New Approach for Analyzing Highway Program Choices and Trade-Offs

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State highway investment decisions have traditionally been based on needs studies, long-range system plans, and midrange or short-range single-option programs. These decision-making tools suffer from a variety of shortcomings—portrayal of enormous and unrealistic dollar requirements to address highway deficiencies, inflexibility, inability to weigh trade-offs between and within program areas, lack of means to maximize statewide benefits over local or project benefits, and failure to consider a broad range of social, economic, and environmental consequences. This paper describes an innovative six-year state highway programming process, developed by the Wisconsin Department of Transportation, that attempts to remove these shortcomings. In this process, the district offices periodically develop, under statewide policy guides, alternative six-year highway programs from alternative project concepts that address deficient segments of the highway system. The low-program option is based on the minimum requirements to maintain the existing system. Higher-level programs are based on alternative future state and federal highway revenue assumptions and policy directions. For budgeting purposes, policy and program choices are presented to decision makers, legislators, and the public by describing for each program its composition, impacts on highway deficiencies and performance, and social, economic, and environmental effects. Key trade-offs within and between programs are identified. The process includes cost/benefit analysis of major projects; allows for staging of investments; is not easily undermined by uncertainty; improves use of staff and budget; informs the public of the department's intentions; and improves coordination of programming and budgeting efforts of state, regional, and local agencies. The department is committed to extending this approach to programming to all modes in the future.

During the past few years, the rate of growth in the revenues available for transportation at the state level has slowed considerably. And increasing gasoline prices, supply shortages, and federal fuel-efficiency standards may result in actual decreases in total revenues for transportation in some states over the next few years. This slowdown in revenue growth, coupled with the tremendous inflation being experienced in the construction industry, increasing routine highway maintenance needs, and necessary expenditures for other modes, has resulted in a sharp decrease in the funds available for highway rehabilitation and improvement.

Wisconsin, like many other states, must make increasingly difficult decisions on how to use scarce highway improvement dollars. Although significant improvements to portions of the primary, secondary, and urban systems appear desirable, it is clear that the design standards reflected in earlier system plans and needs studies will not be met systemwide. Rehabilitation and resurfacing needs are increasing as the system ages, and a large number of bridges, particularly those that have severe load-carrying limitations, are coming due for replacement or further restrictions on use. Uncompleted portions of the Interstate system are facing deadlines set by the Surface Transportation Act of 1978, and Interstate rehabilitation is becoming a critical area of concern.

To assist in analyzing this array of issues and investment choices, the Wisconsin Department of Transportation has, over the past two years, developed and implemented a highway-investment programming process. The primary objective of the process is to provide management with a range of policy choices and an assessment of the transportation, economic, social, and environmental consequences of those choices. This improved programming process and a set of new technical support tools have been used to develop an initial six-year highway program for the years 1980-1985. It is the department's intention to update this program every two years and to expand its scope to cover all modes.

OVERVIEW OF THE PROCESS AND RESULTS FOR 1980-1985

Traditional highway programming in Wisconsin, and in other states as well, has suffered from a variety of problems that include the use of needs studies or system plans that reflect unrealistic revenue assumptions; inability to weigh trade-offs within and between program areas (e.g., bridge replacement versus highway rehabilitation or improvement); lack of systematic methods for maximizing statewide versus local or project benefits; and failure to consider a broad range of social, economic, and environmental impacts. Generally, only one design alternative or potential investment level is considered for each project being programmed and projects are ranked either subjectively or by using a more technical method such as a sufficiency rating, a priority index, or a benefit/cost analysis. For the most part, only one program alternative is explicitly developed and there is little formal program evaluation. In short, program development has been viewed as a somewhat mechanical process of progressing down a priority list until the available funds are exhausted.

Correcting these shortcomings requires that an improved programming process include the following:

1. Provision of a range of policy choices to top management, not simply one recommended alternative;
2. Maximization of system benefits over individual project benefits;
3. Consideration of alternative design concepts (i.e., investment levels) for each project;
4. Explicit development of alternative improvement programs for evaluation; and
5. Use of a range of consistent criteria for evaluation of project and program options.

