NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM
SYNTHESIS OF HIGHWAY PRACTICE 84

EVALUATION CRITERIA AND PRIORITY SETTING FOR STATE HIGHWAY PROGRAMS

TRANSPORTATION RESEARCH BOARD
NATIONAL RESEARCH COUNCIL

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THOMAS F. HUMPHREY
Hingham, Massachusetts

Topic Panel

PHILIP W. BLOW, *Federal Highway Administration*
JOSEPH H. CLEM, *Federal Highway Administration*
MAL HILLIARD, *Florida Department of Transportation*
EVAN A. IVERSON, *Washington State Department of Transportation*
HAL KASSOFF, *Maryland State Highway Administration*
EUGENE McCORMICK, *Illinois Department of Transportation*
JONATHAN M. NEWMAN, *New York State Department of Transportation*

RESEARCH SPONSORED BY THE AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS IN COOPERATION WITH THE FEDERAL HIGHWAY ADMINISTRATION

TRANSPORTATION RESEARCH BOARD
NATIONAL RESEARCH COUNCIL
WASHINGTON, D.C. NOVEMBER 1981

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Systematic, well-designed research provides the most effective approach to the solution of many problems facing highway administrators and engineers. Often, highway problems are of local interest and can best be studied by highway departments individually or in cooperation with their state universities and others. However, the accelerating growth of highway transportation develops increasingly complex problems of wide interest to highway authorities. These problems are best studied through a coordinated program of cooperative research.

In recognition of these needs, the highway administrators of the American Association of State Highway and Transportation Officials initiated in 1962 an objective national highway research program employing modern scientific techniques. This program is supported on a continuing basis by funds from participating member states of the Association and it receives the full cooperation and support of the Federal Highway Administration, United States Department of Transportation.

The Transportation Research Board of the National Research Council was requested by the Association to administer the research program because of the Board's recognized objectivity and understanding of modern research practices. The Board is uniquely suited for this purpose as: it maintains an extensive committee structure from which authorities on any highway transportation subject may be drawn; it possesses avenues of communications and cooperation with federal, state, and local governmental agencies, universities, and industry; its relationship to its parent organization, the National Academy of Sciences, a private, nonprofit institution, is an insurance of objectivity; it maintains a full-time research correlation staff of specialists in highway transportation matters to bring the findings of research directly to those who are in a position to use them.

The program is developed on the basis of research needs identified by chief administrators of the highway and transportation departments and by committees of AASHTO. Each year, specific areas of research needs to be included in the program are proposed to the Academy and the Board by the American Association of State Highway and Transportation Officials. Research projects to fulfill these needs are defined by the Board, and qualified research agencies are selected from those that have submitted proposals. Administration and surveillance of research contracts are the responsibilities of the Academy and its Transportation Research Board.

The needs for highway research are many, and the National Cooperative Highway Research Program can make significant contributions to the solution of highway transportation problems of mutual concern to many responsible groups. The program, however, is intended to complement rather than to substitute for or duplicate other highway research programs.

NCHRP SYNTHESIS 84

Project 20-5 FY 1980 (Topic 12-01)
ISSN 0547-5570
ISBN 0-309-03274-7
Library of Congress Catalog Card No. 81-85599

Price: $6.40

Subject Areas
Administration
Planning

Modes
Highway Transportation
Public Transit

NOTICE

Published reports of the

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

are available from:

Transportation Research Board
National Academy of Sciences
2101 Constitution Avenue, N.W.
Washington, D.C. 20418

Printed in the United States of America.

PREFACE

There exists a vast storehouse of information relating to nearly every subject of concern to highway administrators and engineers. Much of it resulted from research and much from successful application of the engineering ideas of men faced with problems in their day-to-day work. Because there has been a lack of systematic means for bringing such useful information together and making it available to the entire highway fraternity, the American Association of State Highway and Transportation officials has, through the mechanism of the National Cooperative Highway Research Program, authorized the Transportation Research Board to undertake a continuing project to search out and synthesize the useful knowledge from all possible sources and to prepare documented reports on current practices in the subject areas of concern.

This synthesis series attempts to report on the various practices, making specific recommendations where appropriate but without the detailed directions usually found in handbooks or design manuals. Nonetheless, these documents can serve similar purposes, for each is a compendium of the best knowledge available on those measures found to be the most successful in resolving specific problems. The extent to which they are utilized in this fashion will quite logically be tempered by the breadth of the user's knowledge in the particular problem area.

FOREWORD

By Staff
Transportation
Research Board

This synthesis will be useful to transportation planners, administrators, and others concerned with setting priorities for state highway programs. Detailed information is presented on methods of allocating resources and establishing priorities among transportation programs and projects.

Administrators, engineers, and researchers are faced continually with many highway problems on which much information already exists either in documented form or in terms of undocumented experience and practice. Unfortunately, this information often is fragmented, scattered, and unevaluated. As a consequence, full information on what has been learned about a problem frequently is not assembled in seeking a solution. Costly research findings may go unused, valuable experience may be overlooked, and due consideration may not be given to recommended practices for solving or alleviating the problem. In an effort to correct this situation, a continuing NCHRP project, carried out by the Transportation Research Board as the research agency, has the objective of synthesizing and reporting on common highway problems. Syntheses from this endeavor constitute an NCHRP report series that collects and assembles the various forms of information into single concise documents pertaining to specific highway problems or sets of closely related problems.

Declining revenues and escalating costs are placing greater urgency on the need for reliable, decision-making procedures for the allocation of transportation funds. This report of the Transportation Research Board includes a discussion of evaluation criteria for establishing priorities among highway projects and programs.

To develop this synthesis in a comprehensive manner and to ensure inclusion of significant knowledge, the Board analyzed available information assembled from numerous sources, including a large number of state highway and transportation departments. A topic panel of experts in the subject area was established to guide the researcher in organizing and evaluating the collected data, and to review the final synthesis report.

This synthesis is an immediately useful document that records practices that were acceptable within the limitations of the knowledge available at the time of its preparation. As the processes of advancement continue, new knowledge can be expected to be added to that now at hand.

Evaluation Criteria and Priority Setting for State Highway Programs 81-0084 #C TE7.N2U no.84V

Transportation Research Board, Washington, DC.*Federal Highway Administration, Washington, DC.*American Association of State Highway and Transportation Officials, Washington, DC. (
0447800008

Final rept.
AUTHOR: Humphrey, Thomas F.
G6883F4 Fld: 13B, 5A, 50A, 43G GRAI8215
Nov 81 41p
Rept No: TRB/NCHRP/SYN-84; ISBN-0-309-03264-1
Project: NCHRP-20-5
Sponsored in part by Federal Highway Administration, Washington, DC., and American Association of State Highway and Transportation Officials, Washington, DC. Library of Congress catalog card no. 81-85599. Also pub. as ISSN-0547-5570.
Paper copy also available from Transportation Research Board, 2101 Constitution Ave., NW, Washington, DC. 20418.

Abstract: This synthesis will be useful to transportation planners, administrators, and others concerned with setting priorities for state highway programs. Detailed information is presented on methods of allocating resources and establishing priorities among transportation programs and projects. Declining revenues and escalating costs are placing greater urgency on the need for reliable, decision-making procedures for the allocation of transportation funds. This report of the Transportation Research Board includes a discussion of evaluation criteria for establishing priorities among highway projects and programs.

Descriptors: *Highways, *Project management, Allocations, State government, Budgeting, Highway transportation

Identifiers: Priorities, NTISNASTRB, NTISDOTFHA, NTISNASNRC

PB82-188285 NTIS Prices: PC A03/MF A01

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ACKNOWLEDGMENTS

This synthesis was completed by the Transportation Research Board under the supervision of Paul E. Irick, Assistant Director for Special Technical Activities Division. The Principal Investigators responsible for conduct of the synthesis were Thomas L. Copas and Herbert A. Pennock, Special Projects Engineers. This synthesis was edited by Nancy A. Ackerman.

Special appreciation is expressed to Thomas F. Humphrey, Hingham, Massachusetts, who was responsible for the collection of data and the preparation of the report.

Valuable assistance in the preparation of this synthesis was provided by the Topic Panel, consisting of Philip W. Blow, Community Planner, Planning and Programming Branch, Office of Highway Planning, Federal Highway Administration; Joseph H. Clem, Highway Engineer, Office of Highway Operations, Federal Highway Administration; Mal Hilliard, Deputy Director for Financial Administration, Florida Department of Transportation; Evan A. Iverson, Supervisor, Implementation Planning, Washington State Department of Transportation; Hal Kassoff, Director, Office of Planning and Preliminary Engineering, Maryland State Highway Administration; Eugene McCormick, Bureau Chief, Statewide Program Planning, Illinois Department of Transportation; and Jonathan M. Newman, Director of Program Planning Bureau, New York State Department of Transportation.

Kenneth E. Cook, Transportation Economist, Transportation Research Board, assisted the Project 20-5 Staff and the Topic Panel.

Information on current practice was provided by many highway and transportation agencies. Their cooperation and assistance were most helpful.

EVALUATION CRITERIA AND PRIORITY SETTING FOR STATE HIGHWAY PROGRAMS

SUMMARY

The purpose of this synthesis is to report on how state departments of highways and transportation currently make decisions on the allocation of available funds to highway programs and projects. Those decisions require the consideration of four factors, all of which must be used in combination to satisfy the need to distribute limited funds equitably.

1. *Strategic planning*. The responsible state agency should organize and implement a systematic management and technical process for making decisions on how to spend limited funds in the wisest manner possible. This may mean that current planning procedures will have to be evaluated and adjusted to take full advantage of up-to-date data and analysis procedures.

2. *Technical factors*. A number of states make substantial use of data and technical procedures to assist in the selection of priorities. Even in these states, however, it is clear that the technical process provides only one input to and a point of departure for decision making. Technical factors do not determine the final ranking of projects, because a great deal of discretion and good judgment must also be used. Other states collect and analyze data, but the technical procedures have little or no impact on final program decisions because they have lost credibility.

This synthesis describes the following technical procedures: (a) sufficiency ratings, (b) the priority planning procedure, (c) the highway investment analysis package, (d) the priority programming system, (e) the highway economic evaluation model, (f) pavement management systems, (g) pavement condition measurements, and (h) bridge evaluations. The application of some of these procedures and the programming process used in several states are included in the appendix.

3. *Intangible factors*. A discussion of 14 nonquantifiable, or intangible, factors is included in this synthesis. Although they are not easily quantified, such factors have a significant influence on final program decisions.

4. *Political factors*. These are also intangibles, but they are worthy of special attention. Elected officials are responsible for providing the funds for highway programs, and state legislative bodies are increasingly coming to believe that they should be involved in deciding what projects should be funded. The degree of involvement varies from state to state, but at present it is greatest in the selection of the big, expensive, highly visible projects. This is especially true in states where additional or new tax revenues are requested for highway purposes.

CHAPTER ONE

INTRODUCTION

PURPOSE OF SYNTHESIS

The purpose of this synthesis is to identify and report the current practices being used by state transportation agencies in allocating available resources among high-priority programs and projects. The focus is restricted to capital and maintenance activities of highway programs, because limited time and resources precluded a comprehensive evaluation of other modes. This should not be interpreted to mean that the difficulty in establishing priorities and allocating funds to the other modes is easier or less important.

The question to be answered by this synthesis is: given a fixed amount of money for 1 yr or some other period of time, what is the wisest use of that money, taking into consideration all the criteria that must be satisfied? Figure 1 portrays the steps generally followed in fund allocation. The issue is one of spending state and federal money in the most practical, efficient, and economical manner possible. The total amount of money available for federally aided programs is determined by actions taken first at the federal level when Congress and the president agree on a total amount of federal funds to be apportioned to the states for various transportation programs and categories within programs. State legislatures and governors then determine the amount of state funds that will be needed to match federal grants and to spend on transportation programs that are not federally aided.

When the total state transportation budget is known, the next step is to allocate those funds to (a) program categories (e.g., capital, maintenance, operations/administration) and subcategories covering types of activity or improvements; (b) geographical areas within the state, which may be highway or transit districts, metropolitan areas, rural areas, or other political jurisdictions; and (c) specific projects in each of the aforementioned categories.

Another purpose of the synthesis is to identify technical references that may be consulted for more detail on the subjects covered.

RELATION TO PREVIOUS WORK

This synthesis builds and expands on previous reports on transportation planning and programming. There is a growing body of literature on the subject of transportation programming, especially related to highways, because of increased concern that the nation's highway system is showing signs of rapid deterioration and the resources being applied to slow or overcome this problem are shrinking.

A conference on the transportation programming process was held in Orlando, Florida, March 23–26, 1975 (*1*), which generated substantial interest in the subject of transportation programming. One of the efforts undertaken as an outgrowth of the conference was a synthesis of the current practice of priority programming and project selection (*2*). The Transportation Research Board (TRB) Committee on Transportation Programming, Planning, and Evaluation prepared an overview and annotated bibliography on the subject (*3*).

This synthesis does not cover the subject of estimating short- and long-term transportation needs, although this is an important element in the overall transportation planning and programming process. That topic is covered in *NCHRP Synthesis 72* (*4*). Many other publications prepared by TRB, the U.S. Department of Transportation (DOT), state agencies, and other public and private agencies are referred to herein. This synthesis updates previously published work by adding information, giving another perspective based on current experiences, and aiding in the selection of techniques and procedures that are most appropriate in a particular situation.

PROBLEMS AND CONFLICTS

The most central issue in the management of transportation programs is the allocation of funds to program categories, geographical areas, and, eventually, specific projects. It ties together all other funding-related issues, because it is through this allocation that resources are specifically related to a given transportation problem.

Although each state has unique problems, many are common to all states and jurisdictions within states. The common problems that were identified during the process of gathering information and material for this synthesis are summarized below. They are not presented in any particular order and should not be viewed as policy-level conclusions.

