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Accounting for Megaproject Dollars

by Jim Sinnette

Efforts are underway to help improve cost estimating for major highway projects.

Megaprojects present unique challenges when it comes to estimating and managing costs. With these huge projects, which may span decades, the challenges can begin as soon as the project is conceived and often do not end until the books are closed.

According to the *Major Management Challenges and Program Risks: Department of Transportation* (GAO-03-108) report prepared by the U.S. General Accounting Office, "Many large-dollar highway and transit projects have incurred cost increases and schedule delays. Although the Federal Transit Administration (FTA) and the Federal Highway Administration (FHWA) have improved their oversight of large highway and transit projects, additional opportunities exist to improve the oversight of these projects and the approach to funding them."

Caltrans, District 4

The current San Francisco-Oakland Bay Bridge, shown here, is being replaced by a signature span with a much higher cost estimate than the original design proposal for a plain concrete viaduct structure. Photo: Caltrans, District 4.

Congressional and other political leaders, auditing agencies, and the public have been paying additional attention to cost increases on major transportation projects. Although former United States Senator Fred Thompson's *Government at the Brink* book portrays a major project's cost overruns as a lesson for the Federal government, in reality, just over 50 percent of active megaprojects have run over the initial budgets. Given stewardship of the taxpayers' money, it is critical that cost estimates be as complete and accurate as possible if the transportation industry is to maintain the public's trust.

"We spend a lot of money on roads and bridges in this country," says FHWA's Associate Administrator for Infrastructure King W. Gee. "If the cost estimate isn't well done and the cost keeps increasing year to year, the public can easily get the perception

that we aren't managing our program well."

Although cost estimating for megaprojects is inherently challenging, efforts are underway to help project managers estimate costs more accurately at every phase of project delivery.

A Key Component

The importance of an accurate megaproject estimate cannot be overstated because it sets the stage for sound public decisionmaking. News articles and reports show that the public and decisionmakers have expressed frustration after being presented with estimates that increase as the project advances, which is counterproductive for establishing trust and confidence in the project, and the transportation community in general.

Estimates are a key component in establishing accurate performance expectations at each step of the project's development. The public will use the estimate to measure the success of the project, and in a broader sense to measure the general ability of the transportation community to manage transportation projects and programs. "Project leaders must recognize when key decisions are to be made or when key actions are to be initiated so that appropriate and timely estimates are synchronized to reflect the most current project assessment," says FHWA's Deputy Administrator J. Richard Capka.

In smaller projects lower estimates are sometimes offset by higher estimates programmatically. An underestimated megaproject will not have programmatic cover; therefore, it may require significant and adverse program adjustments to offset the impacts. Because of the potentially negative consequences, it is essential to develop reliable megaproject estimates even in the early planning stages.

Although it is important to ensure that megaprojects are not underestimated, a project manager also should not overestimate excessively, which might unnecessarily tie up resources that could be utilized somewhere else. Says Deputy Administrator Capka, "Such is the dilemma associated with the megaproject estimate. Good stewardship of public funds can appear to require a good tightrope walker."

The Difficulty of Estimating

Megaproject estimates are difficult because project managers must provide an estimate, or quantify risk that is associated with short-term to long-term uncertainty, while also trying to be accountable stewards. According to Deputy Administrator Capka, "It's a matter of defining the uncertainty about a project despite the fact that one might argue, 'We don't know what we don't know.'" (See "Megaprojects—They Are a Different Breed" and "Reducing Uncertainty" for examples of the risks and uncertainties associated with megaprojects.)

Scope Creep Adds to Cost

Big projects are sometimes perceived as opportunities for piggybacking additional projects, completing multiple projects, or producing prominent public symbols such as a *signature bridge* rather than opting for a less costly but less prominent bridge design. No matter what the source or motivation, additional scope on a project will add cost to that project.

In 1989, the powerful Loma Prieta earthquake collapsed a 15-meter (50-foot) section of the top deck of the Bay Bridge between Oakland and San Francisco, CA. One car drove off the edge of the gap, crashing onto the lower deck and killing the driver. Although the bridge was repaired in about a month, the earthquake led the California Department of Transportation (Caltrans) to adopt more stringent seismic safety standards that require retrofitting or replacing the Bay Bridge entirely.

