THE CHANGING CONTEXT FOR PROGRAMMING

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Transportation resource allocation decisions are becoming more difficult and complex. Resources are continuing to shrink while the set of problems to be addressed grows and diversifies. The list of concerns competing for transportation funding includes aging and decaying infrastructure, urban and suburban traffic congestion, improving traffic safety, balancing new growth with infrastructure to support it, strengthening the economy, providing rural accessibility, improving independence for disabled persons, achieving air quality standards, and reducing energy use. Recent legislation, for example, the 1990 Clean Air Act Amendments, is forcing stronger integration of some of these concerns into transportation decisions.

The nature of these current transportation problems has focussed increased attention on maintenance and preservation, demand management strategies, operational and efficiency improvements, multimodal solutions, and land-use controls. In many metropolitan areas, major expansion of highway capacity is no longer viewed as a viable solution and the mission of transportation agencies is shifting to the efficient operation of a multimodal system. As a result, there has been a shift in the types of improvements and strategies that must be reflected within transportation programming processes. Few agencies have been able to develop planning and programming methods which successfully integrate these varied concerns and solutions.

The funding side of the picture has become more complex as well—new kinds of special purpose finance mechanisms such as assessment districts, impact fees, and public/private partnerships are being developed. This is creating a greater degree of decentralization in funding; a situation in which there are a larger number of small pots of money which can be made available for specific purposes.

Finally, there is a growing concern for increased accountability and measuring performance. Questions about the appropriate mix of transportation solutions in different settings and the impact of expenditures on facility conditions or system service levels are forcing agencies to rethink how goals and objectives are defined and how results are communicated.

The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) responds to these trends. The Act dramatically increases flexibility in the use of federal transportation funds. Instead of directing what funds should be used for, it emphasizes the use of sound management approaches to resource allocation decisions, and consideration of the full range of solutions to solve problems. ISTEA provides strong incentives and opportunities for improvements in programming processes at the state, regional, and local levels.

Taking full advantage of ISTEA presents technical, institutional, and political challenges. On the technical side, there is a need for new methods to supplement the more traditional, engineering-oriented approaches to needs studies, project evaluation, and prioritization. While improvements in technical methods can play a strong support role in reshaping programming processes, fundamental changes in how resource allocation decisions are made will require strong leadership and revision of current roles and responsibilities, both within agencies and among different institutions which participate in transportation decisions. Political challenges will be presented by any changes which may upset the existing delicate balance of funding.

This paper reviews the objectives and methods of transportation programming, and identifies directions which programming practice needs to move towards in order to function effectively in the present environment.

Legislation

This section summarizes some of the recent legislative initiatives which affect the context for programming.

The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA)

The new ISTEA legislation makes fundamental changes in federal transportation planning requirements and funding programs. The Act emphasizes funding flexibility across modes and facilities, and stresses system management, performance and cost-effectiveness. It establishes a new set of broad federal funding categories, eliminating old programs including those for primary, secondary and urban systems (FAP, FAS, and FAUS). New requirements for statewide long- and short-range transportation planning were also established. These planning efforts must be coordinated with metropolitan area plans and must consider strategies for making the most efficient use of existing facilities, congestion management measures, transit enhancement, coordinated transportation-land use decisions and intermodal access.

ISTEA expands Metropolitan Planning Organizations' (MPOs) powers and responsibilities for selection of improvement projects. These new responsibilities will necessitate a reorientation of existing approaches to

development of Transportation Improvement Programs (TIPs). ISTEA requires that states, in cooperation with MPOs implement management systems for pavements, bridges, safety, congestion, public transit and intermodal facilities. Transportation Improvement Programs (TIPs) for urbanized areas can now only include those projects for which funding can reasonably be anticipated, and must also be consistent with State Implementation Plans (SIPs) for air quality. Urban areas which are not in attainment of air quality standards may not use federal funds "for any highway project that will result in a significant increase in carrying capacity for single occupant vehicles unless the project is part of an approved congestion management system."

ISTEA is expected to have significant impacts on programming practice at state and local levels of government. At a minimum, agencies which had aligned their own programming categories with federal funding programs must now revise their program to reflect the new federal program structure. This revision will leave a significant amount of room for development of new methods for allocating funds. More importantly, the new flexibility provided by the Act encourages programming decisions which best reflect state, regional, and local priorities. This implies a more important role for programming at the state, regional, and local levels. The Act also encourages consideration of a broad range of alternatives for addressing particular problems (including relatively low-cost, demand management measures) without giving preference a priori for particular types of actions. This in turn encourages local programming practices which allow for explicit trade-offs to be made among alternatives, instead of those which are based on narrowly defined categories which are modally aligned. The management system requirements reinforce the philosophy of strengthening local programming methods, and encourage systematic evaluation of conditions and needs, and consideration of life cycle costs and cost-effectiveness in the development of improvements. It should be noted, however, that while many state and local agencies have implemented pavement and bridge management systems, use of these systems to define needs and set priorities has been quite limited. Thus, a key challenge for the future will be to further integrate these systems in decisionmaking processes.

Clean Air Act Amendments of 1990

Amendments to the Federal Clean Air Act passed in 1990 are having major impacts on the transportation planning and project development processes in those areas which are not in attainment of air quality standards. Metropolitan areas which are in serious violation of air quality standards are required to implement transportation control measures in order to reduce vehicle miles of travel and congestion. The most significant provision of the 1990 Clean Air Act with respect to programming is strengthened requirements for conformity between the state implementation plan (SIP) for air quality, and the approval for federal funding of regional transportation plans, programs and projects (excluding maintenance and preservation actions). These activities must not cause new violations in standards to occur, increase the severity or existing violations, or delay attainment of standards or interim milestones which have been defined.