- The major construction programming decisions at the state level are determined predominantly by federal categorical grants, because a major objective of state and local government has been to make full use of all available federal funds. This has meant that some issues have received attention at the expense of others, most notably highway pavement and bridge maintenance.
- Increasing transportation needs for all modes and the decreasing value of available dollars due to inflation and declining levels of funds have caused a growing gap between critical needs and available funds. This has led to serious competition for transportation funds (within and between modes) and general revenue funds (for transportation vs. other state and local needs).
- Different priorities frequently exist among and within the legislative and executive branches and among various levels of government.

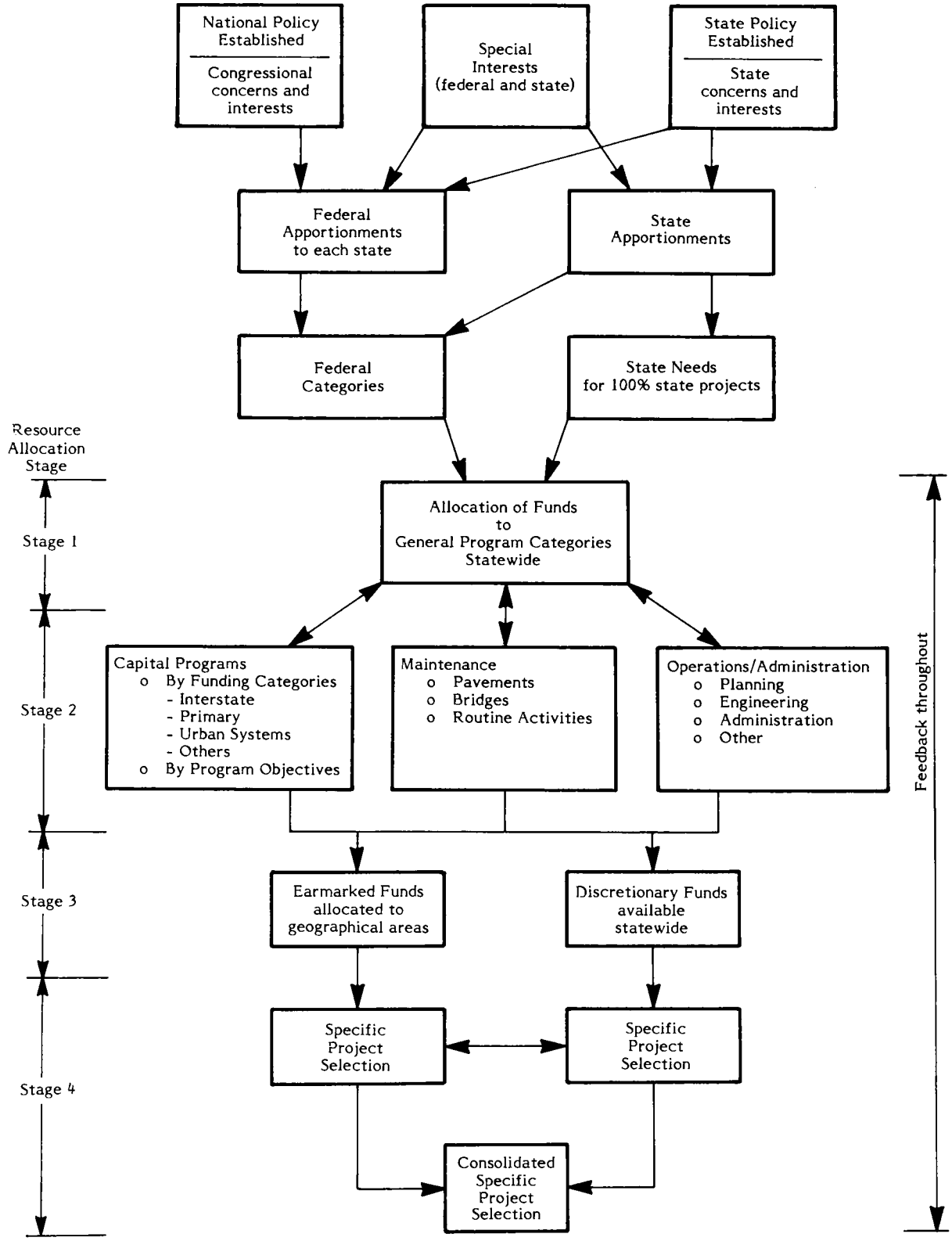

FIGURE 1 Steps generally followed in the process of allocating funds for highway projects.

- Often a great deal of time is needed to prepare a new construction project for implementation, because the process of project development is very complicated. Criteria and priorities, therefore, may change between planning and implementation. The long time delay may also mean that a project requires additional funds because of the impact of inflation.
- Continuing change and uncertainty in the nation and the world regarding energy, inflation, and the economy make it extremely difficult to plan very far into the future. This makes it necessary to remain flexible and be ready for the unexpected. Consequently, short-term planning is becoming a critical need, and long-term capital planning is becoming less useful. All of this means that it is very difficult to make programming decisions in a systematic way and in accordance with reproducible procedures; this is why there is now a period of crisis programming.
- Some states use extensive technical procedures in the priority-setting process, and others do not. For example, some states believe that a numbered ranking system is useful in setting priorities; other do not. Some states have great confidence in such procedures as sufficiency ratings and pavement serviceability indexes; others believe that such procedures are not useful. Both positions may be correct, depending on specific circumstances. The question is: To what degree do or should those procedures influence the establishment of priorities?
- Many states have a substantial backlog of deferred maintenance. The full consequences of deferred maintenance of pavements and bridges are not known, but it will probably mean much greater reconstruction costs and perhaps substantially higher user costs. These factors must be considered much more carefully than they have been in the past, and future federal and state funding priorities must take them into account.
- The criteria considered in establishing priorities are different in various parts of the nation. For example, the Northeast has a major investment in a physical infrastructure that is old and deteriorating rapidly. The Sun Belt states are experiencing rapid increases in population and economic development and are therefore concerned with system expansion. Federal transportation policies, then, should provide for an equitable distribution of funds in a manner that recognizes what could be significantly different needs among states.
- Many state officials have been urging the federal government to significantly reduce the number of categorical programs. Emerging federal policies are moving in that direction and toward a reduction of federal funding support. If that happens, states must be prepared to establish their own priorities and justify the need for additional revenues.
- The criteria used in setting priorities for projects are often different for different types of systems (e.g., Interstate, primary, and urban. This may be satisfactory from a technical point of view, but it may also create unecessary confusion for the public and the legislature. The merging of programs or projects often requires trade-offs among them, which may cause further confusion in the decision-making process.
- Past commitments to projects may have led to the advanced acquisition of right-of-way. If the programming process calls for selling some of that right-of-way, the problem then becomes one of withdrawing projects that had been committed, which may call for criteria completely different from those considered in the past.
- Most states have a trust fund for highway purposes, but in some states (e.g., Delaware, New Jersey, and New York) the highway agency must compete for funds.
- Changes in design and maintenance standards will probably be necessary to reduce the expense of individual projects and thus allow for the programming of more projects. Careful consideration must be given to how this will affect safety.
- Some states have traditionally allocated funds to geographical regions using a rigid distribution formula, often established by the legislature. Many technical and program managers feel that such an approach is inefficient and sometimes counterproductive, but they should be sensitive to the political process. A balance should be established between the two positions.

It is not the intent in this synthesis to provide solutions to all the problems summarized above. The purpose of listing them here is to provide an overall perspective on the issue being addressed and to help focus the discussion that follows.

CHAPTER TWO

THE PROCESS OF ALLOCATING RESOURCES

Figure 1 illustrates the steps usually followed in the process of allocating resources for highway projects, beginning at the point when Congress and the state legislatures appropriate funds and ending with the selection of specific projects. The following four stages characterize the process shown in Figure 1.

Stage 1. The allocation of funds to three general program categories: (a) capital programs, (b) maintenance programs, and (c) operations and administration.

Stage 2. The allocation of funds within each of those three program categories.

Stage 3. The allocation of earmarked funds to specific geographical regions within the state and the allocation of discretionary funds statewide.

Stage 4. The allocation of funds to specific projects.

The four stages do not necessarily take place in the order given above, and continuing feedback occurs among all four.

ALLOCATION OF FUNDS TO GENERAL PROGRAM CATEGORIES

At this preliminary stage, transportation "needs" are identified on a national, state, and local level. Based on this assessment of "needs," overall program levels of funding are established for capital, maintenance and operations/administration requirements of a state transportation program. This part of the overall allocation process depends on continuing feedback among all four stages and among all levels of government.

The process of identifying transportation needs is described in detail in *NCHRP Synthesis 72* (*4*), so it will not be covered here. However, several important points are worthy of discussion with regard to state highway programs.

The federal-aid highway program and the federal Highway Trust Fund have assured a continuing level of funding for state highway construction purposes for more than two decades. The continuing growth in the number of federal categorical grants requiring a state match resulted in the allocation of state funds for that purpose in order to take full advantage of and maximize the benefits of the federal program. State funds necessary for maintenance and for operations/administration were, until recently, typically appropriated at levels sufficient to maintain what was considered the status quo.

Federal funding for construction programs, therefore, has been the major determinant of how state funds have been allocated for state highway programs. For approximately the past two decades those programs have focused on new construction (primarily the Interstate highway system) and the expansion of the total street and highway system, which has resulted in deferred maintenance of pavements and bridges throughout the nation, a problem of growing concern at all levels of government. The total amount of funds for highway construction has increased over the past two decades, but the real value of expenditures in constant dollars has declined. Figure 2 (*5*) shows capital outlays for state highways from 1968 to 1978 in constant 1967 dollars. In real terms, capital outlays have been reduced by about 50 percent. Figure 2 also shows that, as capital outlays have declined, maintenance dollars have not increased commensurately.

Every national and state report on highway needs published in recent years provides vivid examples of the problems that exist because maintenance of highway bridges and pavements has been deferred. The following are among the conclusions of the sixth biennial report to Congress on the status of the nation's highways (*6*):

- Since 1970 highway expenditures by all levels of government have increased but have been eclipsed by inflation; there has been a decrease in real buying power.
- The effects of declining real investment levels and increasing travel are seen in the deterioration of highway system performance since 1975, based on a U.S. DOT analysis.
- Overall pavement age is increasing, resurfacing and rehabilitation needs are mounting, and congestion is growing, especially in urban areas.
- Based on projections made by the U.S. DOT through 1995, the condition of the nation's highways will continue to deteriorate and performance levels will be threatened unless highway revenues and investments increase.

In light of the current status of the nation's highway system, it seems likely that the criteria used to determine needs by general program category, as well as the allocation of funds within each of those categories, are in the process of change at all levels of government.

ALLOCATION OF FUNDS WITHIN PROGRAM CATEGORIES

Funds for capital programs, which are federally aided (except as noted), are allocated by funding category (e.g., Interstate System, primary system, secondary system, urban system, 3-R program [resurfacing, restoring, and rehabilitating], bridge program, safety program, other non-federal-aid programs) or by program objective (e.g., safety, structural preservation, expansion of capacity). Funds for maintenance programs, which generally are not federally aided (except the 3-R program), are allocated for pavements (by several

categories), bridges, and routine activities (e.g., minor repairs and replacements, grass cutting, snow removal). Funds for operations and administration are allocated for planning (with federal assistance), engineering (with federal assistance), and administration.

Capital programs have accounted for large proportions of available resources and thus reduced the amount for maintenance and operations/administration. State funds are usually appropriated to match all federal-aid programs; a decision is then made on how to allocate those funds geographically and by projects. Some states are reversing the process of allocating funds, giving first priority to maintenance and operations/administration and then using whatever is left over for capital programs.

Any of several techniques can be used to allocate resources for projects that are completely state-funded. The most common method is to fund at the previous year's level, allowing some increase to account for inflation. Some states use a project-based approach, in which the amount appropriated is equal to the cost of projects to be implemented (both capital and maintenance) and the cost of administration and operations. Still another method depends on the cash generated by a specific source of revenue (motor fuel tax, registration and license fees, etc.) that has been earmarked for a specific purpose; the program is tailored to the total amount of funds so earmarked.

Many problems are not addressed by current procedures for allocating funds. It is essential that the following issues be examined in the near future.

- The significant funding deficiencies caused by inflation and reduced revenues from motor fuel taxes has created an environment that calls for a much more comprehensive and systematic procedure for establishing priorities. For example, the problem is no longer one of building the first projects out of the pipeline; the challenge now is to make certain that the right projects are in the pipeline.
- More and more states are facing the problem of being unable to match all federal funds without sacrificing most, if not all, routine maintenance activities.
- In most states major programming decisions made at Stage 2 have usually been based on the need to complete projects that had been started (where usable segments could be built) and to carry out long-term commitments (where right-of-way may have been acquired before final engineering was complete). Because of the reduced availability of funds, even those commitments have had to be withdrawn, sometimes causing a significant loss of credibility.
- The definitions of *maintenance* and *rehabilitation* are becoming more significant, because there is no federal participation in routine maintenance. States are often criticized for failure to maintain the highways, when in fact what is being referred to as inadequate maintenance may be the result of an inadequate capital program.

ALLOCATION OF FUNDS TO GEOGRAPHICAL REGIONS

As shown in Figure 1, the allocation of funds to geographical areas is divided into two categories: (1) earmarked funds that are allocated to a particular geographical area (federal-aid urban system funds for each urban area, a fixed proportion of local-aid funds to all communities, and the like) and (b) discretionary funds available for distribution statewide based on other criteria. These funds would have no geographical constraints but would be allocated to meet current high-priority needs, to deal with emergencies, to help achieve equity, and so forth.

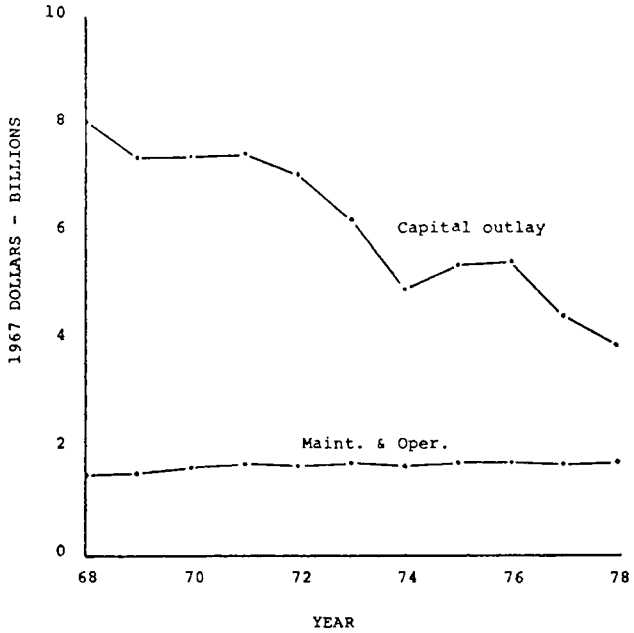

FIGURE 2 State highway expenditures (1968–1978), in constant 1967 dollars (*5*).