Because the most important objective of the process is to improve the department's investment-decision-making capability by providing management with fully evaluated policy choices, it is necessary to first develop explicit alternative improvement programs. In turn, to develop meaningful alternative programs requires that project alternatives, that is, alternative levels of improvement for a given highway segment, also be available. Under some program assumptions (e.g., constrained revenue), the appropriate level of improvement for a given segment might be resurfacing or minor reconditioning; under other conditions (e.g., a revenue increase), a higher-level improvement might be warranted. Unless this dynamic relationship between the project improvement-level scale and program alternatives is explicitly recognized, a key element of program choice is ignored and program alternatives

are simply different combinations of projects, each having only one proposed design.

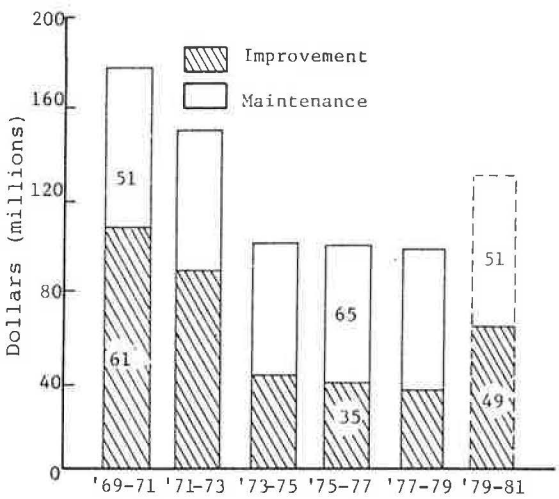
It was recognized that, in many cases, but particularly for candidates for programming in the early years of the program period (1980-1981), project design options could be constrained for any number of reasons. The results of the project development and environmental impact statement process, prior commitments to local units of government, and federal-aid eligibility requirements can all narrow the range of feasible design concepts. Nonetheless, in many cases, more than one feasible design concept was available and the final choice could be determined on the basis of state-level program and policy directions.

To meet the requirement that systemwide or statewide benefits be maximized over project or local benefits meant that consistent criteria had to be established to define deficiencies, develop design solutions, and select projects in all eight district offices of the department.

The basic steps of the new programming process are

1. Analysis of existing conditions and deficiencies,
2. Development of alternative programs, and
3. Evaluation of alternative programs.

Figure 1. Decrease in state improvement funds: maintenance versus construction (constant 1970 dollars).



The approach to each of these steps and selected results are described below.

Analysis of Existing Conditions and Deficiencies

The first step in developing the multiyear program was to thoroughly assess the existing situation with respect to revenue availability and highway system physical and service conditions. As in many states, Wisconsin has seen a steady erosion in the buying power of the highway improvement program. In fact, during the 1967-1977 10-year period, the buying power of state funds available for highway improvements decreased by 75 percent, due primarily to inflation in the construction industry and the ever-increasing expenditures on routine maintenance (not including resurfacing) and nonhighway programs. Figure 1 shows the trend in expenditures on maintenance and improvement over the past few bienniums. (The increase in highway improvement funds in the 1980-1981 biennium was due to the approval of more than $60 million in state general funds for highway purposes.)

Another factor that will affect the decrease in improvement funds in the future is the expected slowdown in the rate of growth of overall revenues. Figure 2 shows the trend in the state gasoline tax revenues over the past 10 years. Gasoline taxes, which currently account for more than 50 percent of total revenues, are expected to decrease in the future due to fuel price increases and improved fuel efficiency in the vehicle fleet. As a result of all these factors, it is expected that Wisconsin will not be able to match available federal aid in the mid-1980s.

Parallel with the assessment of revenue availability, the existing highway system physical and service conditions were also analyzed. The assessment of deficiencies for purposes of the six-year program specifically avoided a needs-study approach and reliance on the traditional highway standards. It instead recognized that, as a practical matter, definitions of need and deficiency vary from time to time, depending on a number of factors such as public acceptability of existing conditions, cost of improvements, and revenue availability.