Between 1994 and 1996, Caltrans explored options for retrofitting the nearly 60-year-old bridge. "They had about 65 percent of the design done, and the cost estimates were about $900 million," says Nancy Bobb, Bay Bridge project manager for FHWA. Because the retrofitting costs were so high and the bridge

already was so old, Caltrans recommended replacing the 3.5-kilometer (2.2-mile) structure. The original design proposal called for a concrete viaduct structure across the entire span. "This was very bare bones, a 'plain Jane' bridge, at an estimated cost of about $1 billion dollars, which was pretty close to the retrofit cost estimates," says Bobb.

As would soon become apparent, plain Jane was not what the Bay area public had in mind. Instead, the Metropolitan Transportation Commission, with input from the public, chose a signature span bridge. "A signature span bridge is one that is unique and architecturally pleasing, and makes a statement about the community," says Bobb. "The type chosen by the community was a self-anchored suspension span. Very few self-anchored suspension bridges have been built in the world, and especially one of this size. So it's a unique structure, and it presents some challenges for construction and for design. And this is a heavy seismic zone so anything you do is going to be complicated." The new bridge design more than doubled the project cost to $2.6 billion. With additional costs since incurred, this $1 billion megaproject is now approaching $3 billion.

Perils of the First Cost Estimate

The further along a project is, the more detailed and accurate a cost estimate will be.

"Typically, we start out by earmarking some sort of funds, typically on a statewide transportation improvement program or STIP, for a new interchange that's 5 or 10 or 20 years away," says Diane Heckemeyer, State design engineer at the Missouri Department of Transportation (DOT), and chair of a new technical committee for the American Association of State Highway and Transportation Officials (AASHTO) that will focus on cost estimating. "And so you put a ballpark estimate out there to start the process moving. You don't want to guess too high because then you've taken away the ability to study another project, and you sure don't want to underestimate. But the point is that you can't really estimate it because you don't really know what is 20 years out in the future."

Cost estimating can be challenging for any large project, but it can be particularly difficult for megaprojects, defined as those costing more than $1 billion. FHWA's King W. Gee oversees the Major Projects Team, a group of engineers, project managers, and financial specialists at FHWA who work specifically on megaprojects.

This computer rendering shows the span design of the new San Francisco-Oakland Bay Bridge signature self-anchored suspension bridge, which is approaching $3billion according to the current cost estimate.

In the past early estimates were significantly qualified; however, assumptions and caveats reduced the usefulness of the "number" that was generated. On the other hand, decisionmakers, particularly those who must shape and present a program's budget, need a specific "number" that defines the funding requirements. "In the past we haven't done a very good job of expressing that the initial estimate is a preliminary, planning-based number," says Gee. "So the planning-level cost estimate can lead to unrealistic expectations." By analyzing

project risks and using appropriate contingencies, the goal is to be able to create an initial estimate that will not change significantly throughout the project's life.

The difficulty in anticipating all cost elements early in the project often results in a low initial estimate—especially when combined with a dose of management team overoptimism. Many elements may be unknown, so the estimator may avoid assigning a cost to them. And sometimes the estimates are prepared in current-year instead of year-of-expenditure dollars, which also results in an unrealistically low initial figure. A significant problem is that the early cost estimates may be made long before the scope of the preferred project alternative has been identified.

Most disturbing is when someone intentionally underestimates the initial cost in order to improve odds that the project will be approved for implementation. Regardless, it is important to make every effort to make the initial cost estimates as realistic as possible by trying to assign costs to the many unknowns.

"Deceit is not an option, nor should lowballing ever be considered when putting together an estimate," says Deputy Administrator Capka. "Decisionmakers deserve to have accurate estimates that enable them to make informed decisions and to be good stewards of taxpayers' investments."

Capturing a Clearer Picture

Once the project moves into the environmental review process, public interest increases, and often the cost does, too. "At this stage the project may be enhanced in a number of ways to make it more compatible with the surroundings," says Heckemeyer, "so the costs can very easily grow."

