LOCAL TRANSPORTATION AGENCY COST ESTIMATING PRACTICES: A CASE FOR IMPROVEMENT

Daren T. Grilley, P.E.

A Thesis Quality Research Project
Submitted in Partial Fulfillment of the
Requirements for the
Masters of Science in Transportation Management

June 2009

MINETA TRANSPORTATION INSTITUTE
San José State University
San José, CA 95192-0219

TABLE OF CONTENTS

List of Figures

List of Tables

Acknowledgements

The author wishes to thank each of the transportation professionals who contributed their time in responding to the research survey. A list of these individuals is included in Appendix D. Special thanks are due to Rod Diridon, Dr. Peter Haas and the faculty and staff of the Mineta Transportation Institute. I also wish to thank Ray Tritt, P.E., Chief of Caltrans' Office of Special Projects, for his assistance with this project. Most importantly, I thank my wife, Anne, for her support and encouragement throughout my education and career.

ABSTRACT

Transportation infrastructure represents a significant expenditure of taxpayer dollars. Inaccurate cost estimates have been a concern for officials and the public for generations. The problem is highlighted by a few recent examples that have gained national and worldwide attention, but the problem also exists on a smaller scale at the local level. There has also been much interest in these issues from professional organizations, university researchers, and Congress in recent years. In addition, to address cost estimating inaccuracy, many large transportation agencies have recently adopted new or updated policies and implemented process improvements for how they prepare, review, and manage cost estimates. While prior studies have focused almost entirely on estimating by federal agencies, states, or large regional transportation districts, this paper provides a review of the estimating practices of cities and counties. Particular attention is given to reviewing the factors that lead to inaccurate cost estimates in order to identify areas where local agencies may consider implementing improvements.

INTRODUCTION

Transportation projects are highly visible, directly impact the daily lives of most citizens, and are typically paid for with public tax dollars. It is no surprise then that the public pays attention to how these projects are developed and constructed. Project features that garner attention include the location, design features, environmental impacts, and construction inconvenience. One particular aspect that often generates public interest and discussion is the cost of the project.

Effective decision making requires reliable and accurate estimates. Transportation projects, such as bridges, roads and intersections, are very expensive and represent a significant investment by the public. Funds available for transportation are limited and, to make the most efficient use of these dollars, projects are often selected by comparing the benefits of the project to its cost. Therefore, the accounting of both sides of the benefit-cost equation must be as accurate as possible.

Estimates are a prediction of the actual cost of a project and there are numerous factors, both internal and external to the agency, that can lead to inaccurate estimates and cost overruns. Some factors can be controlled or minimized and others are beyond the agency's control. Some factors can be predicted, while others may take the agency by surprise. Whatever the cause, inaccurate estimates result in the inefficient use of resources and can delay projects or disrupt an agency's plans for other projects if funds run short. Inaccurate estimates can also damage the reputation of the agency and erode support for future projects or funding requests.

Most studies of these issues have focused on large-scale, so-called *megaprojects* undertaken by large agencies such as state departments of transportation (DOTs) and special transportation districts. Megaprojects exceed $100 million and cost into the billions of dollars. Because of their magnitude, these projects rightfully receive much attention from elected officials, regulators, researchers, the media, and the public. In a 2003 report to Congress, the Government Accountability Office (GAO) testified that "while many factors can cause costs to increase…costs increased, in part, because initial cost estimates were not reliable predictors of the total costs or financing needs of projects" (Hecker 2003). The GAO testimony offered several options for improving the reliability of estimates, including establishment of cost estimate performance standards, increased federal oversight of the estimating process, and requiring states to track and periodically report updated project costs compared to a baseline cost. In response to the growing concern and criticism over increasing cost estimates, as well as actual construction costs that significantly exceeded those estimates, several DOTs have made changes to their estimating practices to improve accuracy and rebuild public confidence.

Cost estimate inaccuracy can also occur on the countless smaller-scale projects that cities and counties build every year. This paper provides a look at the cost estimating practices for several local agencies with the objective of developing an understanding of how estimates are prepared and the accuracy that results. In doing so, areas for improvement can be identified where agencies may be able to adapt the strategies and tools being used by larger agencies for improving cost estimating accuracy.

Organization of this Report

The following section provides a very brief overview of the fundamentals of cost estimating, including common approaches to estimating at different stages of project development, the primary factors that influence cost, and the issue of uncertainty in estimating. The next section presents a review of literature relevant to the topics of cost estimating accuracy, accounting for risk and uncertainty, and cost estimating procedures for transportation projects. This is followed by a survey and analysis of current cost estimating practices used by local agencies large and small in California, Oregon, and Washington. The final section presents a conclusion, identification of best practices and possible strategies for improving cost estimating, and recommendations for future research.

BACKGROUND

Cost Estimating Fundamentals

For the benefit of readers not familiar with common cost estimating methods and terminology, it may be useful to begin with a brief overview of some cost estimating fundamentals that will be discussed throughout the paper. The Association for the Advancement of Cost Engineering

(AACE) defines an *estimate* as a prediction or forecast of the resources (e.g., time, cost, materials) required to achieve or obtain an agreed upon scope for an investment, activity or project. Estimates are used in deciding what projects to build and when to build them. Estimates are used to determine short and long-term revenue needs, and for preparing project-level and organizational budgets. Estimates are used to establish traffic impact fees for new development. Estimates also provide a benchmark for evaluating construction bids and are the basis for cost control and performance measurement of the project.

There are two basic, broad categories of estimating methods: conceptual and detailed. *Conceptual estimating* is described as a "top down" approach and is most often used when comparing and selecting alternatives or preparing long range plans that require an "order of magnitude" estimate when little is known about the project. Conceptual estimates are often used to seek outside funding such as grants and for budgeting purposes when the project is ready to begin design. Conceptual estimates are frequently prepared using *parametric* methods involving a comparison (ratio) of a project parameter, such as lineal feet of roadway, square foot of bridge deck, or number of intersections, to historical costs for similar projects, using the same parameter. Conceptual estimates may also be prepared using published cost indices for projects of certain types and adjusting for project location and size, however, the use of indices for completed facilities (rather than components such as material or labor costs) is far more common in the building industry than transportation. Conceptual estimates are relatively quick to prepare and less costly to produce than detailed estimates, but they are prepared when many details about the project are still unknown and require the estimator to make several assumptions about the project. Because they are produced with less specific information, and rely on close similarity to the historical data used, conceptual estimates are less accurate than detailed estimates.

Detailed estimates are usually prepared once a project has been selected and the engineering design is underway. In fact, during the course of design, several detailed estimates are produced at various stages of design development (e.g., 30%, 60%, 90%), leading ultimately to the engineer's estimate that is produced prior to bidding the project for construction. Detailed estimates (sometimes called "cost-based" estimates) are prepared from the "bottom up" and are based on the expected cost to perform each individual component of work that is required to complete the project. As the design progresses, much more is known about the site, the design features, the quantities of materials needed to build the project, and even current market conditions. Costs for the work items may be based on historical bid data for each particular item or on an "actual cost" basis, taking into consideration the amount of labor, materials, overhead, and profit required for each item of work. Each successive detailed estimate for a project should produce a progressively more accurate cost estimate. "The smaller the element of a work package, the more accurate the overall estimate is likely to be" (Gray 2008). However, there is a cost associated with seeking perfection. Excessive detail is time consuming and costly, while insufficient detail produces poor accuracy. The challenge for the estimator is to find the right balance between detail and uncertainty (Carr 1989).