To provide some objective measures of roadway condition, deficiency data were collected for about 9600 km (6000 miles) of the 19 000-km (11 900-mile) system. These data included surface age and pavement condi-

Figure 2. Gasoline tax revenues: 1967-1983.

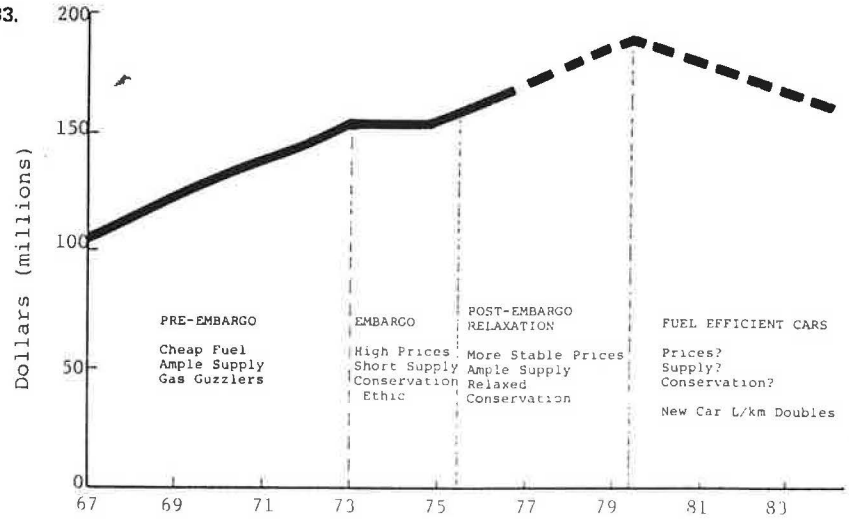


Table 1. Reported lengths of highway that have substandard pavement or shoulder widths or both.

	Pavement Length (km)									
	District									
Functional Class	1	2	3	4	5	6	7	8	9	Total
Principal arterial	238	113	201	172	217	136	258	219	13	1567
Minor arterial	617	456	539	473	455	475	343	632		4031
Major collector	439	159	168	297	293	212	379	159		1989
Minor collector	23	6	8			24				62
Total	1317	774	917	828	966	847	977	1009	13	7648

Notes: 1 km = 0.62 miles.
Numbers may not add due to rounding.

Table 2. Summary of deficiency data.

Deficiency	Avg N	Statewide Avg	Threshold Value	Length (km)	Avg Rate
Accident rate	346	280	At 300	2957	522
			At 500	975	770
			At 750	220	1193
Accident occurrence	277	200	At 300	1225	778
			At 500	446	1239
			At 750	212	1695
Geometrics: percentage passing	56		At 50	2453	31
			At 30	1085	18
			At 20	624	12
Volume-to-capacity ratio	0.40		At 0.60	1092	0.87
			At 0.80	411	1.10
			At 1.00	160	1.37

Note: 1 km = 0.62 mile.

tion, accident rates and occurrences, volume-to-capacity ratios, percentage of no-passing zones, and other geometric and structural criteria. The deficiency data for each segment were placed in a computer file for efficient editing, sorting, analysis, and display.

The computerized information system was used to produce a series of deficiency reports summarizing the extent and severity of various deficiencies statewide and by district, functional class, and such. Tables 1 and 2 illustrate the type of output developed from these reports for identifying the pavement lengths above specified threshold values of deficiency criteria. These reports were then used in the development of specific program alternatives and, subsequently, similar deficiency summaries were used as one means of evaluating program alternatives and summarizing program performance. The computerized information system represented a crucial technical tool to support a process that must necessarily handle a large amount of information and be capable of summarizing that information at different levels of detail, depending on the issues of concern and the decisions to be made.

Parallel with the analysis of deficiencies on the state highway system, system conditions and deficiencies in the other program areas were also identified. In the bridge area, the results of the Federal Highway Administration (FHWA) sufficiency-rating formula and the department's own priority listing based on load-carrying capacity, overall structural condition, and geometrics were used to assess replacement needs. The most recent Interstate cost estimate (1979) prepared for FHWA served as a basis for assessing potential improvements on that system.