As early as possible, it can help to involve the entire project team in identifying potential design through construction issues that may affect costs. "We have everybody looking at the project, from traffic, environment, design, right-of-way, and construction" says Heckemeyer, "so we know what we're committing to."

During the design stage, costs can increase significantly as the engineering analysis uncovers issues or constraints that were unknown during the planning stage. The silver lining at this stage is that finally cost estimates may start to become more reliable.

This computer rendering shows the future Woodrow Wilson Bridge, which will carry I-495 over the Potomac River south of Washington, DC. The bridge superstructure work was broken into three separate contracts, which reduced costs and increased bidding competition.

The Engineer's Estimate

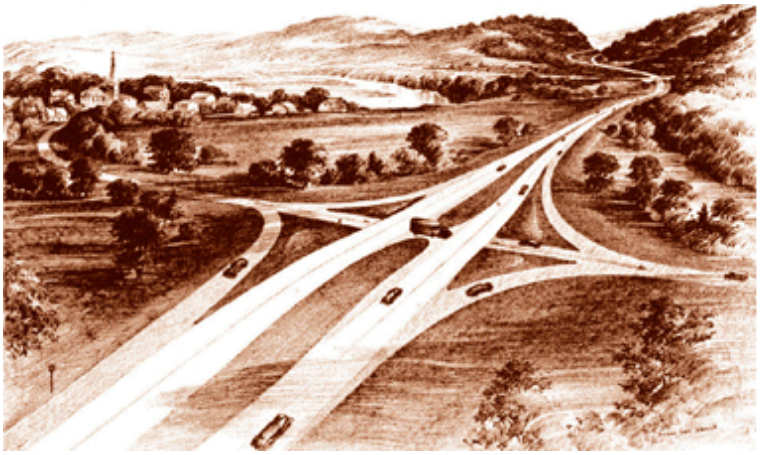
When a project is fully designed and ready to be put out to bid, the engineer's estimate is made. This estimate is usually very specific, based on a complete design. "The plans are all done. You know as much as you can about the project," says Heckemeyer, who is a former engineering estimator herself. "It's a very different animal than the earlier estimates in which you are trying to predict out into the future."

However, a dose of forecasting still is required to assess the impact of a megaproject's influence on the construction environment. Megaprojects and their procurement strategies can have a substantial impact upon the region's construction bidding climate. There are many unknowns for putting together an engineering estimate for an entire project.

Nevertheless, the price tag still can increase if contract bids come in higher than the engineering estimate. This increase could occur because of unanticipated market influences, such as those that occurred on the Bay Bridge project. "There are a lot of bridge construction projects underway in the Bay area, so that resulted in higher bids," says Bobb. "And for the first large contract of our project there were only two bidders. The engineers' estimate was about $800 million, and the low bid was about $1.04 billion, a difference of about 30 percent."

Even in this situation, however, there may be ways to reduce costs. When bids came in too high for the Woodrow Wilson Bridge project, a 12-kilometer (7.5-mile) corridor connecting Maryland to Virginia by a bridge over the Potomac River, the project manager put together a team of engineers and contractors to see how the work could be split up into smaller pieces. "After all of the smaller projects were bid, the amount ended up less than the original estimate," says Gee.

However, there's a flip side to creating multiple contracts as well. By breaking up the project into several contracts, the owner faces the additional risk of managing the coordination and interfaces between the separate contracts and the ripple effect of delays. This long-term risk should be assessed and calculated into the overall estimate.



This artist's conception of an interstate highway showed a grade crossing on a four-lane highway, which conformed to the standards that were approved in 1945. Note the left-turning deceleration and standing areas adjacent to the median strip. For the ultimate megaproject—the interstate system—the original 1955 cost estimate was $27 billion for the whole system, but the actual cost rose to $129 billion.

During construction itself, costs also can increase as "surprises" turn up. For example, old utility lines that were not documented anywhere may seem to appear out of nowhere.