This stage reflects the need for social and service equity in the allocation of available resources to all parts of a state. It could occur before or after Stage 2. A variety of methods are used to allocate funds to regions; the methods are usually a combination of several of those listed below.

- A distribution formula set by the legislature to allocate funds to specific geographical districts or regions.
- The discretion of the highway agency administrators.
- An allocation based on the proportion of needs existing in a particular region.
- Line-item budgets.
- An accounting system that provides for geographical equity over several years (because it is nearly impossible to achieve an equal distribution of resources each year).
- Uniform service levels statewide.
- A technical ranking system.
- The transportation improvement programs developed for urban projects by metropolitan planning organizations (MPOs).

All the above methods have advantages and disadvantages, but each state must determine what is equitable.

A major concern at this stage is the proportion of funds allocated to capital and maintenance projects. For example, a disproportionate amount of funds may be assigned to a district where a major Interstate project is under way. It

would be unwise to remove funds, especially maintenance funds, from all other program categories, but a trade-off might be appropriate; for example, preference on primary system projects could be given to another district where there are few or no Interstate projects.

ALLOCATION OF FUNDS TO SPECIFIC PROJECTS

In Stage 4 specific projects are selected for implementation. As shown in Figure 1, a consolidated set of projects is established for a particular time period after the allocations have been made in each of the Stage 3 categories described above. Assuming a very simple series of steps, at this stage the task is to determine which projects to select in each program category and in each geographical area. A given district, for example, may have $10 million worth of primary system projects but only $1 million available for a particular time period. Thus, some method of priority ranking must be used to determine the projects selected for implementation. Similarly, it will be necessary to establish priorities for individual maintenance projects.

Although there is no clear-cut, totally equitable, or simple method for allocating funds to individual projects, it is becoming increasingly essential to establish a well-defined and systematic way of determining how available funds are used. The remainder of this synthesis deals with techniques that states are using to achieve the most equitable and beneficial distribution of funds.

SUMMATION

In practice the four stages described above occur simultaneously, with continuing feedback and adjustment taking place among the agencies and individuals at all levels of government.

When public funds are limited, methods must be developed to ration those funds equitably so that project choices are made within known limits. These methods, however, may or may not lead to the selection of the same priorities that would be selected by some sort of benefit-cost assessment or other technical ranking method.

A major part of a priority programming process is the development, measurement, and assessment of criteria used to establish a priority ranking of projects among and within the four stages in the allocation process. The criteria should reflect not only how the proposed program satisfies certain physical and economic conditions related to the transportation system, but also how it meets overall community and governmental objectives.

CHAPTER THREE

PROCEDURES USED FOR ESTABLISHING HIGHWAY PRIORITIES

Selecting projects for implementation is the culmination of a process that considers quantifiable and nonquantifiable factors. The most common ones are discussed here, and the appendix includes a description of some of the technical procedures used by states.

TECHNICAL PROCEDURES AND QUANTIFIABLE FACTORS

Quantifiable factors that assist decision makers in establishing priorities include the following:

- Physical conditions (measures of pavement deterioration, such as road surface condition, pavement structure, and condition of foundation, shoulders, and drainage).
- Bridge condition, based on structural and functional condition.
- Geometric characteristics.
- Safety factors.
- Capacities and volumes.
- Economic impact.
- Environmental impact.
- User costs.
- Energy implications.
- Cost of the project.
- Relation to the land use and transportation plans prepared for the state and substate districts.
- Cost of design alternatives (i.e., cost of reducing design standards within acceptable levels of safety).

It is important to understand that using analytical techniques in the programming process is only one part of establishing highway priorities. Many of the analytical techniques available originated from highway needs studies, corridor and project planning procedures, and urban transportation planning procedures and are so demanding of data and so time-consuming that they may have little use or credibility unless a state has been fully committed to them over a long period of time.

A systematic and credible technical procedure is very important, because it will allow for more realistic and orderly decisions that can be justified on the basis of specific decision criteria. It will also provide a rational basis for choosing between such activities as new construction or rehabilitation and for giving full consideration to technical, economic, social, and political considerations.

Technical procedures cannot replace good judgment, but they provide an additional source of information and perhaps serve as a point of departure in helping to evaluate the options that are available.

Sufficiency Ratings

One of the most common technical methods used by decision makers has been sufficiency ratings, which are based on standards developed for highway functional classification studies. This is usually a simple numerical procedure in which point values are assigned to road condition, safety, and service. States have developed variations in the procedure, but all such procedures generally identify the adequacy of existing sections of roadway. Disadvantages of the approach are that it cannot evaluate significant economic factors and it does not consider the cost or effectiveness of alternative improvement programs. Also, sufficiency ratings are often subjective and nonreproducible, so they do not assist in monitoring the performance of the highway system or measuring the impact of program decisions.

Although the point values assigned to particular highway sections are very useful, it is generally agreed that other factors must also be considered in making a final determination on priorities. More details on sufficiency rating procedures can be found in publications of the TRB (*2*) and the Federal Highway Administration (FHWA) (*7, 8*).

Two analytical procedures, developed under sponsorship of the FHWA, have been designed to overcome the disadvantages of the sufficiency rating technique: the Priority Planning Procedure (PRIPRO) and the Highway Investment Analysis Package (HIAP).

Priority Planning Procedure

PRIPRO is a fairly straightforward computerized procedure designed to provide three related but slightly different approaches to setting highway priorities. The first two approaches are in common use, but the third is unique to PRIPRO.

1. *Sufficiency rating.* Improvements are ranked by conventional sufficiency ratings, reflecting the traditional categories of condition, safety, and service.
2. *Traffic volume adjustment.* The basic sufficiency ratings are modified to include a value for traffic volumes. This assigns greater weight to the more heavily traveled routes, as determined by an adjustment for average daily traffic (ADT).
3. *Rank by cost-effectiveness index.* This factor is unique to PRIPRO. Projects are ranked by a cost-effectiveness index that combines the sufficiency rating and the social, economic, and environmental factors with project cost per mile, traffic use, and the expected life of the proposed improvement.

PRIPRO is designed to use either of two approaches in ranking projects. In the first approach, sections of the highway system are ranked using existing sufficiency ratings, which can be modified for traffic volumes. In addition, actual sufficiency levels can be identified for each sufficiency variable, or for combinations of variables, and the computer can indicate which projects do not meet those levels.

In the second approach, priorities are calculated on the basis of cost-effectiveness. This involves (a) ranking the present sufficiency of a project to identify those sections with critical deficiencies, (b) proposing improvements to correct the deficiencies, and (c) producing a new sufficiency rating that reflects the improvements. To that rating is added numerical values for social, environmental, and economic impacts; the user cost per mile; the life of the improvement; and the projected ADT for each improvement. These computations produce a ranking of improvements according to their cost-effectiveness.

Although PRIPRO is a conceptually attractive technique, to date it has not been used successfully in any state. More details of the application of PRIPRO can be found in publications of the TRB (*1–3*) and the FHWA (*7*).

Highway Investment Analysis Package

HIAP is a flexible computerized procedure that considers budget constraints. It provides for an analysis of proposed highway improvements and the development of tentative improvement packages within those budget constraints. This procedure has two basic components, described below.

1. *Improvement analysis and evaluation.* Basic analyses are performed on individual highway sections (either one large section or a group of smaller sections) to produce estimates of user effects (e.g., vehicle operating costs, travel times, accident experiences) and nonuser effects (e.g., noise, air, right-of-way dislocations, government costs). The analyst chooses alternative improvements or combinations of improvements (packages) and makes a comparative analysis of them to develop measures of economy and effectiveness for analysis.
2. *Investment programming.* The purpose of this component is the development of efficient highway investment programs within a large number and variety of user-specified expenditure constraints. Maximum constraints restrict total expenditures within each budgetary period and ensure that investments programmed in any period do not exceed realistic funding levels. Minimum constraints provide users with the mechanism for spreading expenditures over a variety of funding categories. For example, the expenditures in each geographical, legislative, or administrative area of a state can be dispersed equitably by the proper application of minimum constraints.

Under HIAP, programs are developed on the basis of one of four evaluation measures: (a) maximizing economic benefits (e.g., reducing travel time, vehicle operating costs, and

maintenance and administration costs); (b) eliminating fatal accidents; (c) eliminating injury-producing accidents; or (d) eliminating all accidents.

HIAP's investment programming process uses a marginal analysis approach to determine what is theoretically the best mix of projects to be included in the program. In this approach there are no packages in an investment program to begin with, and the best possible improvement packages are successively added to a selected package list until the overall programming period budget is expended. The best possible improvement package at any point in the process is the one with the highest ratio of evaluation measures (the four evaluation measures identified in the previous paragraph) to cost, which is called the EM-C ratio. If other improvement packages exist for the same analysis site, marginal EM-C ratios are calculated and used for the remainder of the selection process. This process seeks to maximize the total net return on the investment program for any given expenditure level.

HIAP is capable of assisting in the analysis of complex improvements involving several interrelated highway sections as well as those proposed for a single section. In developing investment programs, the analyst can use HIAP to help select the combination of packages, in up to four investment periods, that best achieves the objectives and still meets a broad range of financial, legislative, and community constraints. The analysis is adjusted as the programming process moves closer to the final decision point.

More details of HIAP can be found in publications of the TRB (*2*) and the FHWA (*7, 9*). HIAP has been used in Wisconsin and is currently under further development (*10, 11*). New Mexico and Idaho are also considering its use.

Priority Programming System (PPS)

The PPS is a computer-based technique designed to assist states and urban areas in determining user benefits and costs and scheduling large transportation improvements so that total benefits accrued can be maximized for a given time period and within a given budget constraint. The PPS was developed by the Ontario Ministry of Transportation and Communication to aid in the systematic assessment of transportation improvement priorities. The methodology is intended to bridge the gap between long-range planning and project implementation, so that improvements will be implemented in such a way that overall benefits to the public are maximized. The PPS performs the following functions (*12*):

1. Given estimates of traffic characteristics and physical conditions before and after a proposed improvement is implemented, the PPS will project (future) time streams of user benefits of the improvement as a function of when implementation occurs.
2. Given estimates of the cost of implementation, the PPS will estimate the ratio of user benefits to projects costs, in terms of constant dollars, as a function of when implementation occurs.
3. Given estimates of annual budgets, the PPS will recommend the timing of implementation for each one of a set of proposed alternatives so that total user benefits are maximized. Constraints on interrelationships of projects, distribution of funds among programs or geographic areas, and time required for implementation may be incorporated in this optimization.
4. For each of these analytical functions, the PPS will provide a variety of tabular and graphical reports that may be used as aids in decision making.

The PPS is used by the Ontario Ministry of Transportation and Communication to manage a highway investment portfolio of approximately 250 projects. The PPS has the capacity to deal with a large number of improvements and can provide information on the consequences of changes in project timing, costs, and value assumptions (e.g., the dollar value to be associated with each hour of travel time saved).

As part of National Cooperative Highway Research Program (NCHRP) Project 8-18, the Maryland Department of Transportation (MDOT) agreed to implement the PPS as a tool for setting priorities in a test case of 26 statewide highway projects. The 26 projects totaled $1.16 billion, and they were scheduled and put in priority order using a budget constraint of $0.8 billion. Project rankings were developed using four criteria: operating cost savings, travel time savings, accident savings, and total user cost savings.

The PPS is now installed at the MDOT computer facility, and it is fully operational and can be run by MDOT personnel. It is not being used operationally in Maryland, however, because its major application is for large capital projects.

NCHRP Report 199 (*12*) describes the PPS in detail. It also contains a guide for potential users, although it is not a procedural manual. Bellomo and others (*13*) describe an application of the PPS in Maryland.

Highway Economic Evaluation Model (HEEM)

The computerized HEEM model was developed by the Texas State Department of Highways and Public Transportation as an aid in the development of a highway program that provides maximum systemwide benefits for the dollars spent while staying within overall funding constraints. It is designed to measure and evaluate the costs and benefits of a proposed highway project over a long period of time. The analysis is based on the savings in time, accidents, and operations.

The costs analyzed include (a) the capital costs of building the highway and acquiring the right-of-way and (b) the continuing maintenance costs. Social costs, air pollution, and noise pollution, though difficult to quantify, are also considered during project design and analysis.

Every proposed project is examined to see if a reduced scope or alternative design criteria would be more cost-effective than the original proposal. HEEM is used to analyze the larger improvement projects to determine the most cost-effective alternative. The model also estimates changes in mobility and can be used to find the combination of projects that is most cost-effective as an interrelated system. The HEEM cost-effectiveness measures are used to assist in establishing project priorities for programming.

Texas has used this model extensively (*14, 15*).

Pavement Management Systems

There is growing interest in the concept of a formalized pavement management system (PMS) as a management tool

in the establishment of highway pavement program priorities. In its broadest sense, a PMS encompasses all the activities involved in the design, construction, maintenance, and rehabilitation of the pavement portion of the highway network. A PMS is a set of tools or methods that assist decision makers in finding optimum strategies for providing and maintaining pavements in serviceable condition over a given period of time. The function of a PMS is to improve the efficiency of decision making, expand its scope, provide feedback on the consequences of decisions, facilitate the coordination of activities within the agency, and ensure the consistency of decisions made at different management levels within the same organizations.

Pavement management is not a new concept. Every highway agency has established a management system. Perhaps the most significant aspect of a formalized PMS is the process of *providing feedback concerning the consequences of decisions* made on priorities and technical details (e.g., the decision on pavement thickness). Frequently trade-offs must be made without knowledge of the consequences; feedback might help alleviate this problem.

