National Cooperative Highway Research Program

RESEARCH RESULTS DIGEST

March 2001—Number 252

Subject Area: IA Planning and Administration

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Development and Demonstration of StratBENCOST Procedure

This digest summarizes NCHRP Projects 2-18(3), "Development of an Innovative Highway User-Cost Estimation Procedure," and 2-18(4), "Development and Demonstration of StratBENCOST Procedure." StratBENCOST is a decision-support tool for state and local transportation agencies engaged in multiyear strategic planning and budgeting for highways. This digest is based on draft final reports prepared by Drs. David Lewis and Khalid Bekka of HLB Decision Economics, Inc.

INTRODUCTION

This digest provides the details and concepts of a strategic, decision-support tool (StratBENCOST) that will be of interest to highway-planning and budget professionals.

Economic development goals manifest themselves in highway needs differently at different times. A highway need emerges first as a broadly conceived idea, a conceptual scheme for shifting highway user costs. Years later, concepts evolve into detailed engineering plans and blueprints for construction, rehabilitation, and repair. Effective budgeting means maintaining a multiyear strategic perspective that anticipates different regional, urban, and rural development requirements, as well as their highway counterparts, at different times. StratBENCOST is conceived and designed to support multiyear planning and budgeting in this strategic context.

Although StratBENCOST and its sister tool, MicroBENCOST (see *NCHRP Research Results Digest 242*), are each designed for use at state and local levels, they differ in scope and function.

StratBENCOST is designed to assist in comparing large numbers of project options in a jurisdiction, including project options in the concept stage. The amount of engineering and design detail required to conduct an assessment is held to the minimum, even when considering candidate investment alternatives in advanced stages of design and engineering. This minimum level of detail in the assessment allows for economic consideration of many project alternatives and budgetary scenarios, in support of decisions regarding the strategic, multiyear positioning of all claims for highway money.

MicroBENCOST, on the other hand, facilitates operational, rather than strategic, planning and budgeting. MicroBENCOST is designed for in-depth economic analysis of detailed project options. It applies when specific design and engineering alternatives are at issue, rather than the strategic position of schemes and projects in a comprehensive, areawide and multiyear budget.

This digest summarizes the capabilities of the StratBENCOST software and highlights example applications. The StratBENCOST software and the *User's Manual for StratBENCOST32* may be obtained from McTrans Center, University of Florida, 512 Weil Hall, P.O. Box 116585, Gainesville, FL 32611-6585. The program will be listed under the *Transport Planning Project Management* section in the McTrans catalog. McTrans Center may be reached at (352) 392-0378 or by email at mctrans@ce.ufl.edu.

STRATEGIC PLANNING WITH StratBENCOST

In essence, StratBENCOST enables transportation agencies to ask the same questions as those posed

by private firms when considering investment opportunities: "Will owners earn a satisfactory rate of return from the investment?" and "When, in light of all investments, is the best time to make any given investment?" With transportation agencies, the owners of the highway system are the taxpayers and road users in the jurisdiction. From their perspective, StratBENCOST helps agencies establish whether and when to invest in each available highway spending opportunity.

StratBENCOST forecasts the benefits of candidate highway investments in terms of highway user costs and environmental effects and compares these benefits with the capital and ongoing costs the agency would incur in constructing, maintaining, and operating the project. StratBENCOST assesses candidate investments in terms of their net present value (NPV). NPV is the present-day value of a project's benefits summed over each year of its useful life. Projects with NPVs greater than zero are judged worthwhile because their average annual rate of return exceeds the average annual opportunity cost of the capital employed.

In accounting for the timing and costs over each project's life cycle, StratBENCOST provides guidance on the optimum scheduling of new investments. In ranking projects with higher NPVs ahead of those with lower NPVs, StratBENCOST budgets first for investments that yield earlier, rather than later, economic payoffs.

MULTIYEAR BUDGETING WITH StratBENCOST

StratBENCOST facilitates the development of both a benchmark multiyear highway budget and a reprioritized multiyear budget. Reprioritization of the benchmark budget accommodates any discrepancy between the objectives inherent in an undiluted economic ranking (these objectives are reflected in the benchmark budget) and other state and local priorities.

As shown in Table 1, the benchmark budget indicates which projects would be included each year of a multiyear budget to maximize the areawide (that is, state or municipal) economic contribution of the highway sector given the budget constraint. As Table 1 signifies, the budget will omit sound projects (that is, projects with NPV > 0) if cumulative costs exceed the budget constraint before all sound investment opportunities are exhausted.

The benchmark budget is a starting point for allocating highway capital dollars, but, in most cases, it will not satisfy other policy objectives and will need to be modified. In particular, although the benchmark StratBENCOST allocation signifies the multiyear investment portfolio that maximizes the areawide economic contribution of highway investment; such maximization typically exhibits the following biases:

• **Mega-project bias.** Disproportionately expensive projects are often the highest-ranking investments, as well, leaving an unacceptably small portion of the budget available for medium- or low-cost highway investments.

