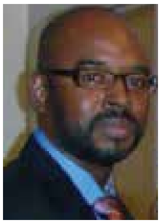

MAP-21 and Bridge Life-Cycle Cost Analysis

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The Moving Ahead for Progress in the 21st Century Act (MAP-21) continues the support of bridge life-cycle cost analysis (BLCCA). The law defines life-cycle cost analysis (LCCA) as "a process for evaluating the total economic worth of a usable project segment by analyzing initial costs and discounted future costs, such as maintenance, user costs, reconstruction, rehabilitation, restoring, and resurfacing costs, over the life of the project segment."

The practice of applying LCCA to transportation decision-making has a long history in the United States. It was first called for in federal law dating back to the late 1950s. Areas of current federal law of particular interest to bridge engineers included by MAP-21 are listed in sections that relate to the development and implementation of a state asset management plan (AMP) for the National Highway System (NHS) in 23 USC section 119, requirements for federally funded bridge projects over $40 million discussed in 23 USC section 106, and bridge performance reporting called for in 23 USC section 150.

In general, a state is to develop a risk-based AMP for the NHS to improve or preserve the condition of the assets and the performance of the system. LCCA and risk management analysis are minimum requirements to be included in a state's AMP. On a project level, states are to perform LCCA as part of the value-engineering study for all NHS bridge projects receiving federal assistance with an estimated total cost of $40 million or more. On a network level, MAP-21 established a National Highway Performance Program that requires states to establish performance targets and report on progress toward achieving those targets. Rulemaking processes for AMP and transportation performance management are currently underway.

This article provides and discusses the BLCCA process in meeting the requirements of MAP-21.

The BLCCA Process

Including BLCCA in the overall decision-making process helps bridge engineers plot a course for bridge performance under budgetary constraints. The BLCCA process involves five basic steps and draws on an understanding of how effective investments in the life cycle of bridges support the achievement of long-term performance goals.

Step 1: Define Alternatives

The first step in the BLCCA process focuses on identifying available alternatives that support the level of service needed. A scenario that includes completing the immediate repairs and maintaining the bridge represents the base case against which proposed alternatives are compared. Alternatives to the base case could include replacing the bridge or replacing the deteriorated components with more-durable products. Another alternative could include accelerated bridge construction techniques such as prefabricated bridge elements and systems discussed in the Federal Highway Administration's (FHWA) Every Day Counts initiative (see http://www.fhwa.dot.gov/bridge/abc/prefab.cfm.)

Step 2: Forecast Performance

Each alternative will provide performance over an expected time horizon; therefore, an understanding of expected performance is needed. The forecasted performance plays an important role in identifying the stream of costs expected over the time horizon of the analysis.

Forecasting future performance is not a science, and many bridge engineers struggle with understanding how to do it. Nevertheless, numerous examples of viable processes exist. Some agencies use past performance trends to provide insights into the future. Others have developed sophisticated algorithms and software tools to assist in this process. One reference is the FHWA's *Bridge Preservation Guide*, which offers guidance on how to apply various proactive measures to postpone advanced deterioration (see http://www.fhwa.dot.gov/bridge/preservation/guide/).

The bridge life-cycle cost analysis includes impact to traffic resulting from work zones. Photo: Federal Highway Administration.

> ### *The Bridge Life-Cycle Cost Analysis Process*
>
> 1. Define alternatives
> 2. Forecast performances
> 3. Estimate life-cycle costs
> 4. Analyze impact of uncertainties/risks
> 5. Recommend an alternative

Many engineers new to BLCCA perceive that there is a challenge to make 75 years' worth of investment decisions today. The goal of forecasting performance to identify probable future costs is not to mandate future expenditures. It is simply a process for making a reasonable investment today based of knowledge, experience, and available technology about expectations of the future.

Most bridge owners have experience with how their bridges perform and can be relied on to provide good guidance on future bridge performance. Complex bridge deterioration algorithms have been proven to serve as good resources as well. The forecasting of performance in the BLCCA provides ample opportunity for capturing new products and technologies in the future that serve to reduce life-cycle costs.

A significant aspect of the BLCCA process is analyzing the impacts to traffic resulting from work zones. This step focuses on estimating the number and demographics of roadway users in the affected traffic streams during construction work zones. This information, typically readily available from state traffic engineering offices, will be used to quantify the impacts on roadway users from the alternative approaches being considered.

Traffic engineers commission specific traffic counts of the numbers and types of vehicles, as well as surveys of vehicle drivers and passengers, to provide insight for use in estimating these impacts. The FHWA offers a guide called *Work Zone Road User Costs - Concepts and Applications*, available at http://ops.fhwa.dot.gov/wz/resources/publications/fhwahop12005/index.htm, that provides guidance on calculating work-zone user costs. Bridge engineers can decide if analyzing the expected impacts to traffic streams can help rationalize the comparative advantages of each investment candidate to identify those that most efficiently provide support for reducing costs to users.

Step 3: Estimate Life-Cycle Costs

Estimating the direct costs to the agency as well as work-zone user costs, involves applying the relevant unit costs to the current and future activities. The costs estimated over the analysis period are discounted to calculate a net present value for each alternative. These amounts can be compared to select the alternative with the lowest life-cycle cost discussed in Step 5.

Step 4: Analyze Impact of Uncertainties/Risks

The analysis is based on many assumptions about the future. Examining the impact of the inherent uncertainties, or risks, on the inputs into the analysis is important. Forecasts of traffic, timing of activities, and impacts on users are not expected to be 100% accurate. Identifying and estimating the variances in those inputs and incorporating the variances into the analysis provide opportunities to make decisions based on statistical outcomes.

This fourth step is crucial in light of past estimates that have left taxpayers questioning why specific estimates were so far beyond planned expenditures. Being able to make investment decisions on the "most likely" outcome leads to better investment decisions. In addition, communicating to key decision makers and the public is more effective with statements such as "Based on our best estimates, this project could result in a 20% cost reduction or as much as a 45% reduction." These ranges of potential outcomes provide more credibility to decisions.

Step 5: Recommend Alternative

The final step involves recommending an alternative that meets the mission of the agency at the lowest life-cycle cost with an understanding of the work-zone user costs that will occur from that alternative.

After engineers have identified projects that best meet individual objectives at the lowest cost, the BLCCA outputs can assist in developing a plan, such as an AMP, or program that supports long-term network goals based on expected funding levels. Specifically, examining the amount of costs of each project provides critical insight in developing a program that maximizes the use of limited funds.

Closing Remarks

Performing an LCCA can enhance the selection of cost-effective solutions for bridge projects. A follow-up article in the Fall issue will provide information on the use of BLCCA tools.