Some of the key factors that affect project costs include inflation, scope changes, site conditions, soils, groundwater, buried utilities, hazardous materials, environmentally sensitive areas such as wetlands or species habitat, season/weather conditions, market conditions/competition, labor availability, cost and availability of materials, complexity or uniqueness of work, traffic conditions, and special restrictions on when the work may be performed. This is a long list, but certainly not exhaustive. Some factors are known or predictable early in design (e.g., site conditions) while some may not be discovered until construction (e.g., utilities). Some factors are controllable (e.g., scope changes) and some are beyond control (e.g., weather).

Uncertainty

Even the most detailed estimate is still a prediction and all estimates have some degree of risk and uncertainty. Traditionally, uncertainty is addressed by adding contingency to the base estimate. *Contingency* is a budget allowance to cover the cost of unanticipated minor changes during design (i.e., risk costs). Contingency is not intended to cover major scope increases in the project. There are a number of ways to determine the amount of contingency to add to the project. It may be a percentage of the base estimate set by policy for all projects, an amount determined by the engineer based on her/his experience, or determined by computer simulation of the project-specific risks. The contingency amount is generally larger early in the design, when the number of unknowns is greatest, and is adjusted downward at each successive stage of development leading to the final design, at which time the design contingency should be reduced to zero and a construction contingency budget is established to cover unanticipated costs that may occur during construction. If the contingency amount is set too high, it may lead to poor cost control during design or prevent the project from being started if it seems infeasible. However, if the contingency is too low, the project budget may be too constrained to achieve the objectives of the project (Wideman 1983). Efforts by some larger agencies to refine the quantification and accounting of uncertainty will be discussed later in this paper.

Accuracy

Estimate accuracy is a measurement of the difference between the estimate and the actual cost of the project. The estimate is most often represented as a single dollar amount. However, it is important to understand that the actual cost lies within a theoretical range of probable costs, either higher or lower than the estimate. Like contingency, the predicted variance, or confidence range, of the estimated cost to actual cost is greater as the project begins and is progressively reduced as the design is developed and more is known about the project. Federal Highway Administration guidance suggests that the final engineer's estimate should be within ten percent of the low bid for at least half of the projects an agency awards (FHWA 2004). Figure 1 illustrates common accuracy ranges for each stage of project development as a set of curves about a central axis representing the estimated cost. At any given stage of design development, the actual cost is expected to fall within these two curves. Most references suggest a higher upper limit (e.g., upper limit of +75% and lower limit of -40%) in the early stages of development, indicating a greater likelihood that the actual cost will be higher than the earliest conceptual estimate. By the time the design is complete, the actual cost (or low bid) should, in theory, have an equal probability of being under or over the engineer's estimate.

Other Considerations

Other basic principles of cost estimating that affect the accuracy and reliability of cost estimates include: ensuring the estimate is complete and includes all major work items, documenting the assumptions made during design and the sources of cost information, regularly updating the estimate, and ensuring costs are either within budget or obtaining approvals for changes (Carr 1989; Martin 1999).

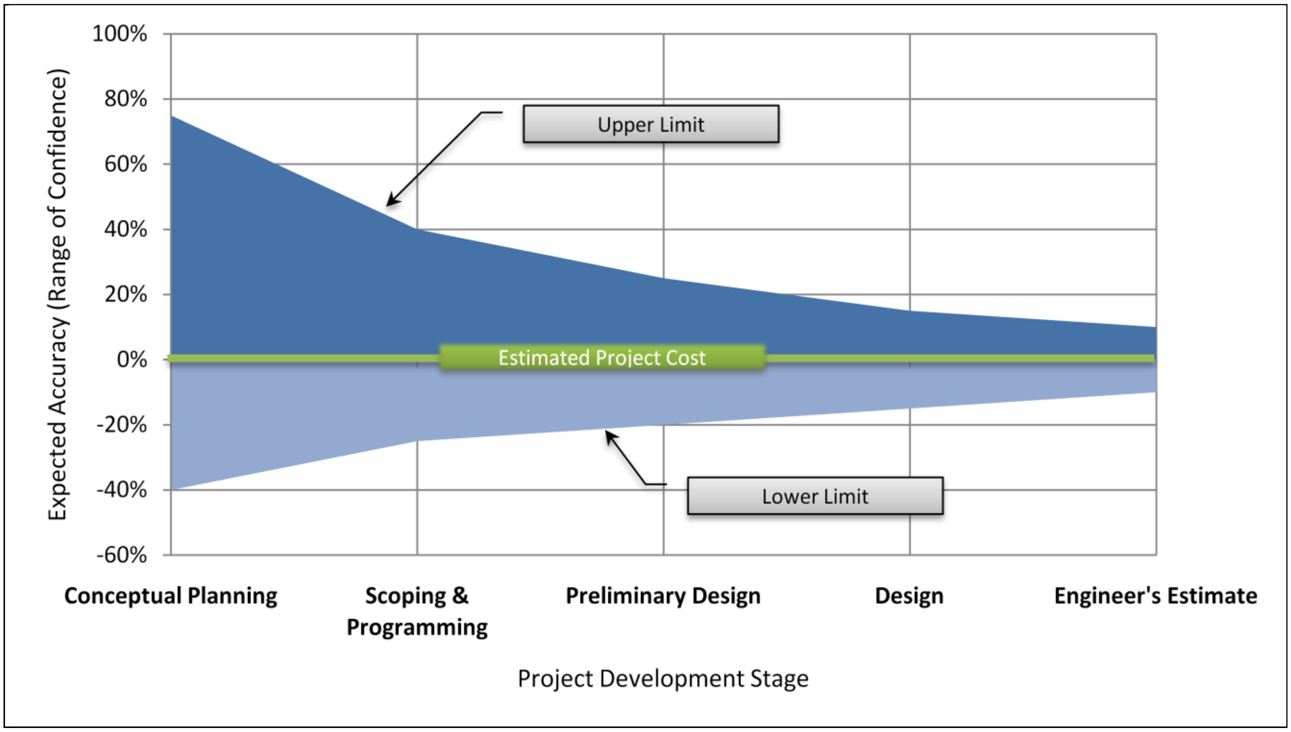

Figure 1 Estimate Accuracy Envelope, Pre-Construction (after Wideman; Martin)

LITERATURE REVIEW

While much has been written about the practice of cost estimating for the building industry, there are far fewer current studies specific to transportation project cost estimating. Though most works dealing with transportation emphasize the very expensive megaprojects constructed by large transportation agencies, many of the issues encountered are also experienced with smaller scale projects constructed by local agencies. This review includes several recent papers and guidelines prepared by practicing engineers and estimators, professional organizations, university researchers, and government agencies. Several textbooks and older studies were also reviewed. The review is organized into specific issues related to cost estimating practice and accuracy.