After the screening of deficiencies on the state highway system was completed, alternative improvement project concepts were developed for those segments judged most deficient. In identifying potential improvement projects, emphasis was placed on those segments both requiring surface renewal during the six-year period and having safety, geometric, and capacity deficiencies. The minimum improvement alternative proposed for each segment was expected to be a resurfacing project or a resurfacing project coupled with the minimum structural renewal necessary to support a new surface. Depending on the severity of the safety, geometric, and capacity deficiencies present, higher levels of improvement proposed for a given segment varied from minor reconditioning projects to major reconditioning and reconstruction and major projects on new alignments.

Again, the purpose of developing alternative improvement concepts for a given segment was to allow the improvement level to vary, depending on the program parameters assumed (e.g., overall revenue level, allocation of revenue by district, subprogram emphasis, and such). For each alternative improvement concept for each segment, data on the key design elements, potential impacts, cost estimates, and schedule were collected and placed in a computer file that could be cross-referenced to the deficiency data file to produce summaries of the deficiencies addressed by different sets of projects and programs.

For about 30 major project sites, a range of alternatives was identified, based primarily on current or past studies. These 30 projects were subjected to formal benefit/cost analysis by using the highway investment analysis package (HIAP) developed by FHWA. [These results are reported elsewhere (1).] Although it is but one of many factors affecting major project decisions, benefit/cost analysis points out the trade-offs involved in successively increasing investments in one or a few project sites versus funding more-moderate improvements at a greater number of sites. In addition, the testing of a range of alternatives at each site often identified other potentially cost-effective alternatives that ought to be developed and analyzed.

Development of Alternative Programs

The deficiency analysis showed that there was a range of key policy issues that had to be explored in developing alternative programs. These issues included the following:

1. The benefits available from a revenue increase under varying assumptions about how additional revenues might be spent,
2. The benefits of greater emphasis on safety or capacity improvements versus pavement preservation,
3. The most cost-effective mix of resurfacing and reconditioning work for maintaining some minimum pavement quality, and
4. The trade-off of funding a relatively few major improvements versus a larger number of small improvements.

Given the expected trend in gasoline tax revenues, the need to explore the potential for a revenue increase and to demonstrate how additional revenues could be used was identified as the most critical issue facing the department.

Although the number of alternative programs that

Figure 3. Relationship between project and program alternatives.