Prior to 1990, conformity was determined on a project basis. The SIP and transportation plan were in conformance as long as the SIP projects were contained in the transportation plan, and the transportation projects were taken into account as part of either the SIP base case or plan itself. The 1990 conformity provisions dramatically change this approach. Conformity must now be based on a demonstration that the total emissions from mobile sources, which would occur as a result of the combination of projects and programs in the transportation plan, are consistent with the emissions levels in the SIP. This determination is to be based on an air quality analysis of projects in the transportation plan. Transportation plans must be analyzed for conformity at least once every three years in order to comply with requirements for demonstration of "reasonable further progress" before the actual attainment deadline. In addition, if a project from a conforming transportation plan undergoes a significant change in scope, the plan must be re-analyzed to determine if the necessary emissions reductions would still be achieved.

At this date, final EPA guidelines regarding conformity have not yet been issued, and there is a considerable amount of debate about the details of conformity determination, the specific analytical methods and assumptions to be required, and the scope of application of the rules. Nevertheless, these new amendments, together with the transportation/air quality provisions of ISTEA, will necessitate much closer cooperation between transportation and air quality planning agencies and a broader evaluation of the impacts of transportation projects. They will also result in a much more aggressive approach to implementation of transportation control measures and more careful scrutiny of projects which increase road capacity or improve the convenience of single-occupant vehicle travel.

Growth Management Initiatives
Growth management legislation in some states is forcing a greater degree of coordination between landuse and transportation decisions than previously existed. Provisions may include:

- Requirements for consistency between land use plans and transportation plans and programs, which means that the expected growth in travel based on land use plans must be accommodated in an acceptable fashion by the transportation plan.
- Making approval of development projects contingent on the concurrent provision of necessary infrastructure to support this development.

These provisions necessitate an additional set of considerations to be accounted for in the programming of transportation improvements. They also imply a greater degree of inter-jurisdictional and interagency coordination and cooperation in planning and programming than has existed historically.

Other Legislation
A variety of other federal, state, and, in some cases, regional and local legislative and policy actions are also changing the factors which must be reflected in program decisions. These other initiatives include Americans with Disabilities Act provisions, wetlands and other environmental regulations, as well as facility siting provisions.

TRANSPORTATION PROGRAMMING IN THE '90s: KEY CHALLENGES

The changing environment in which program decisions will have to be made during the next decade will require changes both in how the overall programming process is structured and in the data and technical methods used to support it. This section summarizes three key objectives of programming and the issues and challenges which must be addressed to improve program decisionmaking.

Objectives of Programming

There are a number of key objectives for the programming process.

Effective Allocation of Resources to Address Policy Objectives
One of the major objectives of programming is to ensure that resources are allocated effectively. There are two aspects to this. First is the question of whether the various policy objectives and priorities which have been defined are being addressed. Given that the program is indeed responsive to policy, a second key issue is whether funds are being spent wisely: are the specific types of projects in the program the most cost-effective way of solving problems or meeting identified needs, and are the projects in the program justifiable from a benefit-cost standpoint?

Facilitating Trade-offs
While programming is sometimes viewed primarily as a technical exercise, it is in reality an effort which requires a consensus between engineers and planners on the one hand, and legislative or governmental bodies on the other. Therefore, a programming process should not be judged by its end results alone, but also by how the process itself is structured and by the information it provides for making key resource allocation decisions. An important objective of a programming process is to assist both technical and policy decisionmakers by presenting options and clarifying cost/benefit trade-offs among the various options.

Supporting Effective Project Delivery and Coordination
Assuming that the right allocation of funds is made, and the "best" projects are selected, there are two additional yardsticks by which a program can be measured. First is the extent to which the program is realistic in the sense that it can actually be delivered in the proposed timeframe and for the proposed budget. Second is whether the program is constructed in such a way as to realize efficiencies by coordinating projects and scheduling of available resources, or at least to not preclude achieving these efficiencies in project scheduling and contracting procedures.

Issues and Challenges

Given the key objectives for programming and the changes in the decisionmaking environment for transportation, a number of issues and challenges must be met. These include:

- **Vague and Conflicting Policies:** Translating policy into action presents a challenge where existing policy statements are vague and conflicting, which is all too frequently the case. This creates a situation in which any action can be interpreted as supporting policy or defeating it. Common examples of this are where broad policies to reduce congestion, increase motorist convenience, promote energy conservation, and improve air quality coexist without the qualifications necessary to provide meaningful guidance for programming. Not only

are there conflicts in policy at a single jurisdictional level; there frequently are even sharper differences among several different jurisdictions or agencies at different levels which may need to coordinate and cooperate on actions included in the program.

• **Lack of Integration with Planning:** An effective programming process depends in many ways on the support of a strong planning process. Long and short range planning efforts are where much of the work of defining specific objectives, assessing alternatives, evaluating options, eliciting participation from affected parties, and defining consensus solutions to problems takes place. They greatly assist programming by providing information that can be used to clarify program trade-offs and communicate the implications of different funding levels. Public involvement and consensus-building efforts done at the planning stage can also serve to screen out projects which are likely to be delayed, thereby improving the realism of the program. However, many long-range planning efforts have not resulted in clear guidance to programming decisions or are not updated frequently enough to provide ongoing direction to program decisions which are often on a one- or two-year cycle, consistent with an agency's budget cycle.

• **Lack of Emphasis on Systematic Evaluation:** Cost-effectiveness and efficiency have become more of an emphasis in recent years due to growing infrastructure needs and declining revenues. The only meaningful way to ensure efficiency and effectiveness is to consider different approaches to addressing needs and solving problems. However, structuring a programming process so that alternatives are explicitly examined and evaluated introduces a level of complexity which many agencies feel is unnecessary, too costly, or both. There are also technical and methodological questions to be overcome in the design of an evaluation framework which accounts for the full range of project impacts.