A Tradition of Underestimation and Public Skepticism

A notorious example of cost underestimation is the Boston Central Artery and Tunnel project. Commonly referred to as "The Big Dig", the Central Artery and Tunnel is described as "the largest and most complex highway and tunnel project in the nation's history"[1]. A 1986 cost estimate projected the cost to be under $3 billion. At the time construction began in 1990, the estimate had doubled to $6 billion. The project was completed in 2007 with a final cost of around $14.8 billion—more than twice the pre-construction estimate and five times more than the preliminary estimate (Molenaar 2005).

The books and studies reviewed clearly indicate that cost estimate inaccuracy is not a new phenomenon. In fact, elected officials, project financiers, and the general public have been concerned with project cost estimate inaccuracy—specifically underestimation—for several generations. The Suez Canal was completed in 1869 at a cost three times greater than the final estimate prior to construction, and 20 times higher than the original estimate (Flyvbjerg et al. 2002). The Holland Tunnel was completed in 1927 at a final cost four times greater than its 1919 estimate (Schexnayder 2003). The Bay Area Rapid Transit system (BART) was estimated at $996 million in 1962 and was completed ten years later at a cost of $1.6 billion—a sixty percent overrun (Merewitz 1972). The projected cost of the San Francisco-Oakland Bay Bridge East Span replacement project, currently under construction and scheduled for completion in 2013, has tripled from $1.85 billion in 1997 to $5.5 billion in 2004[2].

[1]www.masspike.com/bigdig (Accessed May 26, 2009)
[2] www.baybridgeinfo.org (Accessed on May 24, 2009)

An apparent pattern of underestimating has lead to strong public skepticism in the ability of government agencies to produce accurate estimates. A 2006 article in the LA Daily News discussed a Metropolitan Transit Authority (MTA) board meeting at which additional funds were appropriated for three Caltrans highway projects. Referring to several increases in estimated project costs over a six year period, one MTA board member stated, “It looks like whatever you tell us that you want, we give you. Do you have someone who knows how to estimate?” (Doyle 2006). An article in The Bellingham (Washington) Herald described the reaction to a forty percent increase in the estimated cost of an intersection roundabout project. Several elected officials expressed “disappointment” in the cost increase. One council member stated, “I think we’re probably going to have to go ahead with it, but I think it’s a lesson learned” (Taylor 2007). However, this notion that agencies learn from the “lessons” of underestimation has been called into question by recent studies, most notably by Danish researcher Bent Flyvbjerg, now a professor at Oxford. Flyvbjerg’s research has focused on the reasons for inaccurate estimates for megaprojects. He finds that, despite the long history of underestimation and accompanying criticism, no apparent progress has been made in the ability to improve estimate accuracy. A study by Flyvbjerg and others (2002) of 111 transportation projects completed between 1910 and 1998, determined that there was no reduction in the magnitude of cost underestimation over time. This study also examined over 250 transportation projects from around the world, totaling $90 billion, completed between 1920 and 2000. The study concluded that ninety percent of these transportation projects were underestimated. Road projects were typically twenty percent higher than estimates. All transportation projects, including rail and bridges, were twenty-eight percent higher on average. Most significantly, the study concluded that underestimating has not decreased in the past century. Such results serve to reinforce the skepticism of many taxpayers.

In his text on cost estimating practice, Stewart (1982) describes how credibility can be gained or lost by the performance of an agency's estimating and states that, "the cost estimating policy of a company or government organization will have a definite effect on its reputation." Merewitz (1972) describes how the questions of BART cost overruns "sold a lot of newspapers and started an attitude of criticism toward the BART District." This year, nearly four decades after Merewitz's study, the Seattle Times published a story about the Washington State Department of Transportation's (WSDOT) cost estimates for a planned highway tunnel under downtown Seattle that will replace an aging freeway structure called the Alaskan Way Viaduct. The story centers around a statement by the head of WSDOT that "there won't be any cost overruns" on the project. The columnist, who draws parallels between the tunnel project and Flyvbjerg's studies, asserts that "[WSDOT officials] know this tunnel is going to cost more, probably far more." (Westneat 2009). It is interesting to note that WSDOT overhauled how it performs cost estimates in 2002, in part based on Flyvbjerg's study of that same year. The 2009 cost estimate is actually still within the estimate range presented by WSDOT seven years earlier. The agency's cost estimating practices will be discussed in a later section of this paper. This situation demonstrates not only how past performance by an agency can affect public attitudes for years to come, but also how errors made by some government agencies can affect how other agencies are viewed.

Factors that Influence Cost, Accuracy, and Error

In order to develop methods to improve cost estimating accuracy, it is necessary to understand the causes of inaccuracy. The background section of this paper introduced some of the factors that influence the cost of a project and that can lead to cost escalation during design. Anderson and others (2007) have compiled a list of eighteen fundamental causes for cost inaccuracy and divided them into two groups—internal and external. These factors are listed in Table 1 below.

Table 1 Factors Causing Cost Escalation of Projects

Source	Factor
Internal	1. Bias
	2. Delivery/Procurement Approach
	3. Project Schedule Changes
	4. Engineering and Construction Complexities
	5. Scope Changes
	6. Scope Creep
	7. Poor Estimation
	8. Inconsistent Application of Contingencies
	9. Faulty Execution
	10. Ambiguous Contract Provisions
	11. Contract Document Conflicts
External	1. Local Concerns and Requirements
	2. Effects of Inflation
	3. Scope Changes
	4. Scope Creep
	5. Market Conditions
	6. Unforeseen Events
	7. Unforeseen Conditions

* Note: these factors are numbered for reference only. The numbering does not indicate a level of influence.

Source: Anderson et al.; Reprinted as permitted by Cooperative Research Programs.

In their cost estimating guidebook prepared for the Transportation Research Board, Anderson's group developed a set of eight strategies that agencies can use to overcome or minimize these factors. These strategies include improved management of the estimation process, implementing control and change management processes, better assessment and accounting for risks, thorough documentation of the project scope, and ensuring that checks and balances are in place to minimize bias and maximize accuracy (Anderson et al. 2007). Many of these concepts have been the focus of other researchers and some are discussed in this paper.

Going a step beyond identifying the factors that influence cost estimate accuracy, Oberlender and Trost (2001) determined the relative importance of these factors. Their study collected data on 67 projects totaling $5.6 billion with the objective of developing a system for predicting and improving the accuracy of early cost estimates. Forty-five elements that directly impact or indirectly influence cost estimate quality were analyzed. The 45 elements were organized into four divisions: 1) who was involved in preparing the estimate, 2) how the estimate was prepared, 3) what information was known about project at the time the estimate was prepared, and 4) the factors considered while preparing the estimate. The researchers ranked the four divisions in order of their influence on the accuracy of estimates, as shown in Table 2 below.