For example, assume funds are available to implement only one-third of the required overlays in a particular district. Should the design overlay be used for that one-third and nothing done on the other two-thirds? Should a thinner overlay be used on all projects? Which projects are to receive less than desirable treatment? To determine which of the trade-offs is most desirable, one must be able to predict the consequences of each alternative. The prediction of future consequences of present actions (of which one alternative is a "do-nothing" decision) frequently is made informally by using engineering judgment. It is possible to make reasonable judgments in this manner, based on the experience of an individual or group, but problems may result. If many apparently equal choices are available, for instance, it may be difficult to distinguish among them, and a decision may have to be made subjectively, or even arbitrarily. Also, if the predictions turn out to be wrong, it will usually be impossible to pinpoint the source of error in a projection that was made on the basis of intuitive logic. If, on the other hand, a formalized procedure is used, it will be possible in future years to analyze the previous predictions and determine why they were good or bad. In this way technical procedures and decision criteria can be continually updated and improved.

A detailed discussion of formalized pavement management systems is contained in *NCHRP Report 215 (16)*. A simplified flowchart of a PMS is shown in Figure 3. The PMS can use existing data, design models, and technology, but use them more efficiently. In the area of data collection, for example, significant savings may be achieved through the collection and storage of only the information that will be used effectively. In addition, systematic data collection and the use of good prediction models within a total PMS can provide the basis for special studies, such as an evaluation of effects of increased vehicle load limits.

Several states have established some type of PMS, al-

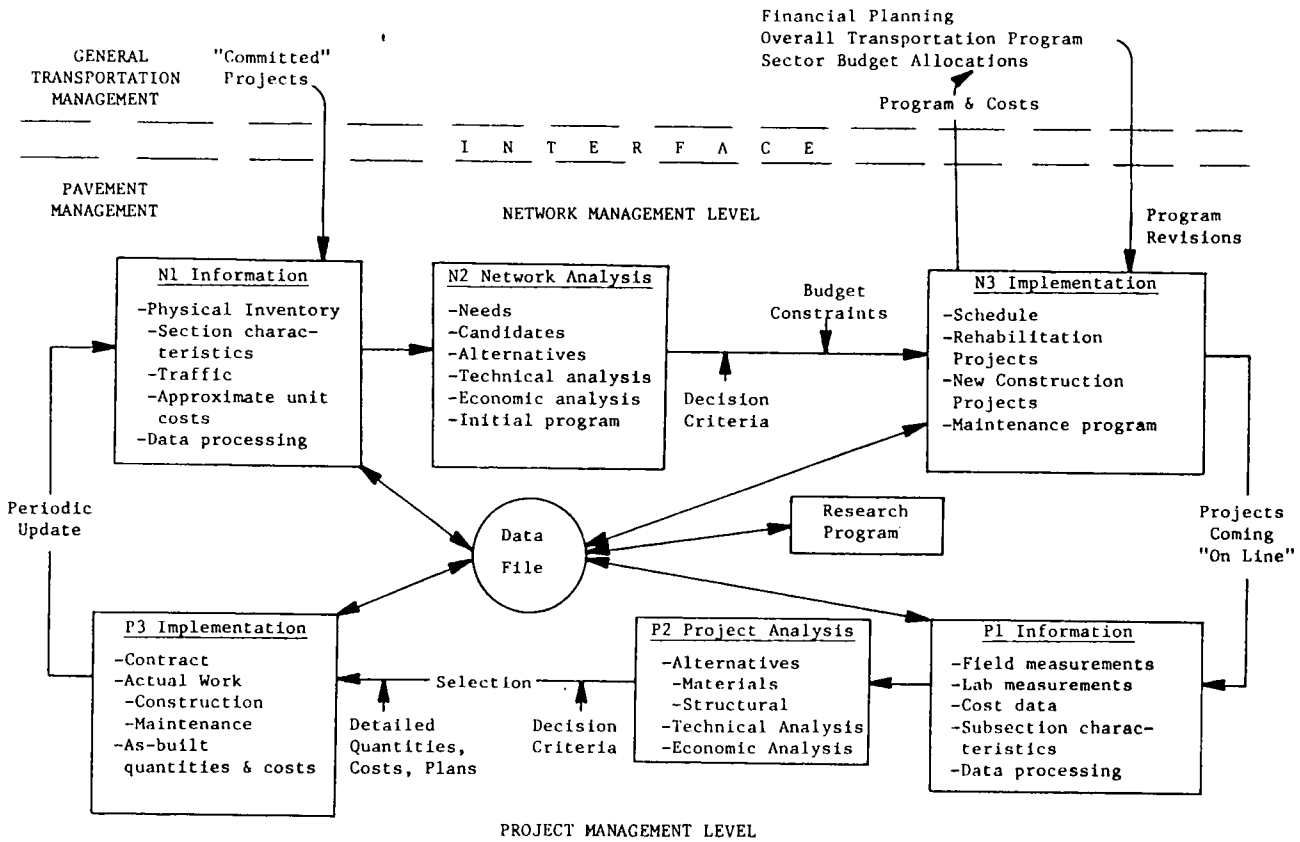

FIGURE 3 Framework and major subsystems for a total pavement management system (*16*).

though none has established the complete and comprehensive PMS described in *NCHRP Report 215* as the ideal PMS. That report summarizes the programs currently being implemented in nine states (Arizona, California, Florida, Kentucky, New York, Pennsylvania, Texas, Utah, and Washington) and two Canadian provinces (Ontario and Saskatchewan). Delegates participated in a conference in Tumwater, Washington, in November 1977 to discuss and compare their respective practices, with emphasis on pavement monitoring and decision criteria (*17*). And two conferences were held in 1980, one in Phoenix, Arizona, and one in Charlotte, North Carolina (*18*). The appendix includes a brief description of the PMS that has been implemented in California.

The PMS, though not the ultimate solution to the problem of establishing priorities for highway programs, is an analytical tool for one category of improvements that can be used as part of the process of establishing overall priorities. What the PMS does is provide a comprehensive systems approach to the evaluation of options based on decision criteria established in each state.

Pavement Condition Measurements

A report published by the FHWA in 1978 (*19*) summarizes a study conducted by the Pennsylvania DOT. The purpose of the study was to investigate current practice, select the best techniques, and recommend equipment and methodology suitable for pavement condition evaluation. Several states were visited to determine measurable properties and to gather data for management decisions. The information collected was supplemented with a literature search and a limited firsthand review of equipment in use.

Potential developments from current FHWA research programs (e.g., truck ride quality, loss of vehicle control, friction and texture investigations for predicting skid resistance at various speeds) were beyond the scope of that study. It is recommended in the report that measurements of skid resistance, roughness, structural capacity, and pavement distress (used to assist in pavement repair strategy) are needed for pavement condition evaluation. The report also provides suggestions on data processing, storage, and retrieval.

Bridge Evaluations

In a discussion of evaluation criteria used in setting priorities for the expenditure of highway funds, bridges deserve special attention. Failures can be catastrophic, with substantial loss of life, and repair or replacement is usually much more expensive and disruptive to traffic than other types of highway improvements.

The Special Bridge Replacement Program in the 1970 Federal-Aid Highway Act provided additional assistance to the states for replacing bridges at a faster rate than could have been accomplished with regular federal-aid highway funds. Standardized criteria have been established to rank bridges both on and off the federal-aid system, so the process used to identify priorities is relatively straightforward.

The national bridge inventory (*20*) identified approximately 250,000 bridges on the federal-aid systems, of which 56,700 were rated as deficient. An inventory and an assessment of condition on the remaining off-system bridges are nearing completion (*6*). It is estimated that the number of deficient bridges will more than triple (to more than 150,000 out of about 500,000) when the inventory is completed.

National statistics can hide many important details, such as the fact that the proportion of deficient bridges in some states is much greater than in others (*6*). Therefore, in addition to meeting national criteria for establishing bridge repair or replacement priorities, states that have particularly acute bridge problems may also be required to sacrifice some highway pavement projects and defer pavement rehabilitation and maintenance.

The current estimate of replacing or rehabilitating all deficient bridges in the country is $33 billion, based on the 1979 bridge replacement report (which is currently being updated) (*6*). The FY 1981 authorization for the bridge program is $1.3 billion, which is about 4 percent of total dollar needs. With the exception of Interstate completion, this ratio of program needs to program funds is higher than any other program category need, reflecting the national priority on correcting this serious problem as rapidly as possible.

NONTECHNICAL, NONQUANTIFIABLE FACTORS

Seven nonquantifiable items play a prominent role in establishing priorities (*2*):

- Political commitments.
- Legislative mandate (line-item budgeting).
- Emergency projects.
- Special emphasis programs.
- Commitments to other agencies.
- System continuity-connectivity (missing links).
- Position in pipeline (project readiness).

Several others are also important and should be added to the above list:

- Equity factors (an important part of political commitments, but worth isolating because of the need to document the rationale used by a highway agency).
- Uncertainty, including such factors as (a) periodic changes in administration at the state and national level; (b) energy uncertainties, requiring that resources be used for contingency strategies and specific programs; (c) the impact of deregulation in the passenger and freight sectors, which affects all modes of travel; and (d) the impact of unanticipated intermodal trade-offs that may be caused by energy-related problems and deregulation.
- Declining revenues caused by reduced gasoline consumption, and the lessened value of the remaining revenues because of inflation.
- Conflicts, such as that between economic growth objectives and environmental concerns.
- The impact of reducing design and maintenance standards because of shrinking financial resources.
- Public input, as obtained through public hearings and the political process.

- Local planning decisions, as may be reflected in zoning policies.

The nonquantifiable factors involved may collectively outweigh the importance of technical analysis. This is not meant to imply that the nonquantifiables make the quantifiables unimportant, but the technician must recognize that, for example, a number ranking obtained from a technical sufficiency rating is not necessarily the final one. The technician must be sensitive to the fact that the expenditure of state funds for any program is part of an overall political process that must consider a great deal of information and pressure.

Similarly, the administrator or political body (e.g., a transportation commission or board) must recognize that there are technical factors to be evaluated in deciding which highway projects to fund. The technical process allows for a systematic, objective evaluation of priorities according to preestablished criteria and assists in efficient decision making.

So a balance must be found between the technical factors, which can be quantified, and the nontechnical factors, which usually cannot. Some sort of balance exists in all states as the result of years of experience, but it may be appropriate to determine whether the scale is tilted too far in one direction to the detriment of the citizens of a state.

SUMMATION

The technical procedures being used throughout the nation provide an opportunity for quantifying some of the more important physical factors that should be considered in establishing priorities. Equally important, however, are the nonquantifiable factors that must be considered.

Technical procedures are an aid in decision making. They do not replace good judgment but simply provide a point of departure for making decisions on how available program funds are expended.

CHAPTER FOUR

PUTTING IT ALL TOGETHER

Priorities are not always established on the basis of the technical procedures alone. In fact, in many instances the results of a technical analysis have little or no impact on the final selection of projects, even when substantial resources have been used in the collection of field data.

In some states decision makers do not make full use of technical procedures. There may be many reasons for this, but two stand out. First, the technical procedures may not be considered accurate or timely enough, so they have not earned their way into the decision-making process. Second, the demand for highway projects may be so overwhelming that only those of highest urgency can be funded, and thus a technical evaluation is not really necessary.

Many states, however, do rely on extensive technical processes in making decisions concerning highway program priorities. (See the appendix for examples.) This chapter summarizes the criteria and processes that the states use to establish those priorities.

RESULTS OF AN FHWA SURVEY ON CRITERIA

The FHWA conducted a nationwide survey in 1977 to determine what criteria are used by each state, the District of Columbia, and Puerto Rico in allocating available funds within their jurisdictions (*21*). It was found that the criteria used by states in allocating funds to various areas and for various projects are, for the most part, undocumented. Of the 52 jurisdictions, only 19 states described their allocation procedures; however, the definition of each criterion was very ambiguous.

Analysis of the data from those 19 states revealed that, of the more than 80 data items in use throughout the country, 13 items account for more than 50 percent of the information used, in terms of frequency of occurrence (see Table 1).

RESULTS OF A TRB COMMITTEE SUMMARY OF CRITERIA

The TRB Committee on Transportation Programming, Planning, and Evaluation identified six categories of criteria that represent tangible as well as intangible factors relevant to transportation priority setting (*3*): needs parameters, physical criteria, fiscal criteria, impact analysis, technological suitability, and transportation performance (see Tables 2–7). The task is to determine how to use these criteria to establish the priorities.

CURRENT STATE PRACTICE—COMMON FEATURES

Figure 1 and the description in Chapter 2 of the four stages of allocating funds for highway projects provide an overview of the process that begins with the appropriation of funds by Congress and the state legislatures and ends with the allocation of funds to specific projects. This section describes the

TABLE 1
FACTORS USED IN PROJECT SELECTION (*21*)

Rank	Frequency Reported by the States	Item
1	24	Citizen and community requests
2	21	Sufficiency ratings
3	21	Fund source and availability
4	17	Economic factors
5	17	Accident ratings or rates
6	16	Continuity of routes or improvements
7	15	Environmental impact
8	15	Urban studies
9	14	Need
10	12	Social effects
11	11	Project or program cost
12	11	Traffic volume
13	10	State district engineer's recommendations

common features of the process used by most states to make the final decisions on spending money for specific projects (Stage 4 in Figure 1). Five steps are usually involved. They do not necessarily take place in the order given here, and continuing feedback occurs among all of them.

1. *Development of a list of projects for some time period, depending on the programming or budget cycle.*

A list of projects by various categories is continually being adjusted. Projects are removed from the list after they are completed or if they are dropped from consideration. Projects are added to the list for many reasons; they may be recommended by communities, district engineers, the legislature, MPOs, citizens, headquarters staff, other state agencies, etc., or they may be identified from a technical analysis, such as a sufficiency (or deficiency) rating, a PMS, HIAP, etc.