• **Uncertainty:** Uncertainties in schedules, budgets, and funding sources are a fact of life, and need to be anticipated in how programs are structured, presented and maintained. Unless these are explicitly planned for, the credibility and usefulness of the process can suffer. While these problems confront virtually every transportation agency, they have often been most acute at the regional and local levels and for transit.

• **Institutional Factors:** The lack of a carefully structured, coordinated process for developing and achieving consensus on improvements can make it impossible to produce realistic, implementable programs which are in line with available resources. Where programming is not recognized as a political process involving negotiation and compromise, credibility problems can arise which undermine the usefulness of the process.

• **Increased Importance of Preservation and Maintenance:** Increasing requirements for repair and rehabilitation of existing infrastructure are dominating the use of available transportation funds in many areas. Many states and cities are establishing policies of preserving existing facilities before new capacity is added. At the same time, questions are being asked about how much preservation and maintenance is really needed, and what are the implications of different expenditure levels. Pavement and bridge management systems are playing more important roles in addressing these questions and in assisting agencies to make effective decisions about the appropriate timing and extent of preservation projects.

• **Increased Emphasis on Management, Operational and Multimodal Solutions:** Over the past decade, a variety of new approaches to management of congestion and accommodating growth in travel demand have been tested. Some of these strategies, such as high-occupancy-vehicle lanes, park-and-ride lots, and ridesharing programs have been pursued aggressively in many areas, and have changed in status from experimental to routine, accepted practice. In addition, new types of solutions are now being developed, such as IVHS. However, integrated programming of funding for these types of solutions, more traditional highway improvements, and public transit system improvements has not occurred. Fund allocation decisions are typically divorced from comparisons of relative effectiveness of these different types of strategies for addressing congestion problems. In fact, planning is often done separately for each type of strategy. There are both institutional and technical problems to be overcome to achieve true multimodal planning and programming.

• **Need for a New Definition of Mission:** Building new highways or transit systems is no longer the primary mission of many transportation agencies. This represents a fundamental change and requires a new definition of mission. The new mission of transportation agencies is inevitably expressed in terms of a broad set of objectives which go beyond improved access and travel times. Transportation is increasingly tied to economic and environmental objectives. This trend means that traditional ways of evaluating and selecting transportation projects need to be re-examined and redesigned.

• **Interagency, Interjurisdictional, and Intermodal Coordination:** ISTEA strengthens the role played by Metropolitan Planning Organizations (MPOs) in transportation programming. The conformity requirements of the Clean Air Act Amendments force stronger interjurisdictional and interagency coordination on programming of transportation improvements. Shrinking resources for transportation and the nature of multimodal, management-oriented solutions create the

need for greater coordination as well. The requirements for congestion management and intermodal management systems will require a more comprehensive approach to programming improvements on the entire transportation system.

• **Integration of new management systems in programming:** ISTEA requires implementation of several management systems which have the potential to improve the technical basis for identification and programming of improvements. The challenge will be how to design these systems and use their results in a manner that works effectively within the framework of transportation decisionmaking processes.

OVERVIEW OF PROGRAMMING PROCESS AND METHODS

The programming process at any level of government or for any specific agency is defined by a complex set of factors including:

- Statutory requirements;
- Federal, state, regional and local funding programs and their eligibility requirements;
- Agency roles and coordination mechanisms;
- Formal and informal statements of policy; and
- Established long- and short-range planning processes.

As several surveys of transportation agencies over the years have found, there is a diversity of approaches to programming in different states, at different governmental levels, and for different modes. Nevertheless, there are certain elements or activities which are normally part of a programming process, or associated planning and project development processes. (See Figure 1.) These activities are briefly discussed next, along with some of the variations in approaches which are found in current practice. This discussion is intended to provide a framework for the later discussion of areas where the effectiveness of programming might be improved.

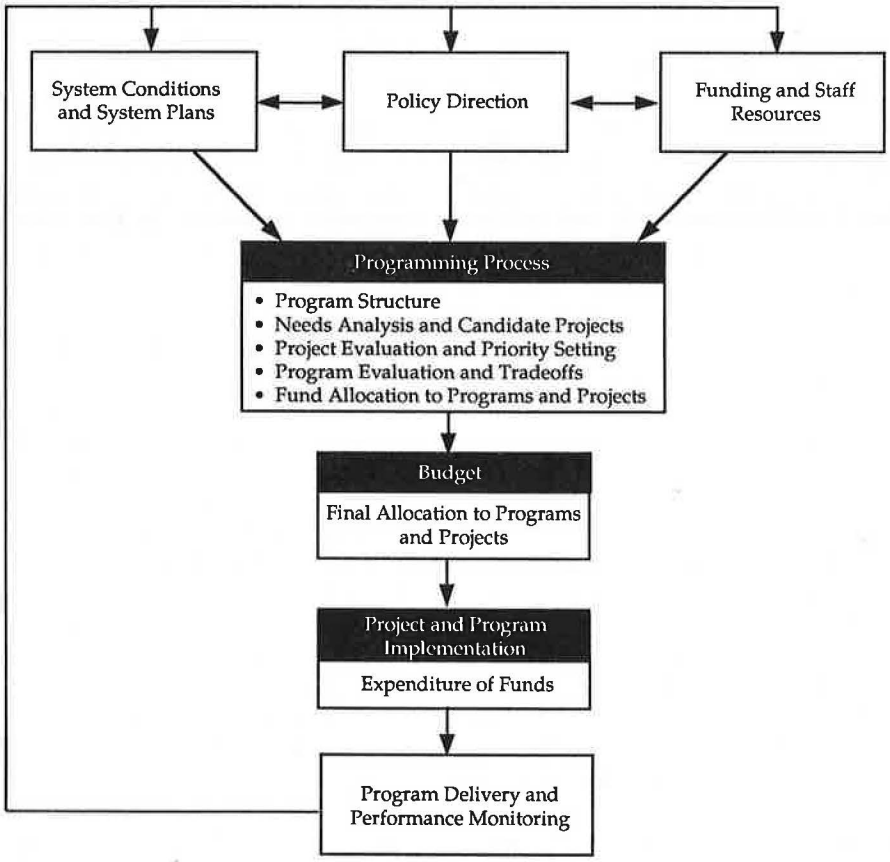

FIGURE 1 Overview of Programming Process.