Table 2 Influences on Estimate Accuracy

Division	**Relative Influence on Estimate Accuracy**
What was known about the project?	38.6%
How was estimate prepared?	23.5%
Factors considered	21.8%
Who was involved?	16.1%

Source: Oberlender and Trost, 2001

Their analysis also produced a relative ranking of the importance of eleven more specific factor groups that impact accuracy. They concluded that the most important factors are the design of the project, the estimating team's experience and quality of available cost data, the time allowed for preparing the estimate, the site requirements, and the bidding and labor market conditions (Oberlender and Trost 2001). Figure 2 illustrates the importance of each of what Oberlender and Trost refer to as the "drivers of estimate accuracy".

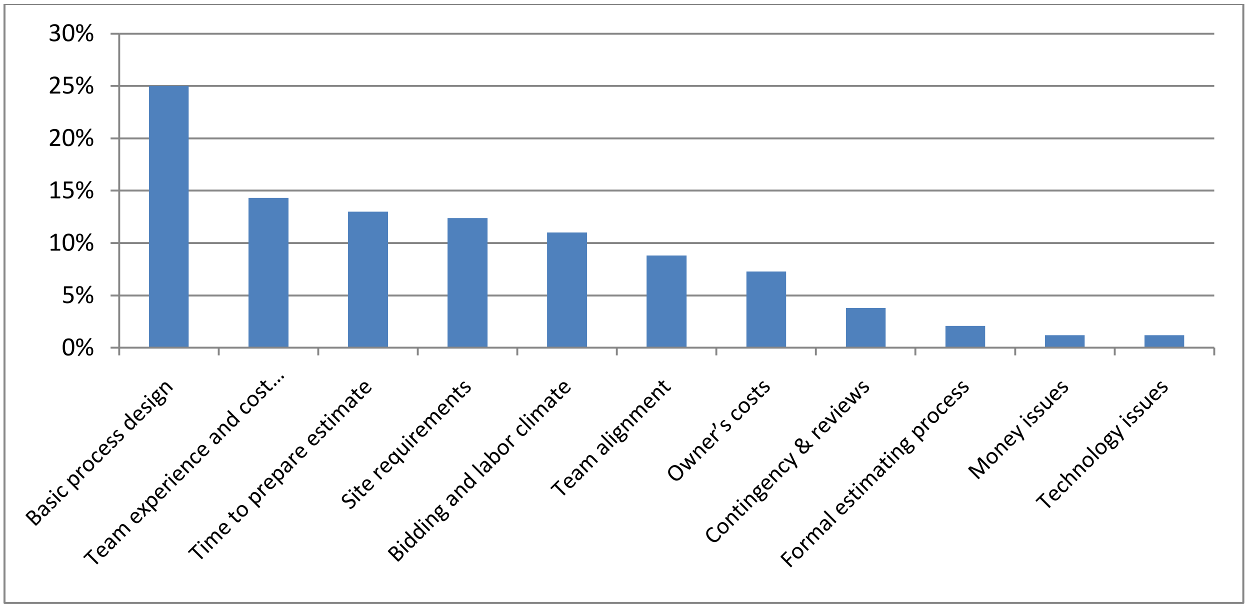

Figure 2 Drivers of Estimate Accuracy (Oberlender and Trost 2001)

Oberlender and Trost's project also developed a software application that allowed estimators to rank their project and, by comparing to a database of similar projects, produce a predicted level of accuracy for their estimate. If the predicted level of accuracy is less than acceptable, the estimator can use the feedback to refine and improve the weaker aspect(s) of the estimate. While the software is not yet readily available and may not be suitable for all agencies, the Oberlender and Trost study provides valuable insight into the relative importance of the factors that affect cost estimate accuracy. The estimator can then prioritize efforts to improve accuracy and control costs by focusing attention on "cost drivers" that have the greatest impact and spend less time on issues that have little impact (Sundaram 2008).

Another study, prepared by AbouRizk and others (2002), sought to determine the level of accuracy for estimates prepared for various stages of project development for Edmonton, Alberta. The objective was to compare actual accuracy levels against the city's expected accuracy percentages. The data involved 213 projects over a three year period, totaling $220 million (CAD). Technical factors, such as those in the Oberlender and Trost study were not identified. Instead, the study found that the desired accuracy levels were generally not achieved due to unrealistic target accuracy ranges and/or variability between the estimating practices used by the engineers (AbouRizk et al. 2002).

Flyvbjerg et al. (2002) also looked beyond the technical reasons for cost estimating errors in their approach to explaining the causes of cost underestimation. Specifically they wished to determine whether inaccuracies are best described as “errors” or “lies”. They divided the sources of inaccuracy into the following four categories: 1) technical errors, 2) economic interests, 3) psychological bias, and 4) political interests.

Technical errors are due to problems with how the estimate is prepared, such as poor estimating techniques, honest mistakes, or inexperienced estimators. However, they argued that the data from the hundreds of projects studied show that the “substantial resources spent over several decades on improving data and methods” have made no impact on accuracy, and therefore technical factors are not a leading cause of error (Flyvbjerg et al. 2002).

Flyvbjerg describes two types of *economic interest* factors that lead to underestimation: self interest and public interest. First, are intentional underestimates that are made out of economic *self-interest*. Because projects create work for engineers and contractors, these stakeholders benefit financially; thus, there is an incentive for these parties to bias the outcome to favor the project moving forward. The second type is economic manipulation in the *public interest*. This involves officials approving the project with a deliberately underestimated budget in order to create an incentive to cut costs and thereby save the public's money" (Flyvbjerg et al. 2002). This is also discussed below in the section on cost control.

Psychological bias in an estimate stems from the "mental state" of the estimator. "Engineers like to build things," and some politicians aspire to build monuments or empires (Flyvbjerg et al. 2002). Flyvbjerg suggests that perspectives such as these can lead to overly optimistic cost estimates. A study conducted thirty years earlier also supports this notion. Hufschmidt and Gerin (1970) reviewed projects of three large federal agencies and recognized the potential for what they called *institutional bias*, where an agency's philosophy to build as many projects as possible may encourage some estimators or project proponents to intentionally lower cost estimates in order to skew benefit-cost analyses. Flyvbjerg and others categorize bias as "self-deception" and consider it an error rather than a lie. However, they surmise that because estimates are typically prepared by highly qualified estimators, psychological bias is not likely to be a significant factor for most estimates. In later studies, Flyvbjerg uses the terms "optimism bias" (Flyvbjerg and Cowi 2004) and "delusion" (Flyvbjerg 2009) to describe psychological bias. Appraisal optimism, in which project proponents are overly optimistic about the project outcome during the planning stages, is likely the most common form of psychological bias (Flyvbjerg and Cowi 2004). Hufschmidt and Gerin suppose that if agencies and estimators are made aware of the potential for bias, it could perhaps be balanced or offset by the "legitimate professional pride of estimators in a task well done" (Hufschmidt and Gerin 1970). However, citing a study by Kahneman and Tversky[3], Flyvbjerg dismisses that supposition and says that "errors remain compelling even when one is fully aware of their nature" (Flyvbjerg 2006). Instead, he recommends that a new

[3] Kahneman, D., and Tversky, A. (1979). "Intuitive prediction: Biases and corrective procedures." Studies in the Management Sciences: Forecasting. Amsterdam.

risk management "culture" be developed at both the local and regional level and should be communicated to the public. This culture should involve mandatory risk identification workshops, use of statistical scenario analysis to analyze risks, and use of independent estimate reviews. The emphasis should be on getting estimates right, discriminating between good and bad cost estimates, rewarding those who produce realistic estimates and penalizing those who do not (Flyvbjerg and Cowi 2004).