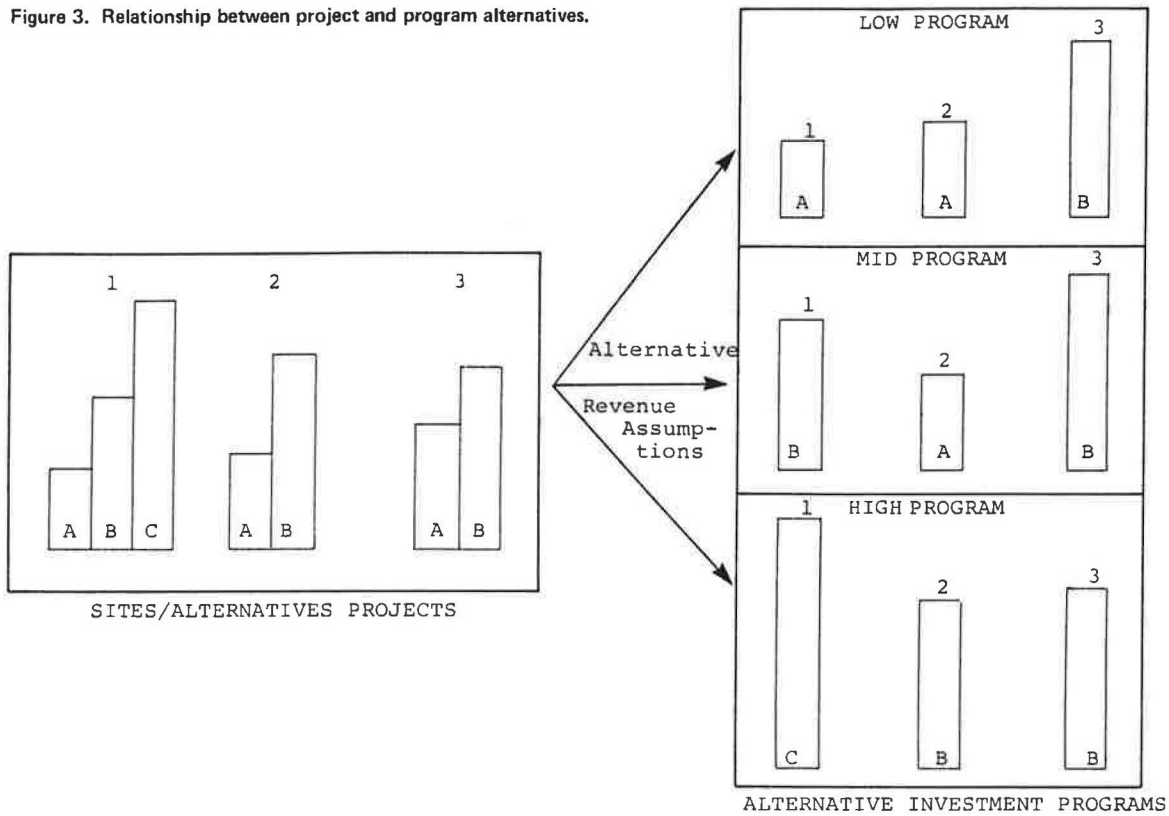


Table 3. Summary of program alternatives: 3R program area.

Program Level	Resurfacing Cost ($000 000s)*	Resurfacing Length (km)	Minor Reconditioning Cost ($000 000s)*	Minor Reconditioning Length (km)	Major Reconditioning Cost ($000 000s)*	Major Reconditioning Length (km)	Reconstruction Cost ($000 000s)*	Reconstruction Length (km)	Total Cost ($000 000s)*	Total Length (km)
Low	112	3912	24	457	44	643	22	115	202	5127
Medium	100	3279	30	546	84	1105	86	395	300	5487
High	99	3261	35	612	112	904	158	603	404	5960

Note: 1 km = 0.62 mile.
*1978 value.

could be developed and evaluated was limited, a range of reasonable funding levels was defined for each of four program areas: resurfacing, reconstruction, and reconditioning (3R); bridge replacement; Interstate; and major projects.

The funding levels selected for each of the program areas were based on the results of the deficiency analyses, expected federal funding availability, previous program commitments, and the policy preferences of top management. The objective was to identify the likely range of expenditures by program area at different total revenue levels and assuming different policy directions. Thus, for the general 3R program area, expenditures of at least $200 million (1978 dollars) were estimated to be necessary during the period 1980-1985 simply to meet surface renewal objectives. On the other hand, even under the most optimistic revenue scenario (i.e., assuming a major revenue increase), the minimum expenditure levels required in other program areas make it unlikely that 3R program area expenditures would exceed $400 million.

As shown below, three program funding levels were selected for each of the 3R, bridge replacement, and Interstate areas. The major projects were grouped into categories identified as committed (e.g., essentially under construction) and high-, medium-, and low-priority candidates without explicit program levels.

Program Area	Program Level (1978 $000 000s) Low	Medium	High
Resurfacing, reconditioning, and reconstruction	200	300	400
Bridge replacement	70	100	140
Interstate	90	135-195	245
Major projects	120	listing of additional projects	

The development of alternative programs for the 3R area was based on guidelines that identified surface renewal target lengths and other priority criteria and on overall funding levels. Although district offices were given initial funding targets, it was made clear that final district funding levels would depend on a statewide evaluation of initial district submittals and the development of a consistent program district to district. Four levels of improvement were defined:

1. Resurfacing—based on criteria of pavement age, maintenance needs, and serviceability index;
2. Minor reconditioning—based on resurfacing criteria plus criteria of pavement width, shoulder paving,

Table 4. Social, economic, and environmental impacts of major-project program alternatives: 1980-1985.