Key Inputs: Policy, System Conditions/Plans, Resources

As shown in Figure 1, the key objective of the programming process is to combine information on system conditions and investment options (e.g. system plan), policy direction (e.g. preferences for specific objectives and performance goals) and resources (staff and funding) to define the most cost effective program for meeting the desired objectives. While simple in concept, the complexity of the transportation decisionmaking environment has resulted in wide variations in how, or indeed whether, this information is communicated to the programming process.

General statements of policy goals, as mentioned earlier, provide little direction for program decision and often conflict. The issue is not what general policy concerns are important, but what is the appropriate balance between conflicting policy objectives. As a practical matter, defining the right balance between multiple objectives generally requires a well-defined system planning process that translates broad concerns with mobility, economic growth, environment and social equity into specific transportation system strategies that can be evaluated. Multi-objective priority programming methods can reflect such plans, but not replace them.

Today it is typical for there to be no strong linkage between system planing and programming and many agencies simply do not maintain an ongoing system planning process. In such cases, programming criteria tend to be narrow (engineering and design standard oriented), and focused on existing (as opposed to future) needs. Recent practices in some agencies, however, have provided counter-examples. The Wisconsin Department of Transportation's Corridor 2020 effort produced a statewide system plan focusing on economic development goals. This, in turn, led to a plan that provides key guidance to WisDOT's major project program. Similarly, the New York MTA's systemwide assessment of rehabilitation and service requirements has shaped a series of five-year programs.

While ultimately budget and resource constraints will determine what is implemented, many programs have not been fiscally constrained or have addressed how projects and investment strategies should shift under varying resource assumptions. Again, ISTEA provisions will require more realistic plans and programs at state and regional levels and the new flexibility provisions will significantly increase pressure to examine the implications of shifting funds between modes, program categories and projects.

Finally, effective use of the required management systems—both the systems focusing on facilities and asset management (pavement, bridge and transit) and those with service objectives (congestion, safety, intermodal) reinforce the need for a comprehensive transportation system inventory. Such an inventory is a critical basis for a sound programming process and must:

- Be comprehensive and include all modes;
- Document current facility and equipment physical condition and system service levels and characteristics;
- Be updated periodically.

The rapid development of GIS technology offers an exciting and effective way to store and display such information and new technology for monitoring system operating conditions (both vehicle and facility related) and inspecting physical conditions offers the potential for very cost-effective data collection and updating.

Program Structure

Program categories are established for a number of purposes, most commonly: (1) to plan and track different sources of funds earmarked for particular purposes, and (2) to provide an intermediate level for fund allocation and priority-setting in between individual projects and the program as a whole. Establishment of program categories recognizes the constraints associated with allocation of certain funding sources. At the same time, it allows similar types of projects to be evaluated against each other. Lack of homogeneity in project types within a category complicates within-category project prioritization. From a decisionmaking standpoint, meaningful program categories assist in clarification of resource allocation trade-offs across different program elements for technical staff and policymakers.

Program categories have been established based on:

- Type of facility or mode (e.g. highway vs. bridge, track vs. signalization, highway vs. transit);
- Facility or service class (e.g. arterial vs. local access, express vs. local service);
- Objective of project (e.g. safety, congestion relief, efficiency); and
- Scale of project (e.g. maintenance, rehabilitation, reconstruction, capacity or service expansion);
- Funding source or matching ratio; and
- Department or administrative unit.

The manner in which categories are defined is an important choice in the design of a programming process. Categories based on type or objective of improvement facilitate understanding of the program. The amount of money to be invested in particular areas can be compared to expectations of what will be

achieved, and used as the basis for establishing broad priorities across categories and setting category funding levels along with objectives. Program categories which are clearly defined assist this process of priority-setting and trade-offs, whereas those which are complex and include a "grab bag" of diverse projects tend to confuse the process. By the same token, programs which have large numbers of categories make inter-category comparisons and trade-offs more difficult than those with relatively few categories. Categories which are based on funding programs must be modified whenever the funding programs are modified.

Subcategories can be defined to distinguish types of projects which represent different approaches to addressing needs, which rely on different funding sources or which require fundamentally different approaches to needs identification, evaluation and prioritization. Subcategories need not necessarily be used as fund allocation categories, but simply as logical program divisions for display of budgets, performance targets and activities.

The typical state has a mix of program categories reflecting different modes (highway, transit, other), federal funding categories (e.g. Interstate), types of facilities (bridge, general aviation airports, etc.), and objectives (preservation, safety, etc.). Some transit properties organize their capital program according to FTA grant applications. In both cases, it is often very difficult to relate program categories to specific agency objectives.

Identifying Needs and Candidate Projects

Most agencies have established procedures for identifying deficiencies, needs and candidate projects. This activity typically falls within the planning (rather than programming) function, but is the source of basic inputs to the programming process. Needs and project identification is done through a combination of methods:

- Facility inventory and inspections;
- Review of accident, traffic or ridership statistics, and vehicle or equipment breakdowns;
- Facility management systems;
- Sufficiency ratings or deficiency threshold criteria;
- Results of planning efforts; and
- Suggestions by engineers, planners and citizens.