Some of the summaries in the appendix describe procedures that several states use to add projects to their lists. Sometimes the lists are part of a computerized project information system; other times they are maintained manually. In some states the district engineer develops a list of projects for a particular time period within a given budget constraint (see the appendix examples for Florida, New York, and Wisconsin); in other instances budget contraints are not explicitly considered.

2. *Review and analysis by a headquarters committee.*

Most states use a high-level committee to make the first policy decisions on the selection of projects. The committee frequently includes the commissioner or secretary in addition to the top-level managers in the agency. In some states members of the state legislature or staff members of key legislative committees are ad hoc members. Each committee has established its own criteria for making decisions, and the members sift through and combine data and analyses, political considerations, and nonquantifiable factors. This is not a scientific process, but one that relies on experience and judgment.

In those states that rely on a technical process, the influence of technical evaluations on the selection of projects is most significant for safety, maintenance, and operational improvements. Political influence typically increases at the other end of the spectrum, where new, expensive, and very visible improvements are being considered. In fact, in some states the legislature clearly establishes budgets for the big, new projects, leaving the allocation of funds on the safety, maintenance, and operational improvements to the discretion of the highway agency. This is obviously a critical point in the process of establishing priorities.

3. *Recommendations to the commissioner or secretary for a particular programming period.*

After selecting projects for a particular programming period, the committee makes its formal recommendations to the person who has the statutory responsibility for making a final decision on the program. Frequently this is a pro forma action, because the commissioner or secretary usually (though not always) participates in the selection process. The commissioner or secretary may then be required to submit formal recommendations to the political body that has the final authority.

4. *Recommendations to an appointed political body.*

Most states have a transportation or highway commission, board, or authority. This body is usually appointed by the governor and is responsible for ensuring that all parts of the state are treated equitably. Usually the body has the authority to disagree or argue with any recommendation made to it. When the overall process works properly, however, such a body seldom raises significant differences or arguments. This is especially true if the people involved in preparing the recommendations are sensitive to the fact that the establishment of highway priorities is a technical process that is part of a political process designed to serve all the people in an equitable way.

5. *Submission of recommendations to the governor and the state legislature.*

The input by the governor and the state legislature varies from state to state. In some cases it is direct, in others indirect, but in any case the roles of the governor and the state legislature are essential. They are key participants in the political process and have the formal responsibilities for recommending and approving budgets.

State legislatures' interest and involvement in the programming process appears to be growing. In some states the legislature is already playing a central role in approving individual projects, but in many states where that has not been the case, there is a trend toward involvement in project selection.

OTHER CONSIDERATIONS IN THE PROGRAMMING PROCESS

Future Federal Programming Directions

A major force in the decisions concerning program expenditures is the manner in which federal funds are allocated to the states. There is considerable discussion at the national

TABLE 2
CRITERIA BASED ON USER AND SOCIETAL NEEDS (*3*)

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

TABLE 3
CRITERIA THAT EMPHASIZE PHYSICAL CHARACTERISTICS OF A FACILITY (*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

TABLE 4
FISCAL CRITERIA (INCLUDING COSTS AND ECONOMIC BENEFITS) OF AN IMPROVEMENT (*3*)

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	5. Surplus/Deficit
7. Benefits		

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.

TABLE 5
IMPACT CRITERIA TO MEASURE EFFECTS OF A TRANSPORTATION IMPROVEMENT ON THE COMMUNITY AND ON THE NATURAL ENVIRONMENT (*3*)

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

TABLE 6
TECHNOLOGICAL SUITABILITY CRITERIA TO MEASURE RISK, FLEXIBILITY, AND DEPENDABILITY OF AN IMPROVEMENT (*3*)

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.

TABLE 7
PERFORMANCE CRITERIA TO MEASURE THE EFFICIENCY AND EFFECTIVENESS OF A TRANSPORTATION IMPROVEMENT (*3*)

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.

level concerning future federal directions. Included in those discussions are the following issues:

- Completion or termination of the Interstate program.
- Use of federal funds for maintenance.
- Substantial reduction in the number of categorical grants.
- Budget reductions for capital programs.
- Increased motor fuel and other user taxes.
- Increased gasoline and diesel costs, leading to further reductions in travel and thereby reducing the demand for some highway services and reducing user revenues.
- More reliance on state and local revenues for urban public transit, thereby increasing the pressure on state and local budgets even more severely.

Other issues that emerge could significantly alter the information contained in this synthesis.

In states where modal trust funds or specific modal funding sources do not exist, such as Maryland and New York, the total programming problem must be evaluated comprehensively. Even in those states that have modal trust funds, however, there is increasing pressure to use general funds to maintain minimum funding levels for highway programs. Consequently, numerous trade-offs must be made on a continuing basis.

SUMMATION

Frequently there is relatively little discretion in how funds are allocated. Previous commitments, legislative mandates, formula allocations, the desire to match federal funds, emergency situations, and overwhelming maintenance needs use up all or most of the available funds. In addition, a growing number of states simply do not have adequate resources to deal with more than the minimum requirements—finishing partially completed projects and handling emergencies and routine maintenance.

In the final analysis, many of the decisions, on the large projects especially, are based on political influence, which covers a broad spectrum. At one end of the spectrum is a political decision based on all the best principles of the democratic process, where all interests are fairly heard and the decision that is made will benefit the most people. At the other end of the spectrum is politics at its worst, where decisions are motivated by the objectives of personal gain. Unfortunately, the general public often associates politics with corruption because of the publicized misconduct of a few elected officials.

The truth lies somewhere between those two extremes, but much closer to the first. However, the political decision-making process suffers from a problem of credibility. Even though the number of transportation decisions that are politically motivated in the worst sense is relatively small, it is difficult to overcome the general public's negative perception. One way to overcome it is for state transportation agencies to provide continuing information to the public on the extensive analyses that are undertaken and to clearly describe and illustrate the criteria and the constraints that are built into the decision-making process. This will help promote understanding, and it will educate citizens as well as elected officials about the complexities of making program decisions.

CHAPTER FIVE

CONCLUSIONS

The demand for highway improvements is increasing much more rapidly than funds are becoming available. Consequently, all jurisdictions in a state feel cheated; they feel they are not getting their fair share of the funds available for highway programs. One state programmer said that perhaps the best that could be hoped for is that everyone would feel equally cheated.

The current era is one of tight federal and state budgets, as has been noted in nearly every report on this subject for the past decade. However, the past several years have been characterized by continuous high increases in costs that state transportation revenues have not matched, making recent problems particularly acute.

Inadequate funds have always been and no doubt will always be a fact of life. For highway programming purposes the challenge is to establish and execute a systematic process that will result in the equitable distribution of available funds, limited though they may be, in providing reasonably efficient highway facilities in the most cost-effective manner possible, while at the same time providing sufficient information on the consequences of various program alternatives.

This state-of-the-art synthesis describes how the states are deciding on methods of allocating available resources to projects and programs. Several case studies are included in the appendix, and some common features are summarized in Chapter 4.

In making decisions on programming projects, four factors should be taken into account: strategic planning, technical factors, intangible factors, and political factors. The conclusions drawn from the information gathered in the preparation of this synthesis are summarized below according to those four factors.

STRATEGIC PLANNING

The term *strategic planning*, as used here, refers to a state agency's need to organize and implement a systematic management and technical process for making decisions that will lead to the wisest expenditure of limited funds for highway projects. An agency needs to take full advantage of the most current information (which might include highway classification and inventory information; road and bridge structural, safety, and service conditions; and the like) and of analyses and forecasts of highway conditions and revenues in order to answer the questions posed by the governor, the legislature, and citizens concerning how funds will be spent.

The federal government and each state spend a substantial amount of money each year in gathering and analyzing data, forecasting future traffic, etc., as part of the statewide highway planning process and the urban transportation planning process (the "3C" process). A significant gap still exists, however, between the use of the results of the planning process and the decisions on how funds are spent on highway programs. This is the right time for the federal government and the states to reexamine the planning process as currently designed to see how it can be made more relevant to the issues of the 1980s. State managers must develop a clearly defined game plan that identifies what they wish to accomplish and how all available resources can be used to achieve those goals.

TECHNICAL FACTORS

Several states make substantial use of data and technical procedures to assist in the selection of priorities. Some of these procedures are described in Chapter 3 and detailed in the appendix. Even in those states, however, the technical process provides only a point of departure for decision making and does not necessarily determine the final ranking of projects. Most state representatives interviewed stated quite candidly that a great deal of discretion and good judgment is combined with the technical data.

Other states collect and analyze data in the traditional way, but the technical procedures have little or no impact on final decisions—for four reasons:

- Technicians may have been too rigid in their interpretation of data and may have relied almost exclusively on technical results. The decisions based on these data may be viewed by the public and elected officials as wrong. This causes technical procedures to lose credibility; they must then earn their way back into the decision-making process.
- Technical procedures often take so long to apply that decisions on the expenditure of funds must be made without the benefit ot those procedures.
- Safety and maintenance projects may be so urgently needed that a technical evaluation is superfluous when funding is limited.
- Formulas, models, and data are often misunderstood and consequently mistrusted by nontechnical people.

It would be shortsighted to dismiss the use of a well-thought-out technical evaluation process. Those states that have traditionally used and still use technical procedures consider them an important part of the process. Those states that do not have much confidence in a technical process might find it worthwhile to reevaluate the way they are imple-

menting plans and adjust that program to better fit the needs of the state.

A well-defined technical procedure is also generally considered essential for identifying and ranking safety and operational improvements (which might provide legal protection for the highway agency and individuals therein if a charge of malfeasance is made because of a highway accident).

INTANGIBLE FACTORS

Chapter 3 summarizes 14 nonquantifiable, or intangible, factors that are an important part of the decision-making process. Decisions on specific projects are not always based solely on a technical evaluation but incorporate good judgment that takes advantage of sound analysis. In fact, in large, new projects, the intangible factors become more important than the technical factors, and such intangibles are often the determining factor. Because there is often little flexibility in how available funds are used (due to previous commitments, legislative mandates, formula allocations, the desire to match all federal funds, emergency situations, and overwhelming maintenance needs), the intangibles weigh heavily in the final decisions.

POLITICAL FACTORS

Elected officials provide the funds for highway programs, so they should be involved in deciding what projects to fund. Their degree of involvement varies widely from state to state, from the approval of line-item budgets to the appropriation of a total budget. There appears to be a trend for legislatures to want more involvement in the approval of individual project funding, especially in states where the executive branch has requested, or soon will request, additional tax revenues for highway purposes.

Most state transportation managers recognize that the process of establishing highway priorities is part of a political decision-making process (although not all technical professional staff do) and therefore are sensitive to the need for considering political factors. Political factors are more influential in large, new projects than they are in safety, operational, and maintenance projects, where the concern is with making sure that funds are distributed equitably throughout the state.

State legislators may become increasingly involved if the federal government reduces the amount of funding for state and local programs and if block grants are established for transportation programs. Those federal policies will result in the need for additional state funds if the same levels of funding are to be maintained for the programs curtailed by the federal government.

The important role of local, elected officials (representatives of cities, towns, counties, and special-purpose districts or authorities) cannot be overlooked. Typically, they get involved by (a) making recommendations for state-funded and federally funded projects; (b) participating in the establishment of priorities for urban highway and transit projects as members of an MPO; (c) participating in the cost of the design, construction, and operation of urban systems projects; (d) influencing the governor and members of the state legislature to implement their high-priority projects; and (e) constructing complementary highway and transit projects using funds raised through local bond issues.

CONCLUDING REMARKS

Many of the persons contacted during the preparation of this synthesis indicated that the current atmosphere of crisis programming is due to the backlog of essential highway projects that cannot be funded. Whether or not this is true, a well-thought-out decision-making process is needed to ensure that the most reasonable decisions possible are made.

There is not one "right way" or one set of criteria that will provide everything one needs to make the best decisions. If there is a single goal to be defined, it might be the need to provide safe highway facilities in an equitable manner within the tight budget constraints that exist. This will be the challenge of the 1980s, and it may call for a significant change in the way decisions are made.

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APPENDIX

EXAMPLES OF STATE PRACTICE

This appendix summarizes the procedures used by California, Florida, Illinois, Iowa, Minnesota, New Jersey, New York, Utah, Vermont, Washington, and Wisconsin in establishing highway priorities. Several of the examples also illustrate the practical application of such procedures as sufficiency ratings, pavement serviceability indexes, HIAP, and pavement management systems. The summaries reflect the official views of the states as documented in the references noted.

CALIFORNIA

The Process Used

The California Department of Transportation (Caltrans) deals with three basic categories of highway improvements: (a) maintenance and rehabilitation, (b) operational improvements to existing highway facilities (including safety), and (c) new construction (to increase capacity). Program priorities are established among those three categories on a policy-level basis, and then priorities are set within each category using a benefit/cost approach. The three categories are further divided into the following 15 components, and evaluation criteria are established for each.

1. Maintenance of land, building, and facilities.
2. Safety roadside rest areas.
3. Safety roadside rest restoration.
4. Highway planting.
5. Highway planting restoration.
6. Vista points and roadside enhancement.
7. Noise attenuation.
8. Resurfacing.
9. Roadway reconstruction and restoration.
10. Protective betterments.
11. Bridge reconstruction.
12. Safety improvements.
13. New highway construction.
14. System operation improvements.
15. New bicycle facilities.

The techniques for rating projects within each of the 15 components varies, but the general approach is to compute a score or numerical rating by multiplying the intensity-of-impact variable (such as highway user time savings or decibels of noise reduction) by the breadth-of-impact variable (such as vehicle-miles or affected housing units) and then dividing by cost to reflect relative priority based on cost-effectiveness considerations. All projects are then assigned

either a ratio or an index number, which serves as the criterion by which projects are ranked to determine the formula priority (*22*).

A key step in the establishment of priorities is the decision made on the allocation of funds to the three major elements of maintenance and rehabilitation, operational improvements, and new construction. The California Transportation Commission, which is appointed by the governor, has the final authority on the determination of those allocations. Its decisions are based on the analysis and recommendations made by the Caltrans staff, but it has the authority to alter those recommendations.

Although the ranking of projects is relatively straightforward, the final selection of projects is not based only on the formula priorities. Other considerations include financial constraints, legal constraints, scheduling difficulties, and political considerations.

