or service of dial-a-ride.

11. Flexibility of expansion. There are no clear winners among the alternatives for this objective. However, the alternatives that require physical improvements were judged lowest since they would be more difficult to expand.

12. Efficient use of existing facilities. This objective is concerned with optimizing the existing investment in capital facilities, e.g., streets, parking facilities, and buses. While all the alternatives were oriented to achieve this objective, those that require further capital investment were judged to perform less effectively than the others.

13. Ease of implementation. This objective is a catchall for an expression of community attitudes, local policies, or difficulty in obtaining funding. Improving fixed-route bus service was judged to be the least controversial and easiest to implement. Parking disincentives and development of automobile-free zones were judged to be the most difficult to implement.

14. Cost-effectiveness. This objective is related to the overall measure of cost versus benefits. Using the ratings for the previous 13 objectives and the anticipated order-of-magnitude costs of purchase, construction, or operation as a guide, each alternative was graded on its potential cost-effectiveness. Commuter buses, car pooling, and parking disincentives received the highest scores.

THE RECOMMENDED PLAN

Further assessment of the alternative transportation management options listed above was conducted along two dimensions: preliminary examination of potentials for automobile diversion (higher mode split to transit) and preliminary analyses of operating and capital cost requirements. These further analyses were limited, however, to only the most promising options and were set within the context of further detailing a recommended CBD transportation management strategy.

A first step involved judgmentally setting a realistic target for automobile diversions. A 1980 target level for desired shifts in access to the CBD for various travel modes was established as the condition under which no additional vehicular crossings of the CBD cordon occur. Under this condition, projected travel growth would be accommodated by transit, bicycles, taxis, motorcycles, walking, or car pooling. If these 1980 targets were achieved by a combination of transit, bicycle, and walking modes, it would mean that the overall transit modal split would be 7.8 percent during the day compared with 2.4 percent today, and 10.9 percent during the evening peak hour compared with 5.4 percent today. From the outset it was apparent that token actions to improve transit service would not bring about this desired change in mode use in a small urban area such as Santa Barbara. Rather, if such a change is desired by the community, significant incentives for nonautomobile travel, balanced with significant disincentives for automobiles, would have to be provided. Moreover, new policies agreed upon by the city and the Area Planning Council will be needed regarding parking and transit if residents of the area are really to alter their current automobile-oriented lifestyles.

Consequently, the recommended plan represents a hybrid of the alternatives described above, drawing upon the various options to form a new package that appears most likely to achieve the planning objectives. The plan recommended inclusion of the following elements:

1. Transit incentives—provide special commuter

service (additional express service with outlying park-and-ride facilities and small-vehicle subscription bus pooling), improve the level of service offered by fixed-route transit (more direct routing to the downtown area and shorter peak-hour headways), provide midday demand-responsive service, and improve the CBD shuttle service (shorter headways, stronger marketing, better route identification);

2. Car-pool incentives—reserve close-in parking stalls for car poolers, reduce parking rates as automobile occupancy increases, provide employer bonuses for car pooling, and assist employers to sponsor van pooling;

3. Implementation of the city bikeway master plan—provide bike trailers for buses, additional bicycle routes, and locked bicycle storage facilities at central CBD locations; and

4. Disincentives for all-day parkers—place a 1-hour limit on all-day on-street parking (currently free); establish an employer transportation assessment district based on the amount of private employee parking provided, to help finance transit-oriented improvements; and increase the off-street parking rates for all-day parkers (including currently free private lots).

A summary of potential automobile-to-transit diversions is shown below.

Plan Element	During the Day	During Evening Peak Hour
Special commuter bus	1200	350
Improved fixed-route service	3200	950
Demand-responsive service	1000	0
Pooling incentives	2600	800
Improved bicycle facilities	1900	350
Total	9900	2450

The numbers of potential person-trips diverted were derived from an expansion of modal preferences disclosed in the employee attitude survey and represent upper-limit values based on questions concerning alternatives to the single-occupant automobile. The potential number of daily and peak-hour commuter-bus users was found to be 6000 and 1800 respectively. However, due to the lower number of buses recommended, the patronage figure was reduced accordingly. In addition, the potential numbers of daily and peak-hour car or van poolers were 4200 and 1250 respectively. However, for these purposes it was assumed that the average automobile occupancy would be between 2.5 and 3.0 and that the driver would be part of the potential number. Although they are admittedly preliminary and judgmental, these estimates suggest that a strong transportation management program does have a good chance of achieving modest increased automobile diversion targets.