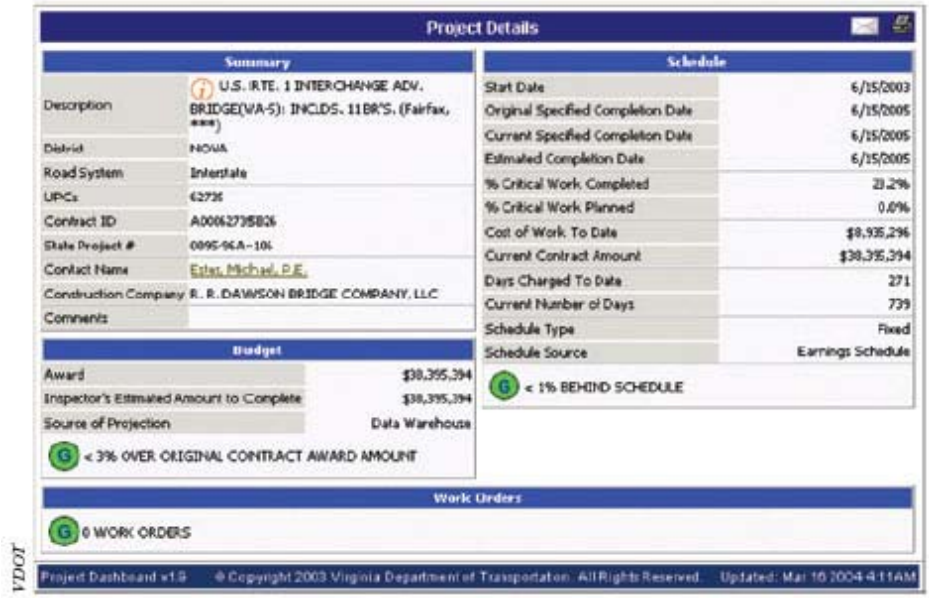
In general, when it comes to estimating costs, the more you know about a project, the better your estimate will be. "Let's say I've decided to build a new house," says Heckemeyer. "If I ask the builder how much it's going to cost, but I can't tell him anything about the house I want, then what kind of figure is he going to give me? But if I can tell him I want a three-bedroom house with [186 square meters] 2,000 square feet with Jacuzzi® tubs in all the bathrooms, then I'll get a better estimate."

Cost Increases, Old News

Uncertainties, risks, and cost increases are not recent phenomena for major transportation projects. In 1955, the original cost estimate for the interstate

highway system was $27 billion for construction of a 66,010-kilometer (41,000-mile) network. By 1958 the cost had increased to $37 billion. Five years later it increased by an additional $4 billion, and by 1965 it had increased yet again to a total of $46.8 billion. Ultimately, building and upgrading the now 68,897-kilometer (42,793-mile) system has totaled about $129 billion.

Many factors increased the costs over the years. They include inflation, additional mileage, and upgraded standards to meet safety, operational, and environmental needs.



The "Project Details" screen on VDOT's Dashboard Web site enables managers and the public alike to view the status of a project, including the current schedule and budget.

Today, even though transportation agencies have advanced computer tools, information-sharing capabilities, and increased experience, it seems that there has been little improvement in cost estimating. For example, 23 of 30 large transportation projects analyzed by the General Accounting Office experienced cost increases of 2 to 211 percent, with costs on about half of these projects increasing by 25 percent or more.

Perhaps one complicating factor may be the expectation today that projects be highly responsive to constituents' needs. "I don't think this process is the same one our predecessors had," says Heckemeyer. "There's a lot more interest in having a context-sensitive solution and something that's environmentally friendly and multimodal, and that will provide economic development opportunities. There are a lot of factors that I don't think were considered 50 years ago."

Improving Communication

Poor communication may be contributing to some of the perceptions, or in some cases, misperceptions regarding cost increases. "We, as an industry, need to be open and clear in communicating cost issues to the public," says Gee. "The contingencies and the assumptions underlying them need to be communicated clearly. If we can do that, then the public may not feel that there have been so many surprises as the project advances."