The category of *political interests* suggests that estimates are intentionally manipulated to serve the interests of elected officials or other project promoters whose primary objective is to get enough funding for the project to be started. Flyvbjerg later describes this as *strategic deception* (Flyvbjerg 2009). Because this is "lying", Flyvbjerg points out it is difficult to accurately gauge how common this situation is—few would ever openly admit to doing this. However, Flyvbjerg's team does refer to other studies[4] to support their conclusion that the pattern of underestimation in the projects studied cannot be explained by error, but is "best explained by strategic misrepresentation". In other words, "lying to get projects started" (Flyvbjerg et al. 2002). One example Flyvbjerg offers is the case of manipulating cost estimates in order to obtain grant funding. When an agency applies for grant funds, it is competing with other agencies for a limited pool of money. The agencies that distribute grant funds try to allocate funds to projects that have the greatest benefit-cost ratio and, by underestimating the costs, the project appears more competitive. It is presumed that once a project is underway, it is then relatively easy to obtain additional funds (Flyvbjerg 2009).

[4] Wachs, Martin (1990). "Ethics and advocacy in forecasting for public policy." Business and Professional Ethics Journal 9 (141-157); and World Bank. "Economic analysis of projects: Towards a results-oriented approach to evaluation.

Accounting for Uncertainty

The importance of early estimates stands in contrast with the lack of information available to prepare an accurate estimate. The project budget is established based on an estimate made when the least is known about the project. The lack of information often creates an estimate that is significantly different from the final engineer's estimate, but those early estimates remain the benchmark that many observers will use for comparing future estimates (Oberlender 2001). Flyvbjerg et al. acknowledge that it is difficult to forecast specific technical problems for a particular project, but counter that it "is possible to predict the risk based on experience" and this risk should be properly accounted for in the estimate (Flyvbjerg et al. 2002). AbouRizk and others believe that most municipalities underestimate the inherent uncertainty associated with estimating and, until improvements are implemented, "it is prudent that we understand our limitations and be realistic in gauging uncertainty in cost estimating" (AbouRizk et al. 2002). Molenaar agrees, stating that "cost estimates should transparently convey the true nature of uncertainty involved with the project at each stage of the process" (Molenaar 2005).

There are numerous ways to determine the amount of contingency to add to the base estimate. The most straightforward and consistent method is to apply a policy-specified percentage of the base cost to all agency projects, or all projects of a particular type (i.e., roadway, bridge, etc). The weakness with this approach is that it does not consider unique risks that may be present. Instead of a one-size-fits-all, policy-based approach, another method involves the use of professional judgment on a project-by-project basis to set the contingency percentage depending on the size and complexity of the project. This method can account for special risks or uncertainty, but relies on a skilled estimator to accurately determine the contingency. In either case, a percentage contingency is applied to the overall project. Wideman (1983) calls this the "big pot" approach; all potential uncertainty is thrown into one big pot instead of taking a more advanced approach of considering probable uncertainty of each item of work. Hufschmidt and Gerin (1970) suggest that contingency factors should not be used as a substitute for detailed cost estimating, but a more refined approach should be applied on an element-by-element basis depending on the uncertainty of that work item. Engineers should publicly convey the project's risks to all stakeholders and raise awareness and understanding of the limitations of the cost estimate (Molenaar 2005).

Estimate Review and Risk Analysis

Reilly and others (2004) describe the development and implementation of a comprehensive estimate review and risk assessment process called the *cost estimate validation process* (CEVP). The process was developed by the Washington State Department of Transportation (WSDOT) and a team of consultants in 2002 in an effort to build public confidence in the agency as it prepared to initiate several large, high-profile projects. WSDOT recognized that traditional estimating practices did not adequately communicate the nature of preliminary estimates, uncertainty, or inflation and resulted in misunderstandings with elected officials as well as the public. The agency had typically presented "best case" estimates as a single dollar amount in current year dollars. The problem is illustrated by the State Route 167 extension project between Seattle and Tacoma. The early planning stage estimate for the project was $150 million, but rose to over $970 million by the preliminary design stage (Reilly et al. 2004). The CEVP approach avoids use of single number estimates in favor of a range of probable values that reflects the level of uncertainty—especially early in design development when the number of unknowns are greatest. Hufschmidt and Gerin (1970) also suggested this approach, stating that "when information is not adequate to reduce uncertainty, or is too costly to obtain, estimates should be presented in ranges."

The CEVP approach involves a comprehensive, "element-by-element" expert peer review of the project cost estimate that is performed by an independent, external group. The group is composed of experts from specialized engineering and construction backgrounds. This step is intended to remove the potential bias that the design team may have introduced into the estimate and ensure that all aspects of the project have been properly accounted for. The review process is conducted in a workshop format beginning with a presentation of the project scope, basis of estimate, and estimate contingencies. The review team follows a specified procedure to review and adjust the original estimate to arrive at a realistic base cost estimate. Contingency is not included in the base cost estimate. Instead, a subsequent risk analysis workshop is conducted to determine the range and probability of potential cost increases due to "risk events", or cost savings through "opportunity events". The risk analysis workshop involves identifying and characterizing potential risks and opportunities, defining the likelihood of their occurrence, and then analyzing the risks and base costs using simulation modeling. Figure 3 below illustrates how a typical range of probable costs is presented using what is referred to as a *probability mass diagram* (Reilly et al. 2004).

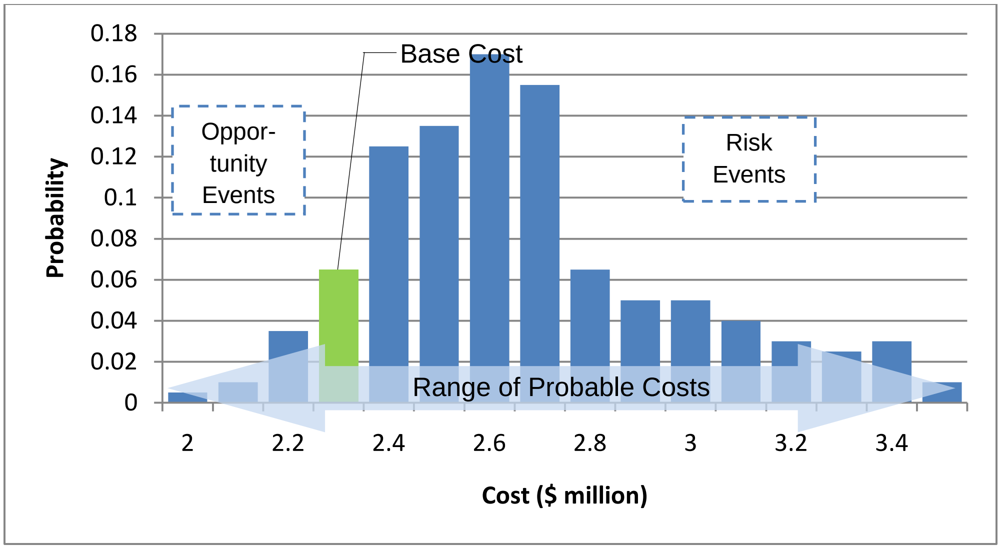

Figure 3 Presentation of Probable Cost Range (after Reilly 2004)

