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PREFACE

The major objective of this project was to identify and document the current information on the criteria used in various priority programming and evaluation schemes that are presently being used at all levels of government in transportation projects. A review of this information will allow an examination of the usefulness and validity of the existing criteria used in evaluation and programming processes for transportation decision-making.

Decisions on when, where, and what type of improvements to make are some of the most important tasks faced by the transportation agencies at all levels of government. But before decisions can be made, certain information is needed. Adequate criteria and standards representing the efficiency, effectiveness and equity aspects of a project need to be established. Techniques are then required to assist in the evaluation of options in a manner that produces timely results for decision-making. Also needed are methodologies to set priorities in programming of projects in a limited financial environment.

Traditionally, decisions have been made independently for each mode of transportation and the processes in use have varied significantly among modes. Intermodal planning and programming has recently received greater emphasis challenging conventional programming techniques to be more responsive to the emerging needs of transportation agencies. The highway program has been the fundamental source of existing information on project evaluation and programming. With the exception of some very large transit authorities and other isolated cases, programming methodologies have been developed only recently for other modes of transportation.

An exhaustive search of the literature has been conducted with the purpose in mind to look beyond the highway program and to identify both highway and other evaluation and programming methodologies that have applications to all modes. However, it should be noted that a large part of a highway program involves maintenance projects and therefore much of the literature deals with such projects.

This report contains a state-of-the-art paper and an annotated bibliography. The paper summarizes the issues involved in transportation project evaluation and priority programming, and then briefly discusses techniques, approaches and criteria.

TRANSPORTATION PROJECT EVALUATION AND PRIORITY PROGRAMMING: TECHNIQUES AND CRITERIA

Kumares C. Sinha and David P. Jukins

Over the past several decades the United States has seen the construction of an extensive network of transportation facilities. During the next decade the challenge facing transportation agencies throughout the country is how to maintain this extensive network of facilities and provide a high level of service. In the face of competing needs for public money and in view of the increasing costs, especially energy, materials, and labor costs, transportation agencies at all levels of government are concerned with the lack of sufficient funding to undertake needed improvement projects.

Caught in the crunch between decreasing revenues and escalating costs, it has become necessary for transportation agencies to more effectively use their appropriations and revenues. A methodology is needed that effectively evaluates and establishes priorities and programs transportation improvements. Furthermore, with increased emphasis on systems planning, multi-modal techniques must consider the social, economic, and political systems of a region.

Purpose and Scope

With the recognition of the need of such a methodology, this review presents a broad survey of the techniques currently used to program transportation improvements.

PROGRAMMING PROCESS IN TRANSPORTATION

Transportation programming is thought of as a process for selecting improvement projects on the basis of relative urgency. A recent report defines the process of transportation programming as "the matching of available projects with available funds to accomplish the goals of a given period (6).

Programming as Dynamic Process

The function of programming, due to constantly changing physical, environmental, social, energy, and fiscal conditions, has become a dynamic process. As such, the programming process must be flexible in order to be responsive to changing community needs. Furthermore there are many extraneous issues that may enter into the process. For example, these issues may arise because of political commitments, some motivated by self-interest and others by sincere differences of opinion on the relative importance of projects. Programming, therefore, includes the art of combining such variables into an orderly process of project implementation. NCHRP Report 48 summarizes the programming process in a 15-step procedure which considers the complexities introduced by the many variables that are involved (6). There is a greater interest at this time, however, in examining that step of the process that involves the setting of priorities. This review is concerned, in particular, with various techniques of priority programming as well as the criteria that are used in establishing a priority ranking of transportation improvement projects.

PRIORITY PROGRAMMING

To obtain the greatest benefits from available funds, an effective programming process must provide for prioritizing of projects based upon need. In addition it must consider external elements such as economic, social, and political influences. The program, to be effective, must have priorities according to certain technical and non-technical, quantifiable and non-quantifiable criteria (6).