Needs estimates have traditionally been based on existing physical and service/operating conditions compared to a set of design and service standards. Everything else remaining the same, the level of standards determines the expected needs. However, in most cases, the standards have not been developed on the basis of traveler preferences or economic feasibility. A logical approach would be to determine appropriate standards according to the public's willingness to pay. The advantage of such an approach is that it can be related to finance and taxation policies in a state, region, or local jurisdiction.

Current conditions are compared against standards to determine the near term need. Projected conditions under expected future traffic are used to estimated long term needs. Physical needs are then translated into dollar amounts within specific time periods. The procedure used in need estimation is generally a variation of a sufficiency rating approach, where the adequacy of a section of a facility is rated on a numerical scale in terms of certain attributes, such as structural adequacy, safety, and service.

The requirements of ISTEA cannot be accommodated by the traditional needs analysis. First, current and future transportation needs analysis must address all modes. Furthermore, attributes of a needs study must also explicitly include environmental impact. The proposed congestion management systems will play a critical role in making sure that non-highway modes and environmental concerns are carefully incorporated, particularly in metropolitan areas.

After needs are estimated, specific projects can be identified, taking into consideration input from citizens, interest groups, elected officials, and various agencies. Much of this input will be received through informal meetings and day-to-day contact with interested persons. Some agencies hold annual meetings for the purpose of obtaining public input on issues concerning all modes. The identified issues are then sent to the appropriate implementing agency for recommending candidate projects. Implementing agencies can be district offices of a state DOT, city councils or local transit operators. Candidate projects can then be classified by mode, program, and project type, so that funding decisions and project evaluation and selection can be made. Minnesota has used such a multimodal program development approach for more than a decade.

Project scoping, costing, and phasing activities also provide basic inputs to the programming process. Because these are typically continually changing, a dynamic process of adjusting the program to the latest project information, and adjusting project schedules based on the program takes place. In some instances, alternative projects for addressing a particular need or problem may be defined; however frequently only one option is developed.

Project Evaluation and Priority Setting

A key program development activity is to evaluate each candidate project to provide a basis for deciding which projects should be funded. There are a number of methods for project evaluation and prioritization, ranging from highly informal and qualitative to highly complex and technical. In some instances, priorities are set based on the judgement of elected officials and/or engineers. Many agencies develop project ranking methods which consider either the severity of the problem to be solved or the estimated benefit or impact of the candidate project. Some do a more formal cost-effectiveness or cost-benefit analysis. Optimization methods have also been used to assist in project selection, particularly for pavement and bridge preservation projects. Ranking or optimization methods can be geared towards individual categories of projects, or may allow for analysis and comparison of very different types of projects.

While a variety of project evaluation and priority setting methods have been used, the three described briefly below emphasize measuring a project's benefit or output as opposed to the severity of the problem (irrespective of the benefits from correcting it) or design standards.

Economic Analysis

While there are several approaches to economic analysis of projects, the accepted practice is to use the net present value method. In this method all costs and monetary benefits during a service life of a project are brought to the present worth. If the service lives of alternative projects are different, annualized cost in perpetuity can be used.

The cost should include both agency and user costs. Agency costs include construction, maintenance and operation costs, while user costs include travel time, vehicle operation and accident costs for highway projects. For transit projects, user costs may include fare, in-vehicle and out-of-vehicle travel time, and other out-of-pocket costs depending on the particular transit mode. Project costs at the planning and programming stage are mostly broad estimates. They should be developed on the basis of past records, and they should be expressed in terms of a range of values.

It is important to note that although the techniques of life cycle cost analysis have been in use for some time for planning and programming purposes, contract management procedures in the U.S. continue to use least initial cost approach in awarding contracts. Thus, there is a serious conflict between project evaluation concepts and project execution practices. Unless the contract management procedures are changed, much of the potential benefit of such analytical exercises as pavement, bridge, and transit facility management systems, will not be fully realized.

Facility Performance and Economic Analysis

The current practice of economic analysis of transportation facility alternatives does not take into account differences in facility performance. Facility performance may be represented by any one or by a combination of the major objectives of transportation investment analysis, such as physical condition, level of service, safety, and environmental impact. For example, the performance of highway pavement related strategies can be considered in terms of curves indicating pavement condition deterioration against time or some measure of demand. Different pavement related strategies will result in different performance curves. As any transportation project involves both agency and user costs, both perspectives should be considered in making investment decisions.

Procedures for incorporating pavement and bridge performance in economic analysis have been developed. Procedures for considering other performance measures over the service life of other types of facilities are necessary.

Cost–Effectiveness Analysis

Cost-effectiveness analysis allows a much broader evaluation framework than economic analysis, in that non-priceable as well as priceable items can be considered. However, the procedure is less structured. In this procedure, the performance of each project under each objective or criteria is identified and then a cost-effectiveness index is developed for each of the criteria. For example, if safety is a criterion, the cost-effectiveness index for safety can be the number of accidents reduced per dollar of investment or present worth of costs. For safety improvement projects, this index can be used to select desirable projects. When a set of projects is to be selected within a given budget, those projects are selected that can be collectively expected to yield the most accident reduction within the budget constraint. Table 1 provides a list of possible cost-effectiveness indices that can be considered in project evaluation. In a multi-criteria situation, an index of system effectiveness can be developed incorporating a number of impact criteria. Such an exercise will obviously involve some sort of weighting of the impact criteria.