For some projects criteria cannot be developed in accordance with the rating procedure described above. These include (a) certain projects that are legislatively mandated; (b) some projects that are nearing completion and must be funded; (c) projects that cannot be easily quantified or that would require excessive data, time, or expense to analyze; and (d) projects given a high priority for policy reasons, such as safety or emergencies.

The formula priorities provide an important input to the decision-making process. Even for projects that are rated, not all technical or cost considerations are always covered by the variables in the rating formula, which means exceptions must be made to the formula ranking. Because of these exceptions, and because of the other constraints discussed above, not all projects selected for implementation match the priorities established by the formula.

Pavement Management System

Caltrans has developed and implemented a PMS for establishing priorities for the resurfacing and the roadway reconstruction and restoration components of the highway program (*23–25*). The Caltrans PMS emphasizes an engineering approach to pavement rehabilitation and a structural systems approach for the management of existing pavements. The PMS is a straightforward method that brings together the following processes: (a) taking inventory of existing pavement conditions, (b) analyzing the extent and severity of pavement conditions, (c) identifying appropriate repair strategies, (d) identifying cost-effective strategies and reasonable alternatives for candidate projects, (e) relating the repair strategies to the appropriate Caltrans highway program structures, and (f) organizing candidate projects for each Caltrans highway program component within each transportation district on a statewide basis and for other regional groupings.

Incorporating these six elements in a structured systems approach enables program levels and trends for rehabilitation to be quantified and justified. The PMS assists in programming and scheduling improvements according to departmental rehabilitation policies and promotes a more consistent level of pavement performance statewide. It has the flexibility to respond to program-level constraints and level-of-service decisions without altering basic engineering logic. The following factors are emphasized in the implementation of the PMS:

- The majority of the work identified falls in the rehabilitation area. The PMS in California is *not* a management system for maintenance.
- The PMS is aimed at making more effective use of available resources through an informed and improved decision process. It is *not* a design system; design is the function of the engineering staff.
- Caltrans rejects many pavement rating systems, including sufficiency ratings, sums of defects, and serviceability ratings, in the belief that they are relatively useless. It is felt that they all have the "apple-and-orange" problem and, at best, are limited to indicating crudely that a pavement needs attention. What is stressed in the California PMS is a determination, on a sound engineering basis, of the appropriate repair, which can be determined only by assessing the pavement conditions, their extent, and their severity.
- Caltrans believes that, at the present time and on the basis of available information, it is unrealistic and impractical to try to predict, on a long-range basis, future dates and modes of failure and the appropriate type of repair. Some pavement management systems that Caltrans has investigated indicate rehabilitation strategies that will be appropriate 15, 20, or 30 yr in the future. It is felt that this is too academic and theoretical and that it is much more realistic to inventory pavement conditions at reasonable intervals to identify real problems and reasonable solutions, allowing sufficient lead time to program repairs.
- California has more than 12,000 individual interchange ramps, collector roads, and the like, that are not on the highway traveled way but still require continuing rehabilitation. Indications are that these facilities are exhibiting even more problems than the highway traveled way. After reviewing the special problems of these facilities, Caltrans concluded that it would be unduly complicated and impractical to incorporate ramps and collector roads in the PMS, so Caltrans addresses them in a separate PMS.

Extensive computerized systems have been developed for all major PMS components. A key to the PMS is a limited series of user reports specifically tailored for each user's needs in the transportation districts and in the Caltrans headquarters.

FLORIDA

The Florida DOT multiyear work program (*26*) is a financial planning document developed through a procedure prescribed by state statute. Before the program can be implemented, the state legislature must appropriate funds estimated to be available for implementing the work program in the next biennium at the same time the Florida DOT is implementing its work program.

Available program funding is allocated by category and year to the six districts. Allocation is primarily by formula but also by need and at the discretion of the secretary. Allocations, in the form of a schedule that accompanies the programming instructions, are made to ensure that resources are

distributed equitably statewide and are turned into transportation service as quickly as possible. In addition, because of the requirement that the district programs be balanced with the allocations, the size of the state's overall program is controlled and the efficient use of resources is ensured.

Florida uses three formulas for distributing funds to the districts: one for urban funds, one for rural funds, and one for funds that are not exclusively for urban or rural areas. The urban formula is the ratio of the population of urban areas over 5,000 in the district to that in the state:

$$D_{u,d} = \frac{P_{u,d}}{P_{u,s}}$$

where

$D_{u,d}$ = distribution factor for urban funding categories
P_u = population of urban areas over 5,000
d = subscript denoting a district
s = subscript denoting state

For rural areas the formula is:

$$D_{r,d} = 0.6(N_d/N_s) + 0.2(C_d/C_s) + 0.1(P_d/P_s) + 0.1(L_d/L_s)$$

where

$D_{r,d}$ = distribution factor for rural funding categories
N = immediate future highway construction needs on the state highway system, as reported in the latest "Highway and Construction Needs Program"
C = projected motor fuel sales
P = resident population
L = lane mileage
d = subscript denoting a district
s = subscript denoting state

The third formula is the average of the two distributions for each district, as determined by the first two formulas.

The allocation of Section 18 (of the Surface Transportation Assistance Act of 1978) funds for rural public transportation is based on the ratio of the nonurbanized area population in the district to that in the state.

The districts select projects for each 25 program categories using the priority lists as a starting point and given the program allocations and instructions. The instructions include (a) requirements for describing the projects and for designating their funding, (b) procedures for phasing the projects for scheduling and control purposes, and (c) project eligibility requirements. Similar information is included for the public transportation (transit, rail, and aviation) program categories.

The districts hold public hearings on their tentative work programs, notices for which are published 10 days in advance in at least one daily newspaper of general circulation in the district. The notice includes the date, time, place, and purpose of the hearing, as well as a summary of any action to be taken by the department at the hearing and the address of the place to write to for a copy of the agenda.

The central office reviews each district's program to see that proposed projects are balanced within the range provided in the program allocations to each district and that the department's policies and objectives are being addressed. The Office of Programming and Budget provides notice of and holds a statewide public hearing on the multiyear work program. The secretary adopts the program following the public hearing.

ILLINOIS

Highway projects in Illinois are classified by type, and the set of criteria used to evaluate them and set priorities depends on the classification, although the IDOT relies on careful engineering judgment to assess the condition of its highways (*27, 28*). The basic criteria, by project type, are listed below.

1. Roadway resurfacing: ADT, surface condition, and highway functional classification criteria are used.
2. Minor roadway widening and resurfacing, leaving same number of lanes: In rural areas, criteria are the same as those used for roadway resurfacing, plus surface and roadway width; in urban areas, judgment is used to evaluate cost-effective improvements.
3. Major roadway widening and resurfacing, with a maximum of two additional lanes provided: Specific criteria are directly related to the costs and benefits of the project.
4. Existing roadway reconstruction: Criteria depend on the specific type of project being considered.
5. New road construction because of problems associated with current facility or because of emerging needs in another site: Criteria depend on the proposed project.
6. Traffic improvement: Criteria focus on the project's contribution to the better use of the existing transportation facilities.
7. Safety improvements: Criteria are based on accident information and past location studies.
8. Structure geometric improvement: In rural areas criteria are based on type of highway, operating rating, general condition, ADT, and width. In urban areas, judgment is combined with the criteria used in rural areas.
9. Structure rehabilitation or replacement: Same criteria used as in item 8 above.

A multiyear highway program is updated annually to respond to the specific program parameters identified by the IDOT. The parameters define the limits of addressing each mix of system deficiencies and alternative solutions within anticipated financial constraints. The program attempts to provide a minimum basic level of transportation service statewide, addressing the most critical situations first. It is a flexible package: it can be altered to reflect changes in project priorities and public concern, and it is designed to allow for continual reevaluation.

The most recent multiyear highway program addresses needed highway improvements over the FY 1980–84 period at an assumed level of funding. The service package identifies the following priorities:

- To preserve and maintain an adequate surface condition on state highways.
- To replace or rehabilitate critically deficient bridges.
- To reduce the number of accidents at high-accident locations.
- To complete the Interstate System.

- To widen narrow pavements where traffic volumes and driving conditions dictate.
- To improve urban intersections and traffic bottlenecks.
- To construct or reconstruct major facilities where there is a demonstrated need.

Although the approved project list contained in each year's program by no means represents commitment by the department to improve certain highways prior to the end of FY 1984, it does represent the department's best estimate of an attainable short-range highway program within the funding constraint assumptions built into the decision-making process. The multiyear programs must be updated annually to reflect changes in departmental priorities, annual program accomplishments, and external variables.

The category mixes outlined in each program serve as the framework for investment decisions; they are intended to show how program direction will affect accomplishments in other categories through the trade-off process. They are not meant to be seen as prescribing the only directions the multiyear program can take, nor are they intended to prevent district offices from offering specific improvement proposals that could compete with projects in other categories. They provide an opportunity for choosing the direction of multiyear programming so that project criteria can be developed within categories to provide intelligent guidance for district project evaluation.

IOWA (29–31)

The Iowa DOT owns and operates 10,500 miles (17 000 km) of the 113,000-mile (180 000-km) public road and street system. Of that total, 1,200 miles (1900 km) are within cities and towns. The state's system serves 70 percent of all intercity travel and 60 percent of the total public road travel.

The primary road system was placed under complete state jurisdiction in 1927, when the highway agency was established. The legislative mandate was to improve the primary system in such a way as to equalize the service level on a statewide basis. In 1959 the legislature (a) directed the highway department to prepare and publish a long-range program (at least 5 yr), (b) reinforced the equalization policy by requiring that a sufficiency rating system be developed and published annually as the basis for priority programming, and (c) required the separate publishing of an annual program showing work to be accomplished in the forthcoming year.

The Iowa DOT, formed in 1974, subsequently became responsible for the highway program mandates as well as for other modal programs. Within the department, the Planning and Research Division has the primary responsibility for programming.

Since 1959, 22 5-yr programs have been prepared and published, and more than $2 billion in highway improvements have been systematically processed. Neither the 1927 nor the 1959 legislation has been altered in any way by the legislature. The policy that guides highway programming is the annually reviewed Iowa Transportation Policy Statement. Within the policy the Iowa DOT pledges to:

1. Promote a transportation system that satisfies user needs and maximizes economic and social benefits for Iowa's citizens;
2. Provide for a participatory planning process that involves public, private, and citizen interest and that encourages complementary transportation and land development patterns;
3. Encourage and support programs that provide commodity movement and mobility for all citizens;
4. Develop and promote equitable policies and procedures for the registration and regulation of motor vehicles and common carriers of passengers and freight; and
5. Promote equitable financing of the transportation system through user and nonuser sources.

The policy includes the statement that the department will "encourage and assist in the general development, preservation, and efficient use of highway transportation through improvement programs to equalize functional adequacy to roads and streets throughout Iowa." That statement embodies the legislative directions of 1927 and 1959, particularly item 2 in the list above.

As a basis for transportation programming, the department develops and maintains a State Transportation Plan as well as modal elements related to airports, waterways, highways, transit, and railroads. The data base and the planning history of highways are the most complete and have formed the basis for detailed planning in other modes. Traditional highway needs studies have been made over the years, and it is now required by state legislation that they be updated every 4 yr. Detailed bridge condition studies, most recently augmented by the federal structural inventory and appraisal process, provide the needed programming basis for that highway element. Currently under development is pavement performance information based on more than 50 yr of experience for portland cement concrete and 25 yr for asphalt concrete. The current area of concern is the 3,000 miles (4800 km) of pavement that is more than 40 yr old; these pavements are nearing the end of their expected service life and will dominate the programming process over the next decade. The pervasive problem of bridge deterioration must also be faced in the next decade.

A program of proposed expenditures to be made over a period of years is no more reliable than the underlying financial assumptions, although a program listing future transportation improvements can be published regardless of the predictability of future finances. A program should seek to answer several questions of interest to individuals and corporations: Where are the proposed improvements to be located? What types of improvements are proposed? Why are they proposed (sufficiency rating, traffic, etc.)? How much will they cost? When are they scheduled? This last question, to many the most important, is also the most difficult to predict consistently because of the vagaries of finance. The foundation of a program is the projection of expected income, coupled with the incorporation of a cost index factor that is neither too high nor too low. From this perspective the act of programming is more an art than a science.

At present, curtailed fuel use, double-digit cost increases,

and the freezing of federal funds guarantee problems. Iowa's current program is based on a very modest income growth (no growth of federal funds) and an inflation rate equivalent to 14 percent compounded. This is perhaps the most severe fiscal constraint employed to date; it will be modified by experience as programs are developed.

Iowa DOT program development has high public exposure and participation. Final program decisions are made by the seven-member transportation commission, whose members are appointed by the governor to 4-yr terms and approved by the state senate. The program follows an annual cycle and is published each December.

The programming office staff begins the process early in the year by assembling the most recent data and processing them through a series of internal meetings. The first of these is with the six district engineers and their staffs, who provide input on the most urgent needs in their areas. A new financial projection is obtained, and early discussion drafts of the work to be done the following year and over the next 5 yr are prepared. Preliminary reports concerning income experience and contract letting experience are provided to the commissioners. Future financial assumptions and the cost index factor are also reviewed and decided on. The "Accomplishment Program" is approved in May in advance of the fiscal year (July 1–June 30) and becomes the current work program for the Highway Division. The 5-yr draft is then taken to a series of public review meetings established for the 10 citizen advisory councils, which function in several regions of the state. The financial basis of the program draft is presented, and the draft is distributed for review and discussion. These meetings are well attended and draw considerable press coverage.

Following these meetings, normally held in May or June, a report is presented to the transportation commissioners to supply them with programming background information. Often, particularly when the program must be reduced to obtain fiscal integrity, individuals and groups will exercise their right to attend one of the commission's biweekly meetings to express concern over the implications of particular items in the draft program. As part of the commission's public participation process, meetings and inspection trips to various parts of the state are regularly scheduled.