The Virginia DOT (VDOT), for example, is proactively working to reduce the surprises in construction projects by providing information to the public via a user-friendly Web site called Project Dashboard. Based on the concept of a vehicle's dashboard, the site offers citizens and VDOT staff project information at a glance. By accessing the site, users can see whether a project's final contract amount is expected to be over or under the original contract award, and by how much. Because VDOT updates the data as the project moves forward, the public can follow a project from the beginning of construction through completion, monitoring for themselves how the cost and schedule change.

Tips to Improve Cost Estimating

Developing Estimates

- Prepare cost estimates in *year-of-expenditure dollars*, inflated to the midpoint of construction, with some allowance for schedule slippage.
- Engage a deliberate process of assessing project risk and ensure that the estimate reflects the probability of encountering those risks.
- Caveats and assumptions that normally accompany estimates must be "converted" to dollar figures that quantify the effect of the associated risks.
- Build reasonable *contingencies* into the cost estimate, including cost growth (1) during construction, (2) at different levels of design, (3) for overall management, to account for third-party and other unanticipated changes, and (4) for other areas that may show a high potential for risk, such as environmental mitigation, utilities, or highly specialized designs.
- Consider the *economic impact* on the local geographical area. For example, material manufacturers that would normally compete may be "forced" to team together to meet the demand for the project. Extremely large construction packages also have the potential to reduce the number of contractors capable of bidding and may need to be broken up into smaller contracts to attract additional competition.
- Perform a *value analysis* to determine the most economical and advantageous way of packaging the contracts for advertisement.
- Incorporate an objective and independent review of the estimate into the development process.

Keeping the Estimate Current and Accurate (Reporting Cost, Schedule, and Status)

- Report on a *periodic basis* (at least monthly) and be as accurate and upfront as possible concerning cost changes and schedule delays.
- Include reasons for *deviations*, impacts resulting from the deviations, and initiatives being implemented to recover any cost overruns or schedule delays. Also report on the transfer of costs to and from contingency line items, including reasons supporting the transfers.
- Include *speculative cost changes* that may develop in the future, a quantified dollar range for each, and the current status of the speculative change. Also, provide a comparison analysis to show that reasonable and sufficient contingency funds remain to keep the project within the latest approved budget.
- Track and report on areas and reasons for cost growth, and use that data to improve *future cost estimates* on major projects.
- *Integrate* the master program schedule for major projects, tying the individual contract milestones to each other.

The Local Politics of Cost Increases

In addition to attracting the attention of the public and leaders at the national level, another political reality of cost increases on megaprojects is that they can pit one State project against another. Each State is allocated a certain share of Federal dollars, and if the bulk of that is for a major project, an increase in costs will take a bigger bite. "Typically what we see in this country is about a 5-percent increase on a highway project because of additional work or unexpected conditions," Gee says. "So 5 percent of $100,000 isn't a whole lot of money. But on major projects, these 5-percent increases could be $50 million." This $50 million might have been able to fund a number of other State projects.

Taking on a megaproject can be risky, because once a major investment has been put into the project, it is difficult to stop.

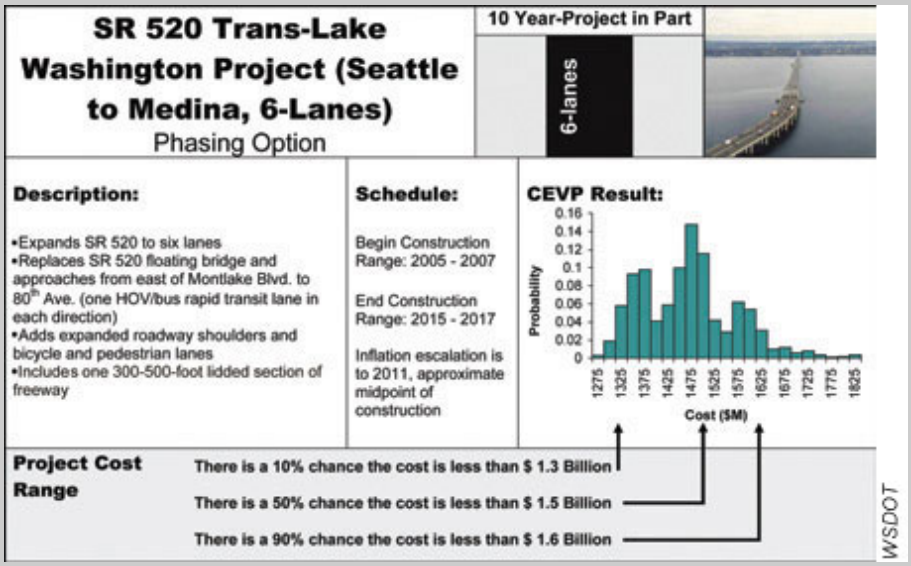
A rendering of the new San Francisco-Oakland Bay Bridge at night. Cost overruns on mega-projects can draw State and Federal dollars away from other projects.