TABLE 1 A LIST OF POSSIBLE COST-EFFECTIVENESS MEASURES

TRANSIT

- Increase in transit ridership per dollar of capital investment.
- Increase in ridership per dollar of additional operating cost.
- Total operating and capital cost per transit rider.
- Total capital and operating cost per seat mile and per passenger mile served.
- Decrease in average transit trip time (including wait time) per additional dollar of total additional cost.
- Increase in transit accessibility of jobs (based on network impedances) per dollar of additional cost.
- Increase in proportion of the population served at a given level of service (in terms of proximity of service and frequency) per dollar of additional cost.
- Total transportation cost per passenger mile (auto and transit).

HIGHWAY

- Increase in average vehicle speeds per dollar of capital investment.
- Decrease in total vehicle delay time due to congestion per dollar of capital investment.
- Increase in highway network accessibility to jobs per dollar of capital investment.
- Decrease in accidents, injuries, and fatalities per dollar of capital investment.
- Change in air pollution emissions per dollar of capital investment.
- Total capital and operating cost per passenger mile served.

Source: Joel Markowitz, "Transit Capital Planning in the San Francisco Bay Area", Transportation Research Record 1266, 1990.

Program Evaluation and Trade-offs

In addition to looking at the relative merits of individual projects, some agencies analyze the costs and benefits of the program as a whole under different assumptions about funding levels by program category. This type of analysis can assist resource allocation trade-offs and final funding decisions. Many agencies do not incorporate a formal program evaluation step into the programming process, but do track and report program accomplishments as part of the budget process.

The objective of program evaluation is to develop the most cost-effective mix of projects within a specific program category and to examine the implications of shifting funds between categories. Generally, the project priority setting and program development and evaluation steps must occur together to avoid the tendency to rank a set of predefined projects independent of the resource constraints and simply pick from the top of the list until funds are used up. Such an approach usually does not result in the best mix of projects.

In an era with a well-defined and rigid program structure with little flexibility to shift funds, the lack of attention to explicit program evaluation and examination of trade-offs between categories within a mode, between modes, and between jurisdictional levels was understandable. However, ISTEA has ushered in a new era where many complex choices will confront decisionmakers and can be funded. Explicit evaluation of program level trade-offs will be a key to defining the implications of these choices.

A number of analytic approaches are possible to support program evaluation and trade-offs. For example, economic analysis and optimization approaches have been developed for some facility management systems and capital improvement project applications. In other cases, a well structured multi-criteria (some quantitative and some qualitative) summary of program impacts will be the most practical and effective approach.

Whatever approach is used, evaluation criteria must directly reflect the policy directions established for transportation and the criteria used to define long-range system planning objectives. If multimodal solutions are to be fairly considered, evaluation criteria must be "mode neutral" (e.g. stress the movement of people and goods, not vehicles).

Fund Allocation

Figure 1 showed the final allocation of funds to programs and projects occurring after the program evaluation step to emphasize that in an era of increasing flexibility, project and program level trade-offs should be examined before final allocation decisions are made. In reality, some portion of the funds available are likely to be allocated to modes, program categories, and geographic regions at the start of the programming process. The more this occurs, the more difficult it will be to examine key trade-offs and establish true multimodal and multi-objective programs, but some predictability in funding levels and partitioning of the problem are also necessary.

Program and Performance Monitoring

Monitoring of the progress of program implementation and the results of the program in terms of system performance, costs, and benefits is an often overlooked but valuable aspect of programming. It provides an important feedback loop into both the technical assumptions made in the process and the policy decisions regarding priorities, strategies, and emphasis areas. A solid monitoring program can, over time, improve the effectiveness of the programming process and enhance its credibility. Again, however, the criteria used to monitor system performance should be directly related to the transportation policy goals of a particular region as defined in statute, policy plans, and system plans.

DEVELOPING A MORE EFFECTIVE PROGRAMMING PROCESS

Figure 2 defines a general framework for an improved programming process. The important elements of this framework are:

- Explicit linkage with policy objectives and system planning to provide guidance on the full range of policy objectives.
- A simplified overall program structure that can facilitate relating policy objectives to program categories (maintenance, preservation, improvement) and make it easier to integrate management systems into the programming process.
- Use of bridge, pavement, and transit facility management systems to guide the maintenance and preservation program needs analysis, target funding analysis (i.e., trade-offs of different funding levels and facility conditions), project identification and evaluation, and program evaluation.
- Use of a broad range of performance criteria together with congestion, safety, and intermodal management systems to guide development and evaluation of service improvement programs.
- Explicit program evaluation and trade-off analysis examining the implications of alternative program funding levels.
- Program and system performance monitoring to establish better accountability for program decisions and to provide feedback to policymakers and an ongoing long-range system planning process.

While the precise steps involved in the programming process will vary widely depending on institutional arrangements, funding sources, and agency procedures, the purpose of the framework is to define the key steps involved in making resource allocation decisions. Similarly, the division of activities shown in Figure 2 between planning and programming functions will also vary from agency to agency. The definition of an integrated set of planning and programming steps is the key issue discussed here.

A number of aspects of the general framework that can potentially lead to a more effective programming process are discussed below.