Development of Priority Programming

At times the arraying of needed improvements is a matter of engineering judgement. However, techniques have developed over the years which establish project priorities according to some predetermined criteria. The essential feature of a highway programming technique involves development of sufficiency ratings. These were derived from evaluation methodologies developed in other fields but which have been applied in transportation (7,4,8). Table 1 lists these methodologies

Table 1. Evaluation Methodologies

Methodology	Description
Marginal Cost Method	Can be used to compare benefits from transportation improvements vs. benefits from other types of expenditures. Determination can be made of which combination of improvement projects or expenditures yield the maximum utility.
Benefit-Cost Analysis	Significant tool in large water resource project evaluation. Criticized for the way monetary values are ass assigned to certain benefits.
Cost-Effectiveness	Broader than B/C analysis since it takes into account nonmonetary information (e.g. number of lives saved).
Systems Analysis	Developed from World War II operations research. Essentially, systems analysis is any analytical study designed to help decision-makers identify a preferred course of action from among possible alternatives by specifying how men, money, and other resources should be combined to achieve a larger purpose.
Planning	Provides managers with: 1. Definition of goals and objectives 2. Evaluation of priorities for allocation of available resources. 3. Monitors a continuous review of on-going programs. 4. Proposes reforms as needed.

As the budget emerged as an important input to the evaluation - planning process, there evolved a technique that would merge fiscal constraints to other programming criteria (10).

The long lead time in project development and implementation and the diversity of applicable criteria required for project evaluation, have made a more rational approach to allocation of resources necessary. Consequently, priority programming has now evolved as a planning and managerial tool to help transportation officials better control programs and budgets. Unlike its predecessors, priority programming simultaneously includes the following functions (4):

1. Focuses on the identification of fundamental objectives and relates transportation activities to them;
2. Explicitly identifies future year implications - gives a multiple year time horizon rather than a single year perspective;
3. Considers all pertinent costs;
4. Provides a systematic analysis of improvements.

With this background it is useful to briefly examine some of the prioritizing techniques and the criteria used.

Priority Techniques

Most priority rating systems for transportation originated in the highway sector and generally are based on some form of adequacy rating. Furthermore, most of these procedures fundamentally consist of both rating and ranking schemes (5).

The rating scheme first establishes the need or desirability of an improvement in terms of sufficiency or deficiency of the existing facilities by using quantitative and qualitative parameters. The ranking scheme, on the other hand, orders the proposed improvement according to its urgency relative to other projects.

Although existing priority analysis procedures for transportation programming vary widely in detail, they can be divided into three broad categories: technical, non-technical, and economic aspects (5,6). Sufficiency ratings are composite ratings based on the actual condition of a transportation facility and its ability to provide the desired level of service in a safe and efficient manner. Projects evaluated in this way are then ranked according to their composite scores thereby determining the priority of the proposed improvements. The procedure used by the Arizona Highway Department is an excellent example in this methodology (13). Priority arraying, on the other hand, adds more complex analyses to sufficiency ratings by incorporating factors such as traffic volumes, accident rates, and social, economic, and environmental concerns. Here, projects are segregated into priority arrays based on ratings of the individual parameters. At the present time, several states, such as Tennessee and Washington, along with various city and county governments have adopted the principle of priority arraying (2,3).

Non-technical priority settings include subjective methodologies that do not generally involve an analysis to weight their relative importance. These methods provide additional insight, particularly where a multifaceted judgment is called for (6).

In setting the financial priority, projects are ranked according to their economic importance, expressed mostly in terms of benefit-cost ratios, rate of return, or cost-effectiveness methods. Pennsylvania uses an improvement-cost ratio for evaluating street improvement programs in urban areas (11).