Impact	Program			
	Low ($160 000 000)	Approved ($260 000 000)	Recommended[a] ($360 000 000)	High[b] ($410 000 000)
Construction jobs generated (person years: 1980-1985)	4500-4800	7300-7800	10 100 to 10 800	11 500 to 12 300
Income generated statewide ($000 000s)	240-480	390-780	540-1090	615-1230
No. of businesses displaced	8	12	25-65	35-89
Improvement in accessibility (peak-period vehicle hours reduced per year)	101 000	379 000	473 000 to 752 000	543 000 to 926 000
Households displaced	45	87	104-217	133-288
Neighborhoods severed	0	0	1-2	1-3
Farmland required (hm^2)	594	610	823-1389	964-1743
Farms severed	53	54	68-109	78-134
Wetland filled (hm^2)	4.0	23	31-95	47-135
Habitat required (hm^2)	147	272	348-605	412-765
Added salt per year (Mg)	3493	4796	5671-6086	6121-6562
Infringement on endangered species	0	0	0	0
Infringement on unique areas				
Total	1	1	3-9	5-13
Historical and archeological	0	0	1-3	1-4
Coastal zone management	1	1	1	1
Air quality				
No. of new pollution sources (projects on new location)	4	4	5-9	6-12
No. of projects on existing location				
Increased CO concentration	1	2	2	2
Decreased CO concentration	1	1	2-4	2-5
No change in CO concentration	1	5	5-6	5-7
Noise levels				
No. of new pollution sources (projects on new location)	4	4	5-9	6-12
No. of projects on existing location				
Exceed present levels by 10 dB(A)	2	5	7-8	7-9
Exceed federal design-year criteria	1	9	2-3	2-4
Energy consumption: materials and construction[c] (PJ)	3.63-5.40	5.90-8.75	7.43-12.0	8.39-13.6
Public acceptability of improvements				
No controversy	1	2	2-4	3-5
Low controversy	4	8	9-13	10-15
High controversy	3	3	4-7	5-8
No. of projects by class[d]				
Type 1	6	11	13-21	15-25
Type 2	1	2	2	2-3
Type 3	1	0	0	0

Notes: 1 hm^2 = 2.47 $acre^2$; 1 Mg = 1.10 ton; 1 PJ = 0.947 × 10^{12} Btu.
Construction jobs and income generated exclude values for completion of I-43 and the connection from Gearke's Corners and US-16.
[a] Approved program plus $100 000 000 worth of candidates (3-11 projects, depending on their cost).
[b] Approved program plus $150 000 000 worth of candidates (5-16 projects, depending on their cost).
[c] Energy consumption values exclude effects of two major bridges.
[d] Under the Wisconsin Environmental Policy Act: type 1 projects are likely to have a significant impact on human environment, type 2 projects may do so, and type 3 projects will not do so.

and minor shoulder widening;

3. Major reconditioning—based on resurfacing and minor reconditioning criteria plus criteria of pavement failure, safety features (isolated curves, crests, and hazards), and federal-aid eligibility; and
4. Reconstruction—based on resurfacing and reconditioning criteria plus criteria of safety, geometrics, capacity, and combinations thereof.

It was, however, necessary to use the overall funding level as well as the deficiency criteria in making project selection. At the lowest funding level for the 3R program area ($200 million), district choices were constrained by the surface renewal target and the majority of projects were resurfacing and minor reconditioning. However, at higher funding levels, there was increasing flexibility to fund major reconditioning and reconstruction projects while still meeting surface renewal goals. The relationship between project and program alternatives is illustrated in Figure 3, and the types of improvements that can be funded by the 3R program alternatives are summarized in Table 3. Additional resources above the $200 million level increase the total length somewhat but dramatically increase expenditures in the higher improvement categories.

Some consideration was given to specifying relatively rigid rules or priority thresholds (e.g., accident rate above a specified level) for projects proposed for higher-level improvements. However, subject to meeting surface renewal goals, the districts were given wide latitude to set priorities. This was a more prudent approach initially, given the variations in conditions district to district and a lack of agreement on an acceptable range for any threshold criterion. More-defensible threshold criteria could be set in future cycles, depending on the degree of variation occurring in initial district submittals.