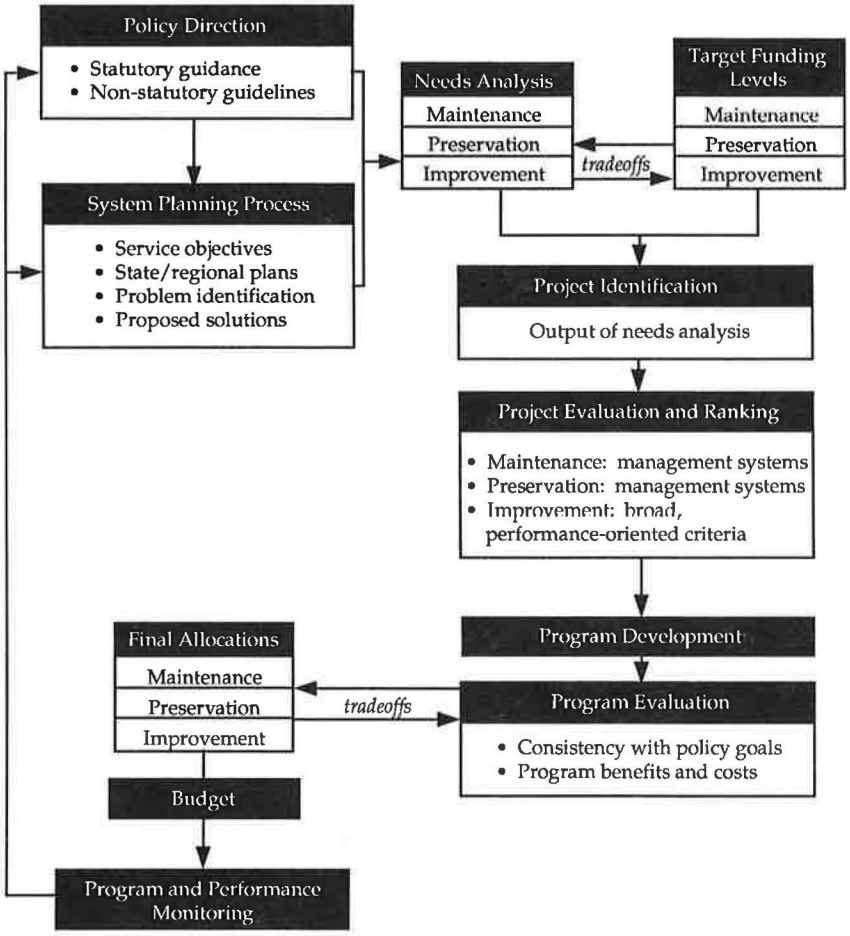

FIGURE 2 Proposed Programming Framework.

Translating Policy into Action

The first measure of effectiveness of a programming process is whether it results in implementation of projects or actions which adequately address stated policy objectives. The most common problem with existing programming processes in this respect is that it is difficult to determine whether they are responsive to policy or not. As noted earlier, policy statements are often too vague or conflicting to provide a basis for judging a program. In addition to well-defined policy objectives, there are a number of program design elements which can be used to assist the process of translating policy into action:

- Program structure and eligibility criteria which are aligned with policy objectives.
- Project evaluation methods which measure contribution to policy objectives.
- An explicit program evaluation step to measure how well the program as a whole is addressing policy. This step can be used to adjust funding allocations and project selections.
- Strong, clear linkages between planning efforts and the programming process. This means that recommended actions in planning efforts should be used as input to the programming process; and planning efforts should be structured, where possible, to provide inputs which are directly usable in programming. This is most easily achieved when there is consistency in the way projects are categorized, i.e., the definition of implementation timeframes and the criteria used for project evaluation.

Facilitating Trade-offs

The programming process should be designed to facilitate choices among different projects and different categories of projects. In order to do this, it is important to structure the process so that different options and funding levels are examined. The implications of different program options should be assessed and clearly communicated. In evaluation of program options, an attempt should be made to describe the full range of impacts which are of interest to decisionmakers. The definition and evaluation of options may need to occur

at several levels of detail to match with the concerns of different decisionmakers who are involved in the programming process.

An important aspect of facilitating trade-offs is to impose enough structure in the program to provide a framework for evaluating concrete alternatives, but not so much structure so as to close off important options. Rigid allocations to program categories and geographic areas, which are not based on an assessment of priorities and relative benefits of investments, tend to restrict the effectiveness of the programming process.

Supporting Effective Resource Allocation

One of the major reasons to have a systematic programming process is to encourage efficient and effective allocation of available resources. In an economic sense, resources are allocated efficiently when no additional benefits can be gained by spending them in a different way. Finding the most efficient solution to the resource allocation problem involves enumerating candidate projects, systematically describing each one in terms of its costs and benefits, and selecting the set of projects which maximize benefits within the established budget.

The choice of the "best" set of projects is very dependent on the level of resources available. As budget levels increase, new opportunities become available, which may be sufficiently cost-effective so as to replace lower-cost options which may have been selected under a smaller budget scenario. The best choice of projects under different budget levels could therefore be quite different in terms of scale and mix. This implies that programming processes which explicitly look at alternative budget scenarios for different categories have a better chance of effectively allocating resources than those which fix category budgets prior to defining and evaluating project candidates. It also implies that programming methods which involve simple ranking of a set of projects and selecting the highest ranked projects until the budget is used up will not necessarily result in the best use of available funds.

Supporting Effective Project Delivery and Coordination

Effective project delivery and coordination means making sure the program is in line with available resources and that the different projects in the program are coordinated with each other to achieve efficiencies. This requires strong financial planning, budgeting and project scheduling functions which are linked to the programming process. Specific considerations for developing these functions in support of effective program delivery and coordination are:

- Financial planning should include regular forecasting of revenues on an annual and monthly basis.
- The fiscal implications of different program options should be analyzed and taken into consideration in program decisions.
- Explicit coordination mechanisms between budget and programming processes should be established.
- Methods should be in place for capturing and communicating project status information in a sufficiently timely fashion to allow for program revisions as necessary to keep expenditures and revenues in balance.
- Interdepartmental and interagency coordination mechanisms should be established for the development and ongoing management of project schedules.
- A tiered approach to programming which includes short–, medium–, and long–range elements can help to reinforce important distinctions among projects in different stages of development and funding commitment.