In the example shown above, the base cost estimate is $2.3 million and there is an 80% chance that the cost will be between $2.4 and $3.1 million. According to Reilly, the use of probability mass diagrams by WSDOT to communicate probable cost ranges to the public was effective and, after recovering from the initial “sticker shock”, was well received by the public and the media (Reilly et al. 2004). Indeed, when WSDOT first presented updated, CEVP-based cost estimates, the June 4, 2002 Seattle Times headline read, “*Washington State Cost Estimates for Highway Projects Skyrocket*” (Pryne 2002), while an editorial later that week praised the updated estimates, calling the new approach a “much-needed dose of fiscal reality” (Seattle Post-Intelligencer 2002). In his review of the CEVP methodology, Molenaar (2005) concludes that the use of range estimates is a better approach to communicating costs and risks with project stakeholders than the use of single point estimates that are “unrealistic and quite easily manipulated at the conceptual stage of planning”. He observes that, although CEVP provides technical benefits and improves public confidence through better managing funds, the process is expensive, time-consuming and often relies on contracting with expert consultants and a significant investment of time in developing probabilistic risk analysis models. Therefore, he suggests that the use of such analysis be considered on a case-by-case basis (Molenaar 2005).

Estimate Documentation

In order to correctly use an estimate, one must understand its purpose, the stage of project development at which it was prepared, and the assumptions made by the estimator in preparing it. Documentation also provides continuity of data as management of the project may change hands during the life of the project. The importance of documentation in monitoring and controlling costs is emphasized in several works. The Association for the Advancement of Cost Engineering (AACE) describes the *basis of estimate* that documents the project scope, schedule, funding, potential risks, estimating methodology, and other essential information about the estimate (AACE 2007). Westney (1985) summarizes the three main components that make up the basis of estimate. *Design basis* is the technical description of the project; essentially a definition of what is to be constructed. For early estimates, the estimator must make assumptions about the basic features of the design, such as how many lanes a roadway will have or what bridge type will be selected. The *planning basis* describes the project schedule, milestone dates, contracting method to be used, and productivity rates. Finally, the *cost basis* includes material unit prices, labor costs, and cost escalation factors. Estimates are also used as historical data in the preparation of future cost estimates. Having good documentation of the basis of estimate, assumptions, information sources, and other factors used in developing the estimate at each design stage assists future estimators in making appropriate use of the estimate data (Sundaram 2008). Consistency is essential because the estimate is used as the basis for important business decisions and so must be in a format that is easily understood, verified, and updated (Anderson et al. 2007). A complete basis of estimate document is a required component of a cost estimate and by itself can allow "any person with capital project experience to understand and assess the estimate" (AACE 2007).

Cost Control during Design

Cost control is a process for controlling costs and preventing unauthorized changes to the project scope (Wideman 1983). The AACE defines *cost control* as the "application of procedures to monitor expenditures and performance against progress of projects", and "to measure variance from authorized budgets and allow effective action to be taken to achieve minimum costs." The early cost estimate often becomes the benchmark for cost control during the design phase; therefore it is important to make the estimate as complete as possible to reduce the amount of change as the design progresses. Changes to project scope are a leading cause of cost overruns and, in fact, cost control is also referred to as *change management* (Gray and Larson 2008). Westney provides a definition of *change* as an item of work "which would not ordinarily be assumed to be required to complete the original scope" of the project. He describes a framework for cost control through periodic review of the three elements of the estimate basis. This process includes reconciling the current scope and estimate with the previously authorized scope and estimate and analyzing the variations in each category—design, planning, and cost (Westney 1985). This process discourages unnecessary or unauthorized scope changes and provides a tool for communicating the origins of additional costs when budget increases are justified. Sundaram (2008) believes that the measure of a project's success is how well it sticks to the conceptual budget and he emphasizes the importance of keeping the scope aligned with the budget. "The designer should continuously monitor design decisions that affect cost" and, at a minimum, review and reconciliation should take place at each significant stage of design development. Rather than seeking approvals for scope changes, he describes a process that calls for making "wise trade-offs between scope, quality, and cost to stay on budget" (Sundaram 2008).

Cost Control through Underestimation: Another Source of Error

In contrast to some studies that encourage providing sufficient contingency to allow for uncertainty and prevent cost overruns, Merewitz states that "anticipating overruns in cost estimates leads to laxity in cost control" and that "keeping costs low is more important than estimating costs correctly" (Merewitz 1972). This is echoed by Wideman, who suggests that a *target cost* be established that the engineer must design to. He suggests that this "design-to-budget" approach will "motivate the designer to make cost effective decisions" (Wideman 1983). Others argue that artificially lowering estimates will ultimately result in cost overruns. Even Sundaram, who advocates strict adherence to the budget, warns that the budget should *not* influence the estimated prices; the estimator must avoid manipulation of numbers to satisfy the owner (Sundaram 2008). Flyvbjerg discusses this possible manipulation of cost estimates on behalf of the public's economic interest. This theory suggests that agency management or elected officials may "deliberately underestimate costs in order to provide an incentive to cut costs and thereby save the public's money" (Flyvbjerg et al. 2002). Flyvbjerg refers to this type of manipulation as a "noble lie"—a lie that is supposedly told for the public good. He goes on to flatly reject the effectiveness of this approach, arguing that unrealistically low cost forecasts skew the benefit-cost analysis for the project and lead to development of projects that should not be built and thus waste taxpayer money. Further, he insists that manipulating cost estimates—for any reason—is a violation of the public trust.

Establishing Principles and Guidelines for Estimating

Hufschmidt and Gerin (1970) observed that “there is an opportunity to reduce errors by improving planning methods and cost estimating techniques”. Carr (1989) noted that the field of financial accounting follows *generally accepted accounting procedures* (GAAP), but the field of cost estimating lacks such a universal guide for good estimating practice. Stewart (1982) speculates that one explanation for a lack of standardization in cost estimating practices in the private sector is due to the competitive nature of the business. Consultants and contractors are reluctant to share proprietary methods that may help give an advantage. However, he suggests that this obstacle can be overcome to help develop a standardized approach that will lead to “realistic and comparable cost estimates” (Stewart 1982).

In his paper, Carr (1989) lays out seven principles of estimating including the need to produce realistic estimates; use of the appropriate level of detail for each stage of project development; providing a complete estimate of all work items and their costs; documentation of the project scope, conditions, methods of construction, assumptions and calculations; inclusion of all direct, indirect, fixed, and variable costs; and accounting for uncertainty with the appropriate level of contingency. Carr expressed a desire that this list would motivate a discussion in the profession that would lead to a set of *generally acceptable cost estimating principles* (Carr 1989).