The development of alternative bridge, Interstate, and major projects also was guided by an explicit set of priority and policy guidelines but, again, the use of a strict formula was avoided. For bridges, primary consideration was given to load-carrying capacity and posted limits, overall structural conditions, and geometrics, as well as to age and traffic levels. For Interstate improvements, priority was given to completion of the system and selected operational and safety improvements on existing facilities. For selected major improvement projects, benefit/cost analysis was performed as one input to priority setting and projects were grouped in priority categories that depended on whether work had been initiated or strong commitments implied and the extent and severity of a range of deficiencies.

Evaluation of Alternative Programs

After the alternative programs had been developed, program evaluation focused on four issues:

1. Summary of each program alternative (e.g., kilometers of improvement by type) and consistency

Table 5. Summary of program options: six-year program.

	State Highway Program		Interstate Program[a]		Bridge Replacement Program[b]		Major Projects Program[c]	
Program Level	Cost ($000 000s)[d]	Key Elements	Cost ($000 000s)[d]	Key Elements	Cost ($000 000s)[d]	Key Elements	Cost ($000 000s)[d]	Key Elements
Low	200	Surface renewal of 5127 km (which does not meet 5500-km target necessary to avoid loss of federal aid); minor structural and safety reconditioning and reconstruction work	90	Work toward completion of I-43; high-priority safety projects including median barriers on I-94 and rest area on I-43; selected bridge deck overlays to preserve existing system; freeway surveillance system in Milwaukee	67	Replacement of 150 bridges [two-thirds of all posted bridges (34 of 49), selected low-capacity bridges, selected bridges in poor structural condition]	120	Work toward completion of $70 000 000 worth of committed projects; begin work on three high-cost projects
Medium	300	Surface renewal of 5487 km (which essentially meets target necessary to avoid loss of federal aid); significant expansion of improvement level	135-195	All elements of low-level program; third-lane projects on I-90 and I-94; park-and-ride lots, rest areas, and bridge fencing; removal of roadside obstacles; improved lighting	103	Replacement of 239 bridges (all those in low-level program, most remaining low-capacity ones, all others in poor structural condition)	>120	All elements of low-level program; additional major projects
High	400	Surface renewal of 5960 km (which exceeds target necessary to avoid loss of federal aid); further expansion of improvement levels	245	All elements of medium-level program; selected interchange improvements on I-94 and I-794; noise-abatement measures, truck weighing stations, additional park-and-ride lots, and expansion of lighting	143	Replacement of 311 bridges [all those in medium-level program, selected functionally obsolete ones (too narrow roadways, restricted clearances, poor alignments), selected ones in marginal structural condition (likely to deteriorate in two-year period)]		

Note: 1 km = 0.62 mile.
[a]Does not include 3R program.
[b]Does not include several high-cost bridges that will require special funding.
[c]Completion of committed projects estimated to cost $70 000 000; construction of other high-priority projects estimated to cost $15 000 000 to $125 000 000 depending on funding availability.
[d]1978 value.

with guidelines (e.g., surface renewal targets and funding levels);

2. Consistency of program submittals from district to district in terms of deficiencies addressed, levels of improvements proposed for given deficiencies, costs per kilometer by improvement type, and such;

3. Benefits of each alternative in terms of prolonged surface life, accident reductions, capacity improvements, and such; and

4. Potential economic, social, and environmental impacts.

The evaluation relied heavily on the deficiency data produced earlier in the study. Both the extent and severity of deficiencies on segments selected for improvement were reviewed, as well as the improvement level specified, given a certain set of deficiency characteristics. Again, without a well-organized information system that could efficiently match deficiency characteristics with project summary data, this evaluation would not have been possible. Manual methods of estimating potential accident reductions and capacity benefits of each program were developed to augment the information obtained from deficiency files and formal benefit/cost studies. The potential economic, environmental, and social impacts of the alternative programs considered are estimated to meet the spirit of state environmental laws and recent U.S. Council on Environmental Quality regulations. The environmental assessment was done by analyzing the specific impacts of the larger improvement projects and performing a generic assessment of the likely impacts of several classes of lower-cost projects. Selected results of this analysis for the major-project area are given in Table 4.