• **Regional bias.** Highway investments in certain geographic sectors can yield disproportionate benefit relative to cost, leaving too little of the budget available for other geographic sectors. For example, projects in highly congested urban areas will typically out-perform suburban and rural projects economically, creating the risk that rural investment will systematically slow urban development to an unacceptable extent.

• **Congestion bias.** Delay-reducing projects often perform better economically than projects to resolve safety or environmental problems do. This better performance creates the risk that congestion-related investments will leave an unacceptably small allocation of available capital for safety and environmental projects.

Reprioritizing the benchmark budget to counter these biases is easily accomplished with StratBENCOST. The reprioritization method involves two steps. (1) Declare sub-budget allocations for specified categories, such as mega-projects, suburban areas, and rural areas. Within each sub-budget, declare target apportionments for congestion reduction, safety improvements, and environmental mitigation. (2) Apply StratBENCOST to rank the contribution of individual projects within the budget constraint of each category (see Table 2).

The Step 1 sub-budgets are inevitably, and correctly, developed subjectively on the basis of judgements about interregional fairness, historical perspective, and so forth. This process is analogous to budgeting at higher levels whereby major allocations are developed for education, transportation, social services, and so forth—all within a total spending constraint. StratBENCOST can be used iteratively and interactively as part of an open process of developing consensus on appropriate sub-budget allocations. Ultimately, however, the allocations are judgmental, reflecting a wide range of state and local priorities.

Step 2 recognizes that although the StratBENCOST benchmark budget is an economic optimum, it unrealistically assumes that economic performance takes precedence over all other considerations, including noneconomic considerations of fairness and balance. The StratBENCOST reprioritized budget provides what economists call a constrained optimization, in which noneconomic priorities are recognized first but economic performance maximized thereafter.

States and localities may have other priorities (for example, highway projects that develop the economy or create employment) that extend beyond StratBENCOST's emphasis on such user cost-related benefits as time savings, vehicle-operating costs, safety, and the environment. However, there is now a broad consensus that projects that withstand the NPV test are the best candidates from an economic development perspective and that StratBENCOST, thus, deals directly with the economic development imperative.

TABLE 1 Benchmark budgeting with StratBENCOST

Descending Project Rank by NPV	Cumulative Project Capital Cost Per Year (in $ millions)	
1	10	
2	25	
3	50	
4	250	
5	275	
6	400	
*	*	
*	*	
112	*	
113	*	
114	1,920	Budget Cutoff Per Year
115	*	
116	*	
*	*	
*	*	Sound Projects Omitted From Budget Per Year
*	*	
120	*	
121	*	
222	*	
223	*	
224	*	
*	*	

As to employment creation, most analysts now agree that projects should pass the NPV test prior to being implemented for employment creation purposes.

ROLE OF ENGINEERING CRITERIA IN THE StratBENCOST PLANNING AND BUDGETING PROCESS

Engineering criteria identify good projects. Economic criteria identify the best among these good projects.

Engineering criteria, such as pavement sufficiency ratings and volume-to-capacity standards, are vital in tracking the condition and performance of highways, in identifying prospective investment opportunities, and in designing specific options.

The StratBENCOST economic criteria, NPV, and rate of return enter the process from a budgeting perspective. The aim is to channel capital resources to their highest and best use so as to minimize user costs and maximize the economic contribution of highway investment within financial constraints.

CASE STUDIES

Ten case studies were conducted using StratBENCOST. The case studies fell into five broad categories on the basis of the type of application. These categories follow.

Single-Segment Improvement Analysis

The single-segment model in StratBENCOST represents a framework for cost-benefit analysis of investments on highway segments that have little interaction with a region's highway network. Typically, evaluation of rural

TABLE 2 Reprioritized budgeting with StratBENCOST

	Urbanized Areas		Suburban Areas		Rural Areas	
Mega-Projects (more than $10 million)	Rank by NPV	Cumulative Capital Cost	Rank by NPV	Cumulative Capital Cost	Rank by NPV	Cumulative Capital Cost
	1		1		1	
	2		2	Sub-budget cutoff	2	
	3	Sub-budget cutoff			3	
					4	Sub-budget cutoff
			18			
	21		20		14	
Congestion Projects	Rank by NPV	Cumulative Capital Cost	Rank by NPV	Cumulative Capital Cost	Rank by NPV	Cumulative Capital Cost
	1		1		1	
	2					
			39	Sub-budget cutoff		
	50	Sub-budget cutoff	40		62	Sub-budget cutoff
	51		41		63	
Safety Projects	Rank by NPV	Cumulative Capital Cost	Rank by NPV	Cumulative Capital Cost	Rank by NPV	Cumulative Capital Cost
	1		1		1	
			2		2	
	67	Sub-budget cutoff				
	68		73	Sub-budget cutoff	89	Sub-budget cutoff
	69		74		90	
Environmental Projects	Rank by NPV	Cumulative Capital Cost	Rank by NPV	Cumulative Capital Cost	Rank by NPV	Cumulative
	1		1		1	
	2				2	
			101	Sub-budget cutoff		
	96	Sub-budget cutoff	102		113	Sub-budget cutoff
	97		103		114	

roads and highway segments in sparse networks fall under this category of analysis.