The process becomes more intensive in August, when an updated fiscal projection and revised program draft is presented for review. The commission includes the programming process on its regular agenda through September, October, and November, continually refining subsequent drafts and making the often difficult decisions related to using limited resources. The process is completed in December with publication of the revised document.

The basic procedure used in the selection of highway improvements is the sufficiency rating process. The Iowa program, as programs in most states, has been changing in recent years from a program of large-scale highway improvements involving reconstruction to one predominantly concerned with system preservation. In the mid-1960s more than 200 miles (320 km) of the primary system was being improved each year. Through gradual loss of buying power, that performance has now been reduced to 50 miles (80 km) per year and is projected to be reduced to about 10 miles (16 km) per year in 1985. A realistic expectation of pavement and bridge life is that a 60-yr replacement cycle is required to continue the system in the long term. Thus, Iowa's 10,000 miles (16 000 km) requires improvement at the rate of 162 miles (260 km) per year. Considerable progress has been made toward the long-term objective of equalizing service on the state highway system based on analysis of current rural sufficiency ratings. The current program focus (to the extent improvements can be funded) is the east central and southeast portions of the state, which are now the areas most out of balance with the rest of the state.

In sum, the highway programming process in Iowa is highly visible and provides many opportunities for public participation. The transportation commission has attempted to be faithful to the directives of the legislature, as reflected in its policy statement. The principal long-term objective is to allocate resources in such a way as to achieve equity of service throughout the state. To that end, the legislature has not constrained the transportation commission by imposing regional allocation formulas or other strictures. Public participation has proven very beneficial, particularly in recent years, when financial constraints have caused severe program reductions. Specific suggestions received from the public have aided the commission in allocating its limited resources.

MINNESOTA

The Minnesota DOT develops its highway program in recognition of the fact that evaluation criteria frequently are difficult to define, that they cannot be easily quantified, and that many decisions must be made in qualitative terms (*32*). Essential considerations include the following: statewide priorities, local and regional priorities, project interdependencies, degree of project readiness, project acceptance (local and environmental concerns), and fair share allocation (geographical).

Regarding statewide priorities, objectives are to (a) maximize and use fully all available federal transportation funds; (b) complete the Interstate System or withdraw Interstate segments and substitute adequate projects; (c) give high priority to highway projects that include special provision for high-occupancy-vehicle lanes or other preferential treatments; (d) emphasize modernization and preventive maintenance of highways over new construction; (e) focus on projects that reduce maintenance costs; and (f) reevaluate proposals for significant highway expansion in consideration of more modest, but safe and efficient, alternatives.

The state DOT recognizes that programs must be developed in light of the constraints imposed by financial resources, human resources, and legal and legislative requirements. The DOT has established a project classification scheme that distinguishes among the various types of highway projects that can be implemented, and the department has also developed technical criteria to assist in project selection within each class of project. The current criteria, used to assist in selecting projects for the 1982–87 program, are listed below.

Project Class	*Technical Criteria and Weight*
Resurfacing and reconditioning	Condition rating (70%) Cost-effectiveness (20%) Functional class (10%)
Reconstruction and new major construction	Sufficiency rating (35%) Cost-effectiveness (20%) Goods movement (20%) Peak-month traffic (5%) Functional class (20%)
Bridge replacement	Structural adequacy and safety (50%) Serviceability (functional obsolescence) (25%) Essentiality for public use (25%)
Interstate	No fixed priority-ranking, criteria-based process; resources directed toward system preservation, gap or stage completion, and overall completion.
Safety	
(A) High-hazard roadside obstacles	Accident analysis (benefits in terms of reducing the number and/or severity of accidents)
(B) Traffic and capacity	ADT, volume/capacity, accident elimination rating
Bridge repair	Bridge inspection and analysis
Trunk highway, urban (Federal Aid, Urban)	Projects evaluated by appropriate construction-type criteria and procedures (any of the above except Interstate).

These technical criteria are used only to *assist* in project selection; other factors, enumerated earlier, are frequently of equal or greater importance in final project selection. Table A-1 summarizes the criteria used in developing Minnesota's highway program for the period 1982–87.

NEW JERSEY (33)

The New Jersey DOT was faced with the problem of deciding how to select projects for two specially funded programs in 1979: (a) the Transpac program, which provided $600 million for public transit projects generated by $120 million in revenues from the Port Authority of New York and New Jersey, and (b) the Transportation Bond Issue, which provided state funds of $325 million for highways and $150 million for public transit, producing a 4-yr capital program anticipated to be $1.7 billion ($886 million for state highways and $863 million for transit). These programs were supplementary.

The criteria used for highway project selection were rather straightforward. The selection process was relatively subjective and had the following goals:

1. Exclude Interstate projects that would be funded from annual state appropriations.
2. Consider only phases scheduled for contract within 4 yr.
3. Provide an equitable distribution of projects in terms of geography, jurisdiction, and function.
4. Develop priority selection in the following order: (a) correcting structural deficiencies on bridges and roadways, (b) correcting hazardous conditions, and (c) increasing capacity on those sections of highway with the greatest level of congestion.
5. Maintain consistency with federal funding categories to maximize federal participation and eliminate or substantially reduce federal balances resulting from years of underfunding the state matching funds.
6. Complete critical freeway gaps to provide a substantial increase in system efficiency.
7. Eliminate projects that will adversely affect existing or proposed public transportation facilities.
8. Give added weight to projects that will revitalize the older, urban core cities.

The Transpac selection method used for transit projects in both programs was more complex. To evaluate and rank projects that represented years of planning without a predictable funding source, an evaluation process was developed based on short-range improvement policies established by the DOT. The procedure, prepared within a severe time constraint, considered a wide scope of projects, each of which had varying degrees of available data. Because a comparison of projects on a strict data basis was therefore often impossible, projects, to be considered, had to (a) preserve and maintain (as justified) service, equipment, and facilities of the existing bus and rail systems (as opposed to establishing new service); (b) provide the greatest immediate real benefit at the most reasonable cost; and (c) be capable of implementation in the shortest period of time within budgetary constraints. The implementation time frame for the Transpac program was 1979–85.

The projects were then arrayed according to the following priority groups:

1. Projects required for the continuance of essential services at current levels.
2. Projects required for the completion of capital improvement efforts that had been initiated.
3. Low-cost, user-oriented projects.
4. Low-cost, operations-oriented projects.
5. Moderate-cost projects of significant benefit.
6. High-cost projects of significant benefit.

Projects being evaluated were assigned their respective priority categories based on their nature. For example, rehabilitation of deteriorating stations is a Priority 1 project. The absolute need for Priority 1 and Priority 2 projects eliminated the need for further ranking within those categories. Each project was proposed for funding.

For Priorities 3–6, projects were further ranked numerically within each priority category based on costs, benefits, consistency with short-range improvement policies, availability of funds from other sources, maturity of project development, and, in the case of Priorities 5 and 6, furtherance of long-range policy goals. The long-range goals were to stim-

TABLE A-1 CRITERIA USED TO DEVELOP MINNESOTA'S HIGHWAY PROGRAM FOR 1982–1987

1982-87 HIGHWAY WORK PROPOSAL
PROJECT SELECTION

PROGRAM	CRITERIA, CONSIDERATIONS & CONSTRAINTS* TECHNICAL CRITERIA (Weight)	MEASURE	CONSIDERATIONS
Resurfacing & Reconditioning	Condition Rating (70%)	Same	Statewide, District & Regional and Local priorities; project interdependencies; system condition coordination with other modes & field reviews.
	Cost Effectiveness (20%)	ADT X projected increase in Condition Rating / $1,000's/MI	
	Functional Class (10%)	Same	
Reconstruction & New/Major Construction	Sufficiency Rating (35%)	Same	Same as above plus system continuity, special funding, and geographic/work load.
	Cost Effectiveness (20%)	20 Year ADT X projected Increase in Suff. Rating / $1,000's/MI	
	Goods Movement (20%)	20 Year HCADT X projected increase in pavement strength	
	Peak Month Traffic (5%)	(Pk. Mo. ADT - AADT) / AADT	
	Functional Class (20%)	Same	
Bridge Replacement	Structural Adequacy and Safety (50%) Serviceability Functional Obsolescense (25%) Essentiality for Public Use (25%)	Replacement Priority Calculation (includes safe load appraisal, geometry, waterway adequacy, ADT, functional classification, etc.)	Same as above
Interstate	No fixed priority ranking criteria based process. Resources directed toward System Preservation, gap or stage completion and overall completion.	N/A	Degree of project readiness, timely completion of system (P.S.&E. as of September, 1986); project acceptance (local and environmental concerns).
Safety: A) High Hazard Roadside Obstacles	Accident analysis (benefits in terms of reducing the number and/or severity of accidents).	Benefit/Cost Ratio	Statewide, District, Regional and Local priorities; project interdependencies; degree of project readiness; and coordination with other modes.
B) Traffic & Capacity	ADT, volume/capacity, Accident Elimination Rating (R)	Priority Rating System = $\left[20\left\{\left[.568+10(v/c)\right] + (\text{Log ADT})^{1/2}\right\} + R\right] \frac{5}{\text{Log (Cost)}}$	
Bridge Repair	Bridge inspection and analysis	Bridge improvement and painting guidelines	Emergency conditions (e.g., scouring at peers, replacement of rails, embankment protection)
Trunk Highway Urban (FAU)	Projects evaluated by appropriate construction-type criteria and procedures. (Any of the above except Interstate.)	N/A	Metropolitan Planning Organizations and local priorities with District and State acceptance; project interdependencies; degree of project readiness. Funding other than State matching.

* Constraints in all programs are financial resources; legal and legislative requirements and manpower availability.

ulate urban center redevelopment; effect major auto diversions and reduce adverse environmental impact; assist the mobility of transit dependents; encourage and support efficient land use; reduce travel time and cost; and increase safety, convenience, and comfort.

It was recognized that top-priority projects from groups 3–6 might later take precedence over lower-priority projects in higher categories, especially where the lack of a project's development precluded its fair evaluation in relation to other priority categories. The final step, therefore, was to eliminate from consideration those projects that were in need of substantial development or were of marginal benefit and to consider borderline projects from different priority groups to arrive at a final overall ranking of projects. Based on this process, a list was submitted for public and official comment. The final list for Transpac and the list of bond proposals grew out of these lists, as adjusted on the basis of public comments regarding funding levels and timing.

NEW YORK

One of the New York State DOT's key functions is identifying its capital program objectives and using these objectives to establish the allocation and use of resources among modes and geographical areas and within categorical funding constraints. This is done from an overall program perspective and also from a specific project analysis approach. These activities interact to produce the best program mix for each region and program objective (*34, 35*).

Program Development and Evaluation

The primary involvement is in resource planning, capital budget development, and capital resource allocation. Resource planning consists of working with state and federal legislative proposals and regulations in an effort to understand and forecast available resources, program objectives, and program constraints. This includes 100-percent-state programs, regular federal-aid programs, Interstate 3-R programs, and so on. Capital budget development is represented by the annual work on the state capital budget justifications, for both the amount and type of capital resources necessary to meet transportation needs. Capital resource allocation involves continual analysis and updating of the 5-yr forecast of needs. These allocations are based on formulas that attempt to distribute available resources equitably among the regions. The formulas, which are based on some combination of population, transportation needs, and highway miles, also may require annual adjustment.

The resource cycle continues throughout the year and involves estimating needs, making budget requests to meet those needs, and allocating federal and state resources to the regions to meet the needs.

Project Selection

The connection between program development and project selection is a consequence of the resource allocation to the regions. Regional directors operate in roughly the same cycle, receiving resource estimates from the main office and initiating project requests within the limitations of those resources to meet the transportation needs in their region. They operate within the constraints of total resources, federal-aid system constraints, state and local jurisdictional constraints, program objectives, state and environmental regulations, state expenditure and federal obligation limitations, intraregional demands for equitable distribution of their resources, and a myriad of other constraints on free choice.

Within these numerous and complex constraints, the regions, in cooperation with their MPOs or local governments, nevertheless continue to initiate project requests. The requests are sent in by the regional director for review by main office functional groups: Preliminary Plan Review Bureau, Traffic and Safety, Structures, Public Transportation, and other areas that are appropriate to the project in question. As a result of these reviews, the main office staff recommends a decision to approve, disapprove, or modify the project as requested by the region. Projects that are approved are added to the region's capital program. Project schedules, aggregate regional programs, etc., are continuously monitored by the Program Planning and Management Group in the main office. The consequences of previous years' accomplishments are used to update needs estimates and program evaluations in the resource cycle.

UTAH

Because of severe limitations on the availability of highway funds for new primary, secondary, and urban projects, and because of the need to complete and maintain the Interstate system, opportunities to program new projects in those categories are very limited and the critical need for establishing priorities occurs primarily in the state pavement rehabilitation program. During the past 15 yr the Utah DOT has conducted extensive research and has designed a pavement evaluation system that permits better management of the state's pavements and thus the preparation of adequate maintenance and improvement programs (*36*). Serviceability, distress, structure, and skid resistance are measured.

- Serviceability is the pavement's ability to serve traffic in its existing condition. The serviceability rating of a pavement surface is called the present serviceability index (PSI), and it varies from 1 to 5. The index is computed by a mathematical equation that uses ride-meter-measured values for roughness and manually obtained values for rutting, cracking, and patching.
- Distress is the visible consequence of various mechanisms that usually lead to a reduction in serviceability; it includes the types, amount, and condition of cracks, rut depths, patching, surface wear, weathering, popouts, and uniformity. Distress ratings vary between 1 (very poor) and 5 (very good) and are obtained by making on-site evaluations of pavement surfaces.
- The pavement's structural ability to support repeated load applications without failure is monitored by measuring its deflections with a Dynaflect. Analytical equations are used to predict the remaining life of pavement surfaces. The

obtained values are then translated into a 1-to-5 rating criterion.

- Skid resistance is a pavement's ability to provide adequate friction for traffic needs. A Mu Meter is used to conduct on-site measurements, and a friction index varying from 0 to 100 is reported; an index value of 35 is the dividing line between acceptable and unacceptable skid resistance.