The availability of program alternatives allowed comparison of the likely impacts of varying funding levels in each area and explicit consideration of the trade-offs within and between each area. Table 5 summarizes the basic elements included in the alternatives for each program area and provides some indication of the trade-offs available by shifting funds from area to area. More detailed descriptions of these trade-offs were used to guide the selection of the proposed six-year program and to document and justify the choices made.

A recommended program was developed based on an assumption that a major revenue increase would not be sought. Subsequently, a change in state administrations required recycling the program-development-and-evaluation activity to produce a recommended program based on a substantial revenue increase. The availability of the key data in the deficiency- and project-summary files made it possible to complete this substantial modification to the program in a few weeks time. This evaluation also focused on the same basic issues, and the results provided the necessary background material to the state legislature for its budget deliberations.

The legislature subsequently passed a biennial budget for 1980-1981 that provides more than $60 million in general funds to supplement the transportation fund. During the current biennium, the department must recommend a permanent funding mechanism to generate additional funds of approximately this magni-

tude for the transportation fund. The department's recommendations on the relative emphasis between program areas and on specific projects were adopted without any significant changes.

CONCLUSIONS

Several important conclusions can be drawn from this project:

1. A multiyear program, even in an era of constantly changing project development schedules and costs, funding levels and categories, and other factors, can be an extremely useful management tool. However, given the increasingly complex environment within which program decisions must be made, both alternative project design concepts for a given highway segment and alternative programs must be explicitly considered to thoroughly explore important policy choices. Simply setting priorities among a list of projects for which only one design concept is proposed is often overly simplistic and ignores a key dimension of program choice.
2. Storing, editing, and analyzing the data necessary to develop and evaluate a range of program alternatives requires a well-designed computerized information system and a range of evaluation support tools, both manual and computer assisted. On an ongoing basis, similar capabilities will be needed to monitor and update the program in light of project schedule and cost increases, new funding constraints, and changes in management policies and priorities. Developing this ongoing capability is the final element of the Wisconsin programming project.
3. A range of evaluation and priority criteria should be used to select project and improvement levels. Although benefit/cost analysis and other technical criteria can be useful, rigid-formula approaches lack the flexibility required to make final project selections in cases where subjective and nonquantifiable factors must also be considered.
4. On an ongoing basis, longer-range system planning and detailed project development activities must be closely coordinated with the program development function. Much of the information on system conditions, surface renewal needs, and such can be a routine product of a periodic system planning report. Similarly, information on project alternatives and impacts is routinely collected during project development studies. In addition, close coordination is needed to maintain alternatives for a given project as appropriate and to minotor project cost and schedule changes. Although it is desirable to maintain a stable multiyear schedule of projects, program modifications will always be necessary and the programming function should be used to identify and analyze the uncertainties and risks inherent in any proposed program.
5. Program-level environmental analysis can provide useful information in formulating proposed programs. Obviously, the level of detail of program-level analysis cannot, and should not, approach that of a project environmental impact statement. Also, the processing and administrative requirements of any formal program environmental report must allow annual or biennial budget decisions to be made and program implementation to proceed smoothly. Nonetheless, U.S. Council on Environmental Quality regulations suggest that program-level environmental analysis is required and, based on the Wisconsin experience, it can be accomplished.

Several areas for further research and development are apparent:

1. The trade-off between highway and bridge maintenance versus improvement and replacement needs to be more thoroughly explored. Additional methods are needed to characterize program benefits and performance to allow more systematic consideration of the trade-offs implied by different programs. Although a start was made on estimating environmental impacts, improved methods are required.
2. Future cycles of the programming process should incorporate all modes of transportation that the state is involved in. Again, expansion to other modes will require the development of explicit evaluation criteria and methods so that program trade-offs can be explored.

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1. J. Batchelder, R. Lange, T. Thodes, and L. Neumann. An Application of the Highway Investments Analysis Package. TRB, Transportation Research Record 698, 1979, pp. 1-5.

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