WSDOT Develops CEVP™

Washington State DOT (WSDOT) has created a multifaceted process to improve cost estimates and address risk assessment, called the Cost Estimate Validation Process (CEVP). Under CEVP, three teams—the project team, the CEVP team, and the administrative team—gather project-related information and conduct rigorous analyses of the data.

The project team is composed of a project manager, engineer, designer, environmental coordinator, scheduler, CEVP team leader, and perhaps—the most critical player—a cost estimator. The project team estimates the cost based on the proposed design.

Next, the CEVP team conducts a peer review of the cost estimates, bringing a fresh perspective. Participants in the CEVP team generally include a certified cost engineer, a decision and risk analyst, a risk modeler, and technical writer. Their task is to model the risks that may develop during the project. The single-figure cost estimate provided by the project team becomes a range of estimates tied to the risks and opportunities.



Washington State DOT's Cost Estimate Validation Process (CEVP) team helps create project summaries such as this one to clearly relay project

schedules and cost estimates to stakeholders and the public.

The administrative team manages the logistics and documentation to ensure that the other two teams work as smoothly as possible under high pressure in an environment that requires fast thinking and creativity.

"The process is extensive and rigorous," says Jennifer Brown, WSDOT's program manager for cost risk estimating and management.

When the process is complete, a detailed report and a one-page summary sheet provide key information at a glance. The media, legislators, citizen committees, and any interested members of the public can view the summary sheets, which include the following information:

- Benefits of the project
- Cost estimates expressed as a range, rather than as a single number
- Construction schedules expressed as a range of dates
- Risks that could affect the cost or the schedule
- A bar graph showing the probability of the occurrence of the risks associated with the costs

To maximize benefits, the use of CEVP should be iterative and an integral part of the project delivery process. In fact, most projects would be well served if managers used CEVP at key decision/commitment points to capture changes that result from managing risk identified in earlier CEVPs and to plug new information into the process.

CEVP is among several programs available today that other States can consider when looking for innovative approaches to improve their own cost estimates. WSDOT took an unusual step for State government by placing a trademark on CEVP. "We registered CEVP for two reasons," says Brown. "First, WSDOT wants acknowledgement for sponsoring the development. Second, we want to ensure that the term is not loosely applied in other cost review procedures that contain anything less than the tools and controls we incorporated in CEVP."

In addition to its other benefits, CEVP appears to be a useful tool for communicating with the public. An editorial in the June 9, 2002, edition of the *Seattle Post-Intelligencer* reported that "the Department of Transportation has performed an unprecedented public service with these latest cost estimates ... [which] were made more accurate by factoring in inflation over time, potential environmental and seismic requirements ... even possible litigation costs."

WSDOT has used CEVP to refine estimates on 15 large-scale projects with estimated costs ranging from approximately $200 million to $11 billion. Only time will tell how reliable the new CEVP estimates will be. Regardless of the outcome, the effort itself is a testimony to the public that WSDOT is making an earnest effort to capture accurate projections. To learn more about CEVP, visit www.wsdot.wa.gov/projects/cevp.

Tools to Improve Cost Estimating

Despite some of the inherent challenges, nearly everyone agrees that improvements can be made in how cost estimates for megaprojects are prepared, monitored, and revised. (See "Tips to Improve Cost Estimating").