CONCLUSIONS

This case study of the Santa Barbara CBD has several important implications for the development of transportation management strategies in other small urban areas.

1. In general, the single area that experiences the most congestion, air pollution, pedestrian-vehicle conflicts, and other negative transportation consequences will be the CBD. The CBD consequently represents a logical focus for transportation management strategies in such cities.

2. As the Santa Barbara example shows, most of the transportation management options now being explored for larger urban areas still seem relevant, on a smaller scale, in smaller cities; this covers the various modes (automobile, transit, bicycling, walking) as well as transportation functions (access, terminals, internal circulation).

3. Because of the analysis, forecasting, cost, and budgetary uncertainties involved, transportation management strategies should emphasize the short-range, low-cost, low-risk aspects of most of the management options that appear to be relevant in smaller urban areas.

4. Development of the Santa Barbara transportation management program indicated the critical importance of balancing transit incentives against automobile disincentives; comprehensive management strategies must be pursued. Moreover, the positive aspects of implementation (e.g., new buses and routes) must be made very visible to the public.

5. While smaller urban areas may have an assortment of problems similar to those of larger areas, potential TSM solutions are not directly transferable. Each area presents a unique situation. Both some sort of goal-achievement analysis and a probing of local community preferences and attitudes are essential.

6. Implementation of TSM will not be easy. Realistic targets for modal shifts should be set, recognizing that significant diversion from automobile modes will not occur overnight.

7. The combination of shorter trip length, available parking, and shorter peak periods indicates that diversion to transit will not be significant without some set of automobile disincentives.

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Research in Urban Traffic Management

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Until recently the design and operation of urban transportation facilities have been aimed at the efficient movement of large numbers of vehicles on freeway and surface street systems. Attention is now being directed toward transportation system management (TSM) programs, which emphasize the coordination of all surface transportation modes through operating, regulatory, and service policies so as to achieve maximum efficiency and productivity for the system as a whole (1). Much of this concern can be directly traced to the current energy and environmental problems faced by our society.

Among the actions to be considered by urban areas as they develop their TSM plans are traffic operations improvements, preferential treatment for transit and other high-occupancy vehicles, management and control of parking, and truck operation controls. The federal TSM regulations are directed at the metropolitan planning organization (MPO), whose responsibility it is to carry out the urban transportation planning process and to develop a transportation plan and a transportation improvement program. However, it remains the responsibility of the individual local units of government to implement, operate, and maintain the various elements of the TSM program. Thus, the new emphasis on system management has clear implications for both the transportation planner and the traffic engineer.

The transportation planner in the MPO will increasingly be called upon to examine and analyze traffic management systems on a microscopic planning scale. Performance and environmental objectives must be defined and measures of effectiveness developed. A systematic methodology for designing alternative control configurations must be formulated. Simulation models must be available to predict the system's response to proposed control configurations. Lastly, an evaluation framework must be devised so that consistent and reasonable decisions can be made.

Similarly, the local traffic engineer can no longer afford to concentrate on operational problems at isolated locations. The operation and control of all surface transportation modes over the urban street and highway network must be addressed from a system point of view, with the goal of optimizing a comprehensive set of mobility, energy, environmental, and efficiency objectives. This will require increased interaction with the activities of the MPO, as well as the application of more sophisticated traffic management concepts and tools.

TRAFFIC MANAGEMENT RESEARCH

It is clear that there are a multitude of research needs in the broad area of transportation system management. One response to these needs is a new multiyear program of research in urban traffic management that was initiated in 1974 within the Office of Research of the Federal Highway Administration (FHWA). This program of applied research is designated as Project 2K in the Federally Coordinated Program of Research and Development in Highway Transportation and is tentatively programmed for $15 million of support from research funds administered by the FHWA.