The last several years have seen new elements added to the transportation programming environment. Consequently, without substantial changes, neither sufficiency ratings, economic analyses, or any non-technical methods, by themselves, are an adequate approach to priority setting. While sufficiency ratings do a good job of measuring the urgency for improvement,economic analysis is needed to measure the benefit or value of the improvement. Evaluating proposed improvements using such methods independent of each other can result in a project with a high degree of structural urgency while having little economic importance or vice versa. Improvement programs must now frequently be evaluated on the basis of issues such as equity, efficiency and public acceptability.

Some of the existing techniques are inappropriate in that they are too demanding of time and data, or are not flexible enough to deal with the broader range of options being considered (6). Consequently, new methodologies are being developed including optimization techniques, sketch planning, multi-modal analysis, and impact prediction techniques. A priority programming procedure developed by Georgia Department of Transportation is one such recent development. The method utilizes an optimization approach which combines the functions of priority analysis, program formulation, and project scheduling into one operation that produces the optimum schedule of projects through the use of computer-based planning tools (5).

CRITERIA FOR PRIORITY SETTING

A major element of priority programming is the criteria used to establish a priority ranking. Such criteria should reflect not only how the proposed program satisfies certain physical and economic conditions, but also, how it meets overall community and governmental objectives. Valid criteria are therefore essential in programming the "best" improvement, that will provide maximum benefits.

Establishing Criteria

There are numerous tangible and intangible factors relevant to transportation priority setting. These factors need to be properly considered in any programming effort. Various criteria noted in the literature are:

1. needs parameter
2. physical criteria
3. fiscal criteria
4. impact analysis
5. technological suitability
6. urban transportation performance

The needs parameter represents a group of criteria based on user and societal needs. Table 2 illustrates these various criteria.

Table 2

Needs Parameter	
User Requirements	User + Nonuser + Operator Req.
1. Improvement which serves the most people based on: - Peak period volumes - Off-peak volumes - Weekend travel	1. Improvement with least cost - capital cost - operating cost - land requirements - effects on property values
2. Travel time: - In-vehicle - Out of Vehicle	2. Improvement which hastens most desirable development. - social - economic
3. Reliability	3. Improvement which provides greater revenue - taxes - tolls - fares - user charges
4. Out of pocket costs	4. Versatility: can the improvement be utilized for other uses such as goods movement
5. Safety	5. Adaptability to deal with peak demand - changing land-use - technology - travel trends

The next group of criteria emphasizes the physical characteristics of the facility such as dimensions, alignment, surface and track conditions, and other structural integrity features (2,3,5,6). Table 3 provides a list of criteria which are relevant to this group.

Table 3

Physical Factors	
1. Physical Condition - sufficiency ratings - deficiency ratings	4. Bridges - condition rating - operating rating
2. Geometrics - pavement width - shoulder width	5. Safety - accident totals - accident rates
3. Alignment - horizontal - vertical	6. Capacity - volume/capacity ratio

Fiscal criteria concentrate on costs and economic benefits associated with an improvement (9). This category also relates appropriations to the allocation of transportation funds. Appropriate criteria are given in Table 4.

Table 4

Fiscal Criteria		
	Financial Feasibility	
Economic Feasibility	System Implementation Funding	Operations Funding
1. Total Capital Costs	1. Total Capital Costs	1. Total Operating Cost
2. Annualized Capital Costs	2. Federal Share	2. Fare, Toll Revenue
3. Annual Operating Costs	3. State Share	3. Subsidy/Tax Requirement
4. Annual System Costs	4. Local Share	4. Federal, State, Local Funds Available for Subsidy
5. Annualized Benefits	5. Local Funds Available	
6. Benefit-Cost Ratio	6. Surplus/Deficit	
7. Benefits		5. Surplus/Deficit

Ref. (8)

Total Capital Costs: Immediate indication of the magnitude of resources required to implement an improvement.

Annualized Capital Costs: Means of comparing nonuniform expenditures by taking into consideration the different economic life of system components and time value of money.

Annual Operating Costs: Indicate a continuing need for financial resources that must be committed to maintain and operate a system.