Wideman states that written policies and procedures are an “essential part of project control” and are needed to ensure organizational consistency (Wideman 1983). He discourages the use of “wordy” manuals and instead suggests that general objectives and firm policies should be stated simply and that estimating processes should be depicted with flowcharts and diagrams. Many state DOTs and government agencies have since developed cost estimating guidelines that include such process flowcharts, along with checklists outlining the agency's estimating practices.

Minnesota Department of Transportation

In late 2008, the Minnesota Department of Transportation (Mn/DOT) launched an initiative to improve their cost estimating practices. This ongoing effort includes establishing policies and guidance as well as producing a manual and training program for estimators. The benefits Mn/DOT hopes to achieve with this initiative are "improved delivery of projects, better use of available resources, greater credibility with the public and other stakeholders, and the satisfaction that comes with more efficiently and effectively meeting public needs"[5]. The improvement initiative has produced several tools to assist estimators and project managers, including checklists and spreadsheet templates that are available from the department's website. The most significant tool developed is the Mn/DOT Cost Estimation and Cost Management Technical Reference Manual. This 500-page manual disregards Wideman's recommendation for brevity, but does contain a wealth of policies, flowcharts, templates and other tools intended to help the department achieve accuracy, accountability, and consistency in cost estimation throughout all stages of project design development.

Caltrans

The Caltrans Project Development Procedures Manual (PDPM) includes a brief chapter on project cost estimating policy and procedures. Specifically, this guide outlines the department's

---

[5] Mn/DOT Cost Estimation Process Improvement Vision Statement, http://www.dot.state.mn.us/cost-estimating/pdf/vision-statement.pdf (accessed February 19, 2009).

estimating goals and objectives, staff roles and responsibilities, estimating methodologies, document formats, requirements for monitoring and updating, and policy-based contingency levels for cost estimates at various stages of design development (Caltrans 2006). A recent study of planning level cost estimates by the Caltrans Committee Task Force on Cost Estimating assessed the effectiveness of the project cost estimating process described in the PDPM by comparing preliminary estimates to the final engineer's estimates. Though there had not been a previously established performance expectation, the study found that most projects were within an "acceptable" difference of 20% (Caltrans 2008). The task force developed the following new performance expectations: planning estimates should be within 20% of engineer's estimates, the engineer's estimates should be within 10% of the low bid, and the final cost should be within 5% of the contract award amount. Additional recommendations were made regarding document formatting standards to ease monitoring and future analysis.

Washington State Department of Transportation

As mentioned previously, WSDOT recently overhauled its estimating procedures resulting in the development of the Cost Estimate Validation Process (Reilly et al. 2004). While the CEVP approach is typically reserved for very large, complex, or controversial projects, the department also has a comprehensive Cost Estimating Manual for all projects. The purpose of this manual is to provide a consistent approach to cost estimating policies and procedures, estimate preparation, risk assessment, review, documentation, communication and management of estimate data (WSDOT 2008). Figure 4 illustrates the estimating process from project initiation through final engineer's estimate. The 40-page manual presents policies and guidance for each of the steps shown and also includes standard templates and links to additional resources.

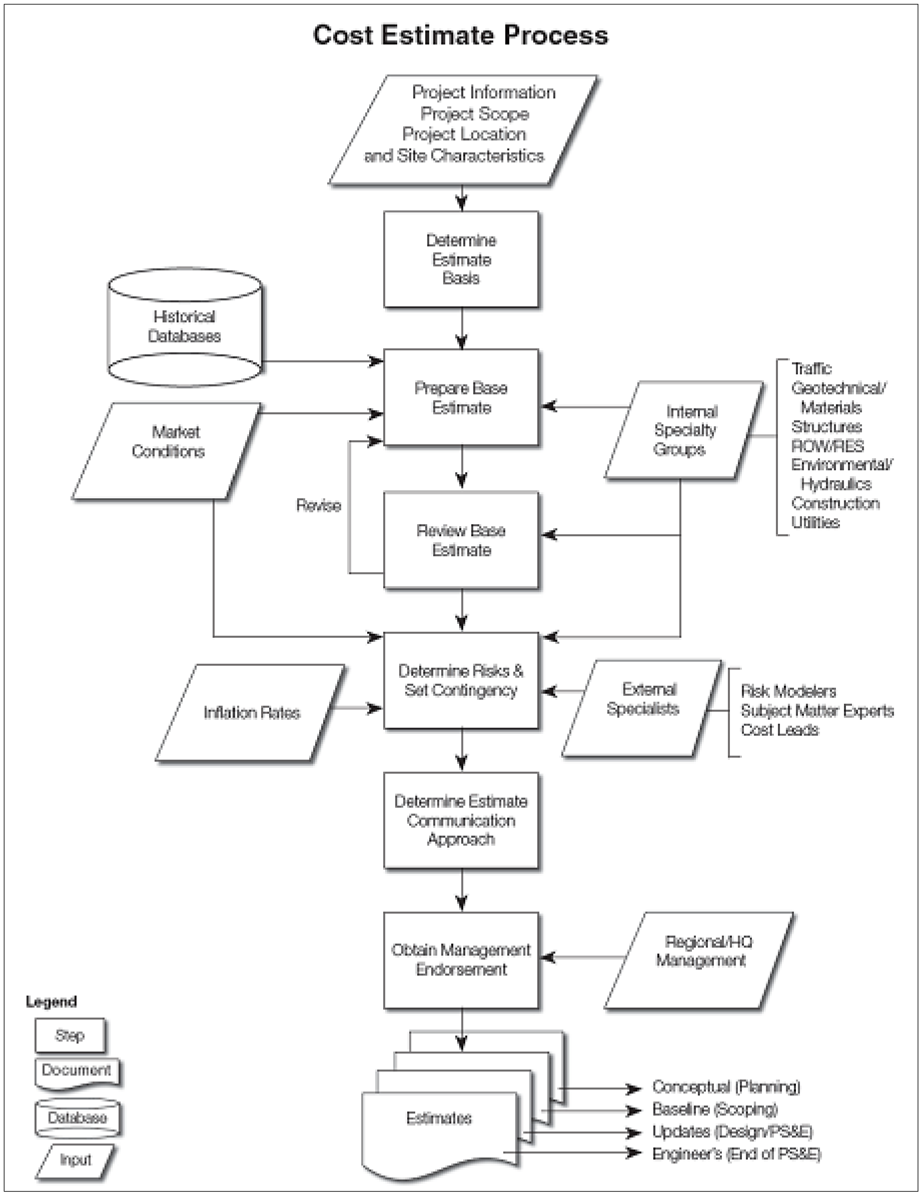

Figure 4 WSDOT Cost Estimating Process (WSDOT 2008)

City of Sacramento Department of Transportation

In 2007, the City of Sacramento adopted its Project Delivery Manual in an effort to improve on-time/on-budget delivery of transportation projects. The manual outlines Sacramento's project delivery policies and procedures, roles and responsibilities of staff, quality control processes, and quality standards and also serves as a training tool for new employees. In preparing the manual, the department used the opportunity to review and clarify their existing policies and incorporate industry best management practices. The manual describes the “project report” that documents the basis of the estimate—defining the project need and purpose, scope of work, funding source, anticipated right-of-way needs, environmental impacts, and utility relocation needs. The Project Delivery Manual describes the preferred estimating methodologies, how each aspect of the project should be considered in the estimate, how risks should be documented, and what levels of contingency should be applied. The manual also includes standard forms for the estimate and checklists for quality control, estimate reviews, and approvals.