Once the values of these various indexes have been computed, they are combined with demand indicators (ADT, number of 18-kip [80-kN] single-axle loads) and the pavement's functional class and running speed in order to obtain a general index that allows priorities to be set for maintenance needs. Priority listings are then distributed to district offices, planning and programming sections, and other offices throughout the DOT, where they are used to determine the types and timing of required improvements, the degree to which corrections are needed, and the overall priority ratings of the proposed improvements.

The procedure described above is used as the basis for identifying a total universe of potential rehabilitation projects. A surveillance team then reviews all projects in the field, and this review, combined with the judgment of the district directors, is used to identify three categories of rehabilitation projects: those that must be done immediately, those that can afford to be delayed, and those that are in need of significant reconstruction (e.g., where severe geometric problems exist in addition to pavement deficiencies).

Projects are then programmed on that basis. This process has served as justification for seeking and obtaining approval from the state legislature for additional funding, but not enough new funding has been available to serve a growing list of high-priority needs.

VERMONT (*37, 38*)

The Vermont Agency of Transportation (AOT) evaluates highway projects according to the following criteria:

1. Sufficiency ratings, which measure and evaluate the condition of the existing facilities and are very useful for maintenance projects.
2. Economic development potential.
3. Adequate engineering and capacity standards.
4. Continuity of route improvement.
5. Proximity to the Interstate System and other primary highways.
6. High-accident locations and overall safety considerations.
7. Equitable geographical distribution.

Vermont's bridges are also evaluated before being included in any of the three existing state bridge programs. The following criteria are used:

1. Bridge sufficiency rating.
2. ADT.
3. Number of accidents over the past 5 yr.
4. Width of structure.
5. Remaining life of structure.

Vermont uses a pavement serviceability rating (PSR) to evaluate roadway surfaces. The Vermont PSR has been adapted from (a) various sufficiency rating systems that were derived in other states and (b) data gathered from the American Association of State Highway Officials' road tests conducted during the late 1950s. The system provides a score describing the average value of pavement serviceability based on riding quality, cracking, rutting, excessive patches, surface deterioration, and subbase failure. The rating scale is from 0 to 5, with 5 representing a perfect condition and 0 an impassable one. The ratings, established by a rating panel, are factored to take into account the influence of traffic volumes. This procedure promotes the repaving of the more heavily traveled highways. Pavements with a PSR of less than 2.5 are considered to require resurfacing or treatment. After all the PSRs have been obtained, rehabilitation projects are put in priority order annually according to their condition, traffic, and budget limitations.

The Vermont AOT prepares a list of projects for implementation based on the sufficiency rating derived from the PSR and recommendations from cities, towns, and the AOT's district offices. The planning division uses a relatively subjective analysis to evaluate and select the projects that are to be included in the program and submits it to the secretary for review and approval. The secretary then submits the proposed program to the state transportation board, whose members are appointed by the governor. After their review and approval, the governor makes a final review and then submits the program to the Vermont General Assembly, which makes the final determination on the funds to be expended and the projects to be selected. (In theory, this body could change every item in the project list, but in most cases it does not.)

WASHINGTON

In Washington the process of program development and priority setting begins with the update of the statewide transportation plan every 2 yr. The plan contains policy guidelines and recommended improvements for each mode of transportation (*39*). Improvements are selected for inclusion in the plan by corridor after a series of public meetings and discussions with district administrators of the Washington DOT, MPOs, city and county officials, interest groups, and an advisory committee. In the plan's development process, each major project is given a rating that indicates its relative importance on a statewide basis. Those projects given the highest ratings are included in the update plan. Project priorities are not set in the planning process. Major projects included in the 6-yr program are taken from the transportation plan.

The legislature has mandated that, in the development of the highway program, projects be classified into one of three categories and that priorities be established within each category. Category A consists of improvements necessary to sustain the structural, safety, and operational integrity of the existing state highway system (other than improvements to the Interstate System). Category B consists of improvements for the continued development of the Interstate System, to be funded with federal aid at the regular Interstate rate under federal law and regulations. Category C consists of develop-

ment of major transportation improvements (other than improvements to the Interstate System), including designated but unconstructed highways that are vital to the statewide transportation system.

In addition, fund allocation among categories must consider (a) relative needs in each category, (b) the need to provide adequate funding for Category A improvements to protect the state's investment in the existing highway system, and (c) the continuity of future highway development of all categories of improvements with those previously programmed.

The state legislature requires that certain criteria be used to evaluate and set priorities for highway projects within categories. Criteria for Category A projects (existing, non-Interstate highways) are (a) the structural ability to carry loads imposed, (b) the capacity to move traffic at reasonable speeds without undue congestion, (c) adequacy of alignment and related geometrics, (d) accident experience, and (e) fatal accident experience.

The criterion for Category B projects (Interstate highways) is that the project will aid in completion of the Interstate System (statewide policy prioritization).

Category C projects (major non-Interstate transportation improvements) are selected for the 6-yr program based on the priority of each highway section proposed for improvement in relation to other highway sections within the state. Full regard is given to the structural, geometric, safety, and operational adequacy of the existing highway section, taking into account (a) continuity of development of the highway transportation network; (b) coordination with the development of other modes of transportation; (c) the stated long-range goals of the local area and its transportation plan; (d) potential social, economic, and environmental impact; (e) public views concerning proposed improvements; (f) the conservation of energy resources and the capacity of the transportation corridor to move people and goods safely and at reasonable speeds; and (g) the feasibility of financing the full proposed improvement.

Prior to the development of the program, the transportation commission decides on the priorities to be followed in distributing funds among the three major categories.

WISCONSIN (*40, 41*)

To develop the highway program areas for its 6-yr highway improvement program (1980–85), the Wisconsin DOT first analyzed several key general issues: (a) the emphasis on improving versus maintaining the system; (b) appropriate investment (expenditure) levels and appropriate revenue sources; (c) the relative importance that should be given to energy, environmental, social, and economic development concerns; and (d) the emphasis on highways versus other modes.

As a result of the analysis, four program areas were identified for the highway program:

1. The RRR program area, which encompasses different combinations of resurfacing, reconditioning, and reconstruction projects that seek to maintain and modestly improve the state trunk highway system.
2. The major project program area, which includes all projects that have significant social, economic, and environmental impact; high costs; multiyear commitment; high public and legislative interest; and unique priority and evaluation criteria. Also, the projects must be at least 2.5 miles (4 km) long and require major additions or relocation.
3. The bridge program area, which includes bridges requiring either rehabilitation or replacement work, but not minor or corrective maintenance.
4. The Interstate program area, which includes all projects concerning resurfacing, restoration, and rehabilitation work and structural, safety, and operational improvements on portions of the Interstate System.

Several primary concerns were identified for each program area. In the RRR program area there are four concerns: (a) the surface quality to be provided; (b) the emphasis on deteriorated low-volume facilities; (c) appropriate improvement levels, based on deficiencies, severity, and extent; and (d) federal-aid eligibility. In the major project program area there are five concerns: (a) deficiency, severity, and extent; (b) high-cost justification; (c) long-term financial commitments; (d) concentration of benefits; and (e) relative importance of time savings, accident reductions, fuel savings, and environmental, social, and economic impact. In the bridge program area there are three concerns: (a) matching of available federal aid; (b) analysis of replacement versus rehabilitation alternatives; and (c) the economic and energy impact of posting detours. In the Interstate program area there are four concerns: (a) completion of system versus preservation of existing one; (b) priority of work elements; (c) maximization of federal aid; and (d) user versus nonuser benefits.

These general concerns helped the Wisconsin DOT identify the various relevant issues for each program area and thus provide general guidelines and criteria for the later evaluation and priority setting of individual projects within programs. The DOT also developed more detailed criteria to evaluate and select projects for its previously defined program areas. Criteria for RRR projects are (a) surface renewal needs; (b) hazardous safety problems; (c) safety-related deficiencies; (d) severity and extent of deficiencies; (e) social, economic, and environmental impact; and (f) local and public support. Criteria for major projects are (a) severity and extent of deficiencies; (b) local and public support; (c) benefit-cost analysis; (d) projects under consideration; (e) past investment; (f) funding availability and total costs; (g) social, economic, and environmental impact; and (h) system continuity. Criteria for bridge projects are (a) structural, condition, and geometrics assessment; (b) statewide priority lists; (c) posted bridges; (d) bridges in poor condition; (e) local and public support; and (f) social, economic and environmental impact. Criteria for Interstate projects are (a) completion of basic system; (b) safety improvements; (c) preservation of existing system; (d) utility of existing system; (e) additional capacity for safety and efficiency; (f) local and public support; and (g) social, economic, and environmental impact.

To quantify overall highway surface renewal needs, the Wisconsin DOT has developed a PSI, which is a mechanical measure on a scale from 0 (worst) to 5 (best) that enables the evaluation of pavement ridability. The index is obtained by using ride meters to measure the relative motion between the

TABLE A-2
CRITERIA FOR ESTABLISHING PRIORITIES

Criteria	Resurfacing	Reconditioning Minor	Reconditioning Major	Reconstruction
PSI	●	●	●	●
Pavement age	●	●	●	●
Maintainability	●	●	●	●
Pavement width		●	●	●
Pavement failure			●	●
Safety[a]			●	●
Shoulder width			●	●
Safety				●
Geometrics				●
Capacity				●
Combination of problems				●

[a]Isolated curve, crest, hazard.

rear axle and the chassis of an automobile traveling at 50 mph (80 km/h). PSI ratings are used to assess minimum surface renewal needs at the *system* level, but they are most useful as a policy variable; by determining alternative "cutoff" or "terminal" PSI values and defining strategies to meet each of the required levels of work, one can assess the extent of the needs and thus of the resurfacing program required. For example, a policy designed to resurface all state roads having a PSI of less than 2.5, regardless of their functional class, would require work on 5,031 miles (8100 km) of the system from 1980 to 1985. If the "cutoff" PSI level is reduced to 2.25, then only 4,096 miles (6600 km) has to be resurfaced. And if the PSI level is fixed at 2.00, then only 2,888 miles (4600 km) would need resurfacing.

Despite its usefulness, PSI does have drawbacks. First, it is not an absolute indicator of pavement rehabilitation needs, because other important factors (e.g., structural adequacy) may not be reflected in ride quality. Also, PSI is only one of a number of criteria for establishing needs. (Others are given in Table A-2.) A PMS is being developed in Wisconsin to supplement the PSI.

It should be noted that, during the period that the Wisconsin DOT was compiling data, PSI measurements over time were available for only a relatively small portion of the state trunk highway system, so their usefulness was limited to aggregate analyses. This small sample was used to develop pavement deterioration curves, based on type and age, that were then applied to the entire system. As the PSI data base expands based on biennial PSI measurements, these deterioration curves will be reevaluated and updated.

The Wisconsin DOT also maintains a computerized bridge appraisal system that enables it to rate bridges on the basis of load-carrying capacity, structural condition, geometrics, and functional characteristics such as narrow approach roadways and restricted clearance. The American Association of State Highway and Transportation Officials' bridge sufficiency number rating system, which reports the condition of the various bridge components as a single index, is used to determine if bridges are eligible for federal aid (they are if the sufficiency number is less than 50).

The Wisconsin DOT selected HIAP, the investment analysis model that was developed by FHWA and discussed in Chapter 3 of this synthesis, to help in the selection of new projects for inclusion in its 1980–85 program, primarily in the major project area. The application of HIAP involved four steps:

1. Adapting the general programs to the specific conditions prevailing in the state (using accident rates and pavement deterioration tables).
2. Acquainting DOT staff with HIAP's capabilities, focusing on those who actually would be making use of the model.
3. Applying HIAP to two specific studies, the first an analysis of 13 reconstruction and 10 resurfacing projects considered as possible additions to the 1979 highway improvement program, and the second a more extensive analysis of alternative improvements at 30 sites where major projects had been proposed for the 1980–85 program. In the latter study 107 alternatives were evaluated at the 30 sites, and the most cost-effective alternative for each site was chosen on the basis of incremental benefit/cost analysis. Other kinds of analysis were also tested. Programs with nonbudgetary constraints, alternative funding levels, incremental funding increases, fund allocation by category, variations of certain key parameters, and alternative selection criteria were developed in order to provide additional information for the preparation of the final program.
4. Developing an applications guide for future model users. In the final evaluation, the Wisconsin DOT recognized the usefulness of HIAP within its ongoing programming process. It will be used for (a) performing early and continuing analyses of candidate major projects to assist in designing the most appropriate levels of improvement; (b) periodically revising candidate projects that have been subject to significant cost variations, design changes, or delays in project development; and (c) biannually reviewing the 6-yr investment program to determine the best responses to changing budget levels or allocation procedures and to provide guidelines on appropriate levels for projects in the preliminary design stages.

HIAP will be applied within its proper scope, however: as an aid and not as a substitute for decision making. Professional judgment will still be required when HIAP data are prepared and the results analyzed and interpreted. More detailed information on HIAP and its application in Wisconsin can be found in publications of the FHWA (*9, 42*), Batchelder and others (*10*), and Gruver and others (*40*).

The allocation of funds provided by the state legislature to the state trunk highway system for a given program period covers three basic areas: (a) those projects needed to maintain the integrity of the existing state highway and bridge system, (b) major *new* projects, and (c) bridges. More detailed procedures for selecting projects in the first area have been formalized in a state law, effective as of October 1, 1981. Briefly, the funds available for these projects are allocated to each district office. The allocation is in two increments. The first, or basic level, is necessary for system preservation only and is based on each district's relative PSI ratings of the state highway system. The second increment is based on vehicle-miles of travel and registered vehicles and

permits, on a selected basis, the consideration of improvement levels higher than basic surface preservation. The districts make specific recommendations on projects based on technical evaluations and community input. Programs are then submitted to the central office, where a final program is prepared and submitted to the state DOT secretary. The legislature is then asked to approve the budget needed to fund the projects. The number of projects in the program depends on the funding level approved at this stage.

The legislature plays a much more central role in the selection of major projects. The staff of the Wisconsin DOT prepares a list of major projects recommended for funding; this list is based on a technical analysis, one facet of which is the use of HIAP. The legislature then approves a funding level. The legislature in Wisconsin is becoming more interested in approving individual projects.

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