Annualized System Costs: Represents the total annual resource investment required for system implementation and operation considering time value of money.

Annualized Benefits: Marginal gains to society from implementation of the improvement over the benefits of baseline alternative. Those that can be quantified in dollar terms.

Benefit Cost Ratio: Comparison of marginal benefits and costs.

Benefits Net of Cost: Reflect dollar amount by which benefits exceed the costs of an improvement.

Impact criteria measure the effects a transportation improvement has on the community and on the natural environment (9,12). It also includes those effects an improvement will have on community goals and objectives. Table 5 lists the various criteria.

Table 5

Impact Criteria	
1. Impact on Natural Environment	2. Impacts on Built Environment
Air Quality	Relocation
Water Quality	Neighborhood Disruption
Noise Levels	Green Space
Energy	Safety
Ecosystem Analysis	Construction Impacts
	Conformity with Community Goals
3. Impact on Overall Goals	
Evaluation here insures that all other criteria are consistent with national and regional goals and local policy, rather than specific plans.	

Technological suitability measures risk, flexibility, and dependability of a particular improvement (6,9). A brief description of the criteria involved here is presented in Table 6.

Table 6

Technological Suitability
1. Quality
This criterion is essential since demand for improved transportation will be generated by increased standard of living. Since investment is limited, resources should be put into facilities which will have maximum utility.
2. Flexibility
This indicates the capability of staging transportation improvements so that change in policy may be put into effect at some time in the future as new conditions may warrent. This prevents the development of systems that will be obsolete before they are complete.
3. Technical Risk
This criterion implies selection of an improvement that is directly related to the degree of development required to bring the system's performance to an acceptable level.
4. Service Dependability
Indicates reliability and maintainability of a particular improvement.
5. Procurement Risk
Assesses the supplier's willingness to produce the necessary supplies at acceptable costs and required lead time.

Finally, performance criteria are important in measuring the efficiency and effectiveness of a transportation improvement. Table 7 describes these criteria.

Table 7

Urban Transportation Performance
1. Efficiency
Efficiency analysis evaluates improvements in terms of the amount of resources required to produce transportation services. This should be considered for the entire system as well as incremental improvements.
2. Economic Efficiency
Assesses the various improvements based on various cost elements per outputs produced and consumed.
3. Effectiveness
Indicates the degree to which outputs are utilized. Measures increasing patronage levels of an improvement in conjunction with level of service aspects.

It should be pointed out that the entire question of criteria to be used and the manner in which they are expressed is intimately connected with the method of applying them to evaluate improvements. Furthermore, there are many problems and uncertainties in the choice and definition of project evaluation and priority programming criteria. It is to be emphasized that considerable effort still needs to be applied in the definition and measurement of appropriate criteria for project selection and priority programming.

CONCLUSION

Brock Adams, former Secretary of Transportation in a statement on national policy, stressed the need for improved resource allocation as one of the major concerns in transportation (1). An effective process of project selection and priority programming is critical in insuring optimal allocation of limited funds for transportation facilities. The criteria for this process, however, cannot be restricted to the specific systems; the broad goals of energy conservation, environmental protection, improved quality of life, economic growth and other community and areawide objectives must also be considered.

Priority programming techniques and evaluation criteria have been developed essentially from highway needs studies and for maintenance programs. Because of the changing national goals and increasing emphasis on environmental and social considerations, the existing techniques and associated criteria are not adequate. New federal requirements for transportation improvement program (TIP) for metropolitan areas have necessitated a considerable re-orientation in the formulation of the types of criteria used in transportation programming. More emphasis is now being placed on less capital intensive projects and on analyzing trade-off among modes. In addition, transportation officials are becoming increasingly aware of performance of transportation systems in providing service, and there is a growing trend among states in using system performance indicators to allocate transit funds among regions. It can be expected that as resource constraint becomes increasingly severe because of inflation and revenue shortfalls, performance criteria involving system efficiency and productivity will become more and more important in transportation decision making.

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