Contra Costa County Transportation Authority

The Contra Costa Transportation Authority (CCTA) is a regional public agency formed by voters in 1988 to manage the county's ½-cent transportation sales tax program and to perform transportation planning throughout the county. The CCTA implemented cost estimating guidelines over a decade ago and have updated them regularly, most recently in 2008. The Cost Estimating Guide is a 30-page document that “sets out a consistent framework for estimating project costs at the conceptual level” (CCTA 2008). The objective is to produce more accurate estimates that will allow project proponents (cities, towns, and transit operators) to establish reliable funding plans for their projects and allow CCTA to adequately program project funding. The guide describes *conceptual* and *detailed* estimating methodologies and when they are appropriate to use. The guide outlines procedures for preparing both types of estimates, including how to calculate material quantity take-offs, where to find historical unit cost data (e.g., Caltrans), and how to account for land, engineering, and contingency. CCTA also provides spreadsheets and other templates for agencies to use in preparing consistent cost estimates.

Transportation Research Board

NCHRP Report 574, *Guidance for Cost Estimation and Management for Highway Projects During Planning, Programming, and Preconstruction,* was produced in 2007 under the National Cooperative Highway Research Program (NCHRP) administered by the Transportation Research Board (TRB). The guidebook presents a strategic approach to cost estimation to "overcome the root causes of cost escalation and to support the development of consistent and accurate project estimates through all phases of the development process" (Anderson et al. 2007). The guidebook identifies challenges related to developing accurate cost estimates and the primary causes of cost escalation. The authors then present the following eight "global strategies" for addressing the challenges:

- Management strategy
- Scope & schedule strategy
- Off-prism strategy: engage external participants
- Risk strategy
- Delivery & procurement
- Document quality
- Estimate quality
- Integrity

The guidebook is organized by project development phase, with each chapter describing how the eight global strategies should be implemented for that particular phase. The guide presents a very high-level framework that is general enough to be applied to most transportation agencies. The guidebook appendices also include examples of estimating tools and templates from several state DOTs, addressing issues such as budget control, documenting and communicating estimates, estimating methodologies, ensuring consistency, estimate review, and management of risk and change.

Government Accountability Office

One of the roles of the US Government Accountability Office (GAO) is to assist Congress in providing oversight of how federal funds are expended. The GAO recognized that reliable cost estimates are critical to budgeting and managing capital projects and without that ability, agencies may encounter cost overruns and fail to meet performance expectations. In March of 2009, the GAO published the Cost Estimating and Assessment Guide, a compilation of generally accepted best practices in cost estimating and cost management. The objective of the guide is to present a methodology based on best practices and can be applied consistently across agencies. To illustrate certain cost estimating and management issues, the guide includes dozens of case studies. Because the guide is intended for a wide range of agencies (e.g., military, space, health and human services), not all material may be applicable to traditional transportation projects.

The guide presents the following list of basic characteristics of credible cost estimates:

- Clear identification of the task
- Broad participation in preparing estimates
- Availability of valid data
- Standardized structure for the estimate
- Provision for program uncertainties
- Recognition of inflation
- Recognition of excluded costs
- Independent review of estimates

The guide also outlines a process for producing reliable cost estimates, shown in Figure 5 below, and includes chapters on developing a work breakdown structure (WBS), dealing with risk, validating estimates, and managing program costs.

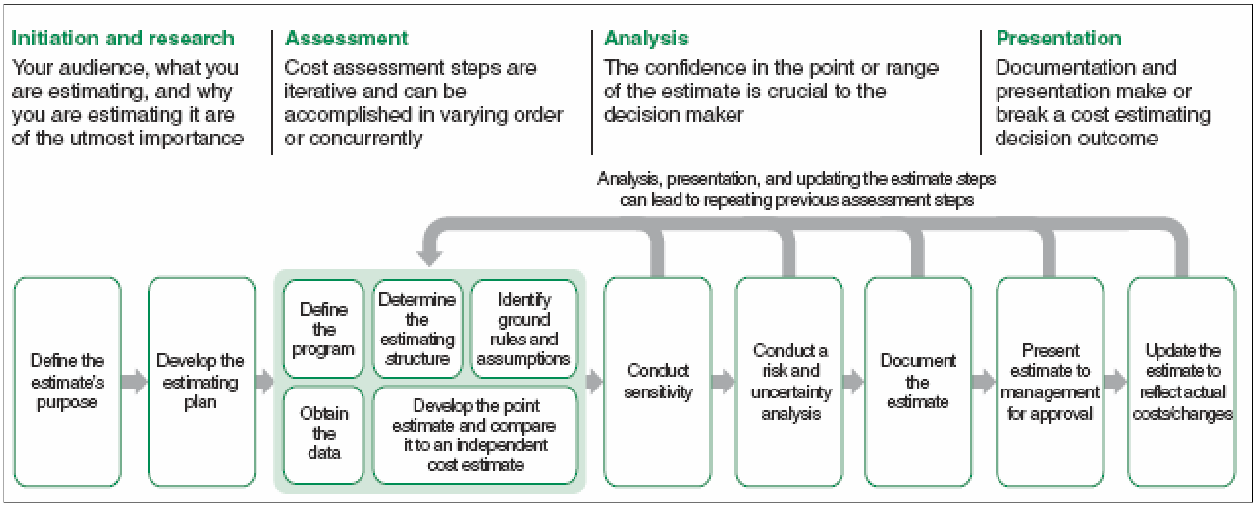

Figure 5 GAO Cost Estimating Process Source: GAO 2009

Summary

There is a history of underestimation in transportation projects that continues today. This is most notable and controversial with large-scale megaprojects. Recent studies have looked at the potential causes of inaccuracy and offer recommendations for improvement. Negative attention and criticism from elected leaders and the public has prompted several agencies to implement strategies to improve the accuracy and reliability of cost estimates. These strategies include improved assessment and communication of project uncertainty and risk, minimizing the chance of bias in estimates through independent peer review of estimates, and improved consistency in how estimates are prepared.

PROBLEM STATEMENT

Because cost estimating inaccuracy is not isolated to large agency megaprojects, the objective of this paper is to examine the current cost estimating policies, practices and experiences of several local agencies, gauge the level of satisfaction with the accuracy these practices produce, and identify best practices that agencies may adopt in order to improve estimate accuracy.

METHODOLOGY

A questionnaire was developed requesting information on agency estimating policies, general