As it is now structured, the project has a dual focus. One area of emphasis is on the transportation system or traffic management process that complements the long-range urban transportation planning function. The other general area of emphasis addresses the design, implementation, and evaluation of specific traffic management control strategies. A brief review of several research activities that will support this dual focus is presented below.

Describing System Effectiveness

The continuing process of gathering and analyzing relevant, timely information is a key ingredient in an urban traffic management process. To date, traffic system data-gathering activities have been focused on such characteristics of the traffic stream as travel speed or time, number of stops, delay, volume, and occasionally density. The only socioeconomic or environmental consequence that is consistently recorded is accident experience, although there have been recent efforts to measure

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and incorporate a wider range of these factors in the evaluation of alternative highway designs (2, 3).

Research is now under way to determine appropriate measures of effectiveness for the traffic management process. Specific attention is being devoted to establishing the relevant system objectives to be optimized, accounting for the interdependencies of the system parameters and the system objectives, and developing a cost-effective system monitoring and surveillance program.

System Performance Models

An urban traffic management process also requires the capability to predict the system's response to alternative traffic control configurations. There has been a great deal of work over the years in the development of travel demand and network simulation models for long-range strategic transportation planning (4). However, these models have generally been of too low a resolution for application to traffic management decisions.

Using a different approach, traffic-flow theorists have developed traffic-flow simulation models at both the microscopic and macroscopic levels. One such network simulation model is UTCS-1, developed under the sponsorship of FHWA (5). UTCS-1 simulates an urban street network as a system of links and nodes. Each vehicle is specifically represented and its movements are computed according to car-following relationships and queuing logic.

In order to use simulation for the testing of a traffic control strategy that has a significant effect on traffic distribution, it will be necessary to simulate an area that contains a substantial portion of the routes the vehicles may follow. This area is often too large to be simulated efficiently by microscopic simulation techniques that represent individual vehicle movements. Furthermore, existing microscopic simulation techniques do not have the capability for assigning vehicle trips according to their origins and destinations. Therefore, a simulation model with a traffic-assignment algorithm and the ability to macroscopically process groups of vehicles is scheduled for development early in the project.

Control Strategies

A key element in the urban traffic management process is the generation or search for feasible alternative control configurations that would offer potential improvements in overall system performance. Both research and operating agencies are currently applying a wide variety of control techniques with varying degrees of impact on the operation of the urban area's transportation system (6). Detailed information regarding the effects of these techniques on system operation is to be obtained for a number of different operating conditions both to support the development of control-strategy design methods and to provide factual guidance to traffic engineers who must implement and operate these traffic management controls.

System Evaluation

The proposed traffic management process will also require a rational, comprehensive decision-making framework that is sensitive to established system objectives and measures of effectiveness. Because of the variable nature of the traffic management decisions that will have to be made, it is essential that the evaluation framework reflect a corresponding flexibility in its application. It must be capable of revealing trade-offs between conflicting objectives, as well as the incidence and distribution of the control system outputs over time and space.

Because the movement of vehicles simply reflects the means by which people and goods move between points of origin and destination, the evaluation framework must also possess the ability to array system consequences in terms of particular user and community groups.

Summary

The project's scope, as it has been briefly described, is designed to produce a set of methods and guidelines that will enable the local transportation planner and traffic engineer to systematically plan and implement traffic engineering and traffic control improvements. But, perhaps more important, the project will provide local officials with the methodology for performing a systematic analysis of the total metropolitan area and controlling and operating the system in that area in a manner that will ensure that it is used to its fullest potential.

Project 2K is just under way and, because of the emphasis on field evaluation of control strategies, there is ample opportunity for active state and local participation in the research program. Moreover, the FHWA Office of Research is actively seeking comments and suggestions from the traffic engineering and transportation planning communities in relation to the objectives, scope, and substance of the proposed research. This type of input is considered to be a valuable ingredient in achieving a truly coordinated and productive research product.

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