The improvements on such isolated segments typically improve travel characteristics on the segment for the current vehicular traffic level and for increased vehicular traffic levels. The application does not reflect any effects of the investment on other parts of the neighboring highway network, and, hence, this model should only be applied when regional effects are negligible.

Network-Level Improvement Analysis

StratBENCOST's network model estimates the benefits and the cost-benefit metrics associated with highway investments that are expected to affect traffic and travel over several links on a regional highway network, rather than over just one segment. Typically, major investments that affect a regional scale and investments in urban areas would fall under this category.

Agencies typically maintain regional network models at different times over a 20-year forecast period. Usually, regional metropolitan planning organizations that develop and maintain these models conduct the analysis at 5-year intervals. StratBENCOST interpolates the benefit stream from three discrete times: the base year, the year after construction is completed, and the last year in the analysis period. Thus, network model application highly depends on results from travel demand models.

Alternatives Analysis

This application of StratBENCOST deals with comparing alternative project proposals in the same region from an economic benefits standpoint. The process involves applying StratBENCOST to each of the proposed alternatives separately and then comparing the corresponding cost-benefit metrics among them.

Project-Timing Analysis

The objective of a timing analysis is to evaluate the benefits of accelerating or decelerating a project by scheduling it earlier or later on borrowed money or by some other means of innovative financing. The analysis essentially entails considering whether the additional costs involved with using funds early justifies the additional benefits of advancing the stream of benefits. Traffic growth rate and the levels of traffic factor significantly in this analysis.

Portfolio Analysis

Although StratBENCOST is designed as a model to evaluate individual investments, the model can be applied to evaluate the cost-benefit metrics associated with a portfolio of public highway investments. This application involves classifying the projects in the portfolio into specific groups and applying StratBENCOST to these aggregated groups. This type of an application evaluates the costs and benefits associated with an entire portfolio of projects, rather than evaluating projects individually. This application is useful in analyzing whether a particular regional investment policy is a sound use of public funds.

COPING WITH UNCERTAINTY AND RISK WITH StratBENCOST

Highway user costs reflect both the physical and economic effects of highway performance on highway users. The physical effects are speed, travel time, vehicle-operating performance, accident rates, and environmental emissions. The economic effects hinge on the economic value of time and delay, the cost of operating and maintaining cars and trucks, the amount users are willing to pay for safer roads compared with the amount for other kinds of social progress (that is, the economic value of safety), and the economic value of cleaner air relative to the economic sacrifices required to obtain it.

Uncertainty is the key attribute of both the physical and the economic components of highway user costs. Research is an ongoing process, and uncertainty will always remain. In synthesizing and applying the state-of-the-art research, StratBENCOST uses risk analysis to reflect both what is known and what is uncertain in the effect of highway condition and performance on user costs.

The synthesis provided by StratBENCOST reflects two important steps in the work conducted for NCHRP Project 2-18, "Research Strategies for Improving Highway User Cost-Estimating Methodologies." The first step was to conduct a comprehensive literature review and analysis. The analysis provided both the median estimate for each variable relevant to the estimation of user costs and a probability range that reflected variation in the variable resulting from different methods and data sources. The second step was to present the medians and ranges to panels of experts. The panels engaged in dialogue and made subjective, consensus-based adjustments to the medians and ranges.

Thus, StratBENCOST provides the following:

- A median value for each physical and economic component of user cost and traffic demand,
- A probability range for each physical and economic component of user cost and traffic demand (the probability range reflects the range of possible effects and outcomes in light of uncertainty in each component), and
- A probability range for the NPV and rate of return for each project in light of the uncertainty in all underlying user cost and traffic-demand estimates.

StratBENCOST conducts comprehensive statistical simulations to provide the probability range of each project or portfolio's NPV. The simulations reflect uncertainty in each NPV-calculus factor, including demand.

Thus, StratBENCOST provides important insight for planners and decision makers in honing their benchmark and reprioritized project rankings. Two projects, each displaying an equal NPV, offer unequal promise if one exhibits a materially greater downside risk of low return. This exhibiting can occur, for example, when the traffic forecasts underpinning one project are less certain than another.

Any portfolio has a place for riskier investments; the important thing is to be aware of them and to choose them judiciously. StratBENCOST provides the management information needed to make such decisions wisely and transparently.

ACKNOWLEDGMENTS

This research was conducted under NCHRP Projects 2-18(3), "Development of an Innovative Highway User-Cost Estimation Procedure," and 2-18(4), "Development and Demonstration of StratBENCOST Procedure." It was guided by the projects' NCHRP project panel, chaired by Mr. Walter T. Beckett, with members Gary R. Allen, Kazem Attaran, Asif Faiz, Robert A. Gorman, Dale A. Janik, Richard G. McGinnis, and Mark J. Wolfgram. The contract was undertaken by HLB Decision Economics, Inc., with Dr. David Lewis as the principal investigator.

These **Digests** are issued in order to increase awareness of research results emanating from projects in the CRP. Persons wanting to pursue the project subject matter in greater depth should contact the Cooperative Research Programs Staff, Transportation Research Board, 2101 Constitution Ave., NW, Washington, DC 20418.

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