Several agencies and organizations are working to improve state-of-the art estimating for megaprojects. The Major Projects Team serves as a resource for FHWA division offices responsible for megaprojects. One of the team's specific tasks is to develop guidance for estimating costs for major projects. "We're taking the lessons learned for cost estimating from about a dozen major projects and putting them together to provide some guidance to share with States," says Gee.

The Major Projects Team also is conducting risk management workshops that help division offices put what they know on the table and helps them judge how big the risks are. "We're putting the responsibility on our local divisions to be

knowledgeable about the local issues when they work with their State," says Gee.

The Transportation Research Board's National Cooperative Highway Research Program (NCHRP) is developing other guidance. NCHRP Project 8-49, *Procedures for Cost Estimation and Management for Highway Projects During Planning, Programming, and Preconstruction*, will result in a guidebook on highway cost estimation.

An AASHTO Cost Estimating Technical Committee also will be developing guidance on cost estimating for all highway projects. "We're going to build off of the NCHRP guidebook," says Heckemeyer, "and identify some of the best practices going on throughout the DOTs."

New methods and tools also are being developed to help in cost estimating, including Washington State's Cost Estimate Validation Process (CEVP). (See "WSDOT Develops CEVP") In addition, the AASHTO software program "Trns*port Estimator" includes several modules related to cost estimating. (See also "Other Cost-Estimating Resources in the Transportation Community" below.)

Other Cost-Estimating Resources in the Transportation Community

A number of other organizations and agencies are engaged in cost-estimating activities. Examples of State DOT tools and guidelines include:

- Maryland DOT State Highway Administration's Consolidated Transportation Program Cost Estimate Program (www.sha.state.md.us/businesswithsha/costEstBudgets/CTP/oppe/consolidated_trans.asp)
- California State DOT Project Development Procedures Manual (www.dot.ca.gov/hq/oppd/pdpm/pdpm.htm)
- New Jersey DOT Construction Cost Estimation Manual (www.state.nj.us/transportation/eng/CCEPM)
- Florida DOT 2002 Transportation Costs (www11.myflorida.com/planning/policy/pdfs/TransCost.pdf)
- The Transportation Estimators Association (http://tea.cloverleaf.net)
- Trns*port User Group (TEA/TUG) (http://tug.cloverleaf.net)—an independent association of State DOT personnel involved in cost estimating
- NCHRP Report 20-7, Project Cost Estimating: A Synthesis of Highway Practice (www4.trb.org/trb/crp.nsf/All+Projects/NCHRP+20-07), dated June 2003, provides a summary of current highway cost-estimating practices.
- TRB's Transit Cooperative Research Program, *Managing Capital Costs of Major Federally Funded Public Transportation Projects*, is focusing on cost estimating for public transit.
- The FHWA Office of Planning (HEP) is collecting cost-estimating practices and approaches used by State DOTs and metropolitan planning organizations and will post examples on HEP's Web site.

Benefits of an Independent Review

Significant investment decisions will be made based on the megaproject cost estimate. Decisionmakers and managers will rely on an impartial and objective assessment of costs prior to making decisions. At times, a second, independent assessment may enhance the process.

Although there are certain risks associated with producing two estimates—such as two strikingly different numbers that may become the source of future controversy—the effort might be very worthwhile. Corroborating estimates through independent reviews adds more credibility to the estimate and can be very encouraging to decisionmakers, because the reviewers would not have a significant stake in the results, thus dispelling the possibility of intentional misrepresentation.

Differing estimates must be reconciled and the process of reconciling them can produce a deeper understanding of the challenge that lies ahead for the project team. By using an independent assessment, the management team will have demonstrated a genuine interest in providing objective and quality information to decisionmakers.

The Bottom Line

The main purpose in generating an estimate for any project is to provide managers and decisionmakers, at any stage of project development, with reliable information that will enable them to make quality decisions, to manage the project effectively, and to reach accurate assessments of project progress. Although producing a reliable project estimate is much more challenging for a megaproject, it is the bottom line against which public trust and confidence will be measured.

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