Strengthening the Linkage Between Plans and Programs

As mentioned earlier, an effective and ongoing planning process is likely to be the most direct way to provide useful policy direction to program decisions. Vague policy statements or the ISTEA list of 15-20 factors to be addressed by state and regional planning, by themselves, provide no guidance. Meaningful guidance must address the appropriate balance between competing policy issues and concerns. There will be no one right answer, and the appropriate balance will vary from area to area and over time.

While the desirability of a strong linkage between planning and programming is apparent, making the linkage effective has often not been straightforward. Requirements that programs "be consistent" with plans or only contain projects included in plans may not be sufficient to provide this linkage. Barriers to a stronger tie between plans and programs include:

- **Timeframes**: Planning has tended to focus on the long term with only general concern for implementation staging, while programs focus on the near term.
- **Update Cycles**: Plans are often updated on an irregular basis while programs are constantly adjusted and updated, typically on the same cycle as the budget (generally annually or biennially).

• **Policy Issues and Evaluation Criteria**: There often is almost no consistency between the issues addressed and the evaluation criteria used in planning and programming.

• **Funding Constraints**: Plans are often not constrained by realistic funding levels while the programs developed by operating agencies invariably reflect budget constraints in the near term at least.

• **Organizational Responsibility**: Planning and programming functions are often carried out by different organizational units in an operating agency with an ill-defined interface. In metropolitan areas, the MPO planning and TIP responsibilities generally involve parallel similar activities within each local jurisdiction or operating agency.

Notwithstanding these barriers, ISTEA does represent a unique opportunity to strengthen the planning and programming linkage. To take advantage of this opportunity, several steps should be emphasized:

- Establishment of consistent criteria for defining:
  - policy goals and service objectives;
  - needs and project identification;
  - project evaluation and priority setting;
  - program evaluation; and
  - program and system performance monitoring.
- Use of the required management systems as a central approach to defining needs, examining system trade-offs, and identifying projects.
- Updating plans and programs on a consistent cycle.
- Establishing phased implementation strategies as part of the long-range planning process.
- Use of consistent financial constraints.

Encouraging Multimodal Solutions

While much of the analysis of multimodal options and trade-offs may occur within the planning function, there are several steps that can be taken to encourage consideration of modal trade-offs. These steps include:

- Avoidance of narrowly defined program categories that by their nature (i.e. defined by type of facility or funding category) tend to focus on a narrow range of solutions;
- Emphasizing evaluation criteria that reflect the movement of people and goods, not vehicles; and
- Encouraging similar programming processes across modes and jurisdiction in terms of timing, program period, evaluation criteria, and tradeoff analysis.

Obviously further steps to provide greater funding flexibility at state, regional, and local levels and strengthening multimodal planning efforts at the state and metropolitan levels would facilitate these changes to programming.

Defining a Role for Management Systems

Pavement management systems have been implemented widely at the state, regional, and local levels. More recently, bridge management systems have received increased attention, and a number of transit properties have developed asset inventories and started transit facility management systems. Vehicle and equipment maintenance systems are also common. Yet despite these activities, management systems in many agencies to date have had little impact on program decisions. ISTEA has attempted to address this issue by creating new requirements for the development and use of facility management systems for pavements, bridges, and transit, and service-oriented systems focusing on safety, congestion, and intermodal coordination. The development and use of these systems offers a tremendous opportunity to strengthen the linkage between planning and programming, provide better information for program decisions, and restructure the planning and programming process at the state and regional level.

Ideally a management system should provide direct guidance on:

- Impacts of different budget levels on facility conditions or system service levels;
- Implications of different facility or system service objectives;
- Allocation of budget to programs, networks, regions, and specific projects; and
- Deployment of inspection, surveillance, and data collection resources.

The facility-oriented systems (pavement, bridge, and transit) could serve as the central focus for developing and evaluating the appropriate goals and budgets for maintenance and facility preservation programs. The core of these systems will be new analytic tools. The basic concept of the service-oriented systems (congestion, safety, intermodal) is the same and they can provide a new focus for multimodal planning and programming for improvement programs. However, these systems are likely to be more complex, involve a broader planning process, and be supported by a variety of data sources and technical tools.

While collectively the management systems offer a new opportunity and approach for examining a wide range of program choices and trade-offs, the barriers encountered by pavement and bridge management systems in many areas must be overcome. These barriers include:

- Significant data collection costs, though new technology offers much potential for more cost-effective facility inspection and service level monitoring.
- Lack of top management and policymaker understanding and support for these tools which are often developed in research or operational units.
- An engineering and design standard perspective that resists consideration of an "optimal program" that doesn't meet predefined standards in every case.
- Conflicts between the "centralized" or system perspective imposed by management systems versus a tradition of decentralized program decisionmaking in district offices of many state DOTs or a variety of local jurisdictions and operating agencies in metropolitan areas.

While these and other barriers (both institutional and technical) are significant, the potential exists for management systems to serve as the focal point for redefining planning and programming and providing better information for program decisions.

CONCLUSIONS

The environment for programming is changing and traditional approaches to program decisionmaking must also change to confront the challenges of:

- A diverse and conflicting set of policy goals and objectives concerning mobility, economic growth, and the environment.
- New and significant funding flexibility that removes a key barrier to considering a wide range of program choices and trade-offs.
- Increased emphasis on multi-jurisdictional and multimodal coordination.

To address these challenges the programming process will need to:

- Strengthen the ties to planning at all levels of government.
- Explicitly consider a wide range of program options and trade-offs including multimodal choices.
- Broaden the concept of need and the evaluation criteria used throughout the planning and programming process.
- Improve the accountability for program decisions by establishing a program and system performance monitoring function.

Accomplishing these objectives will require new institutional arrangements, programming procedures, and technical support tools and data. The choices are complex, but the opportunities for innovation are tremendous and the profession must respond if effective resource allocation decisions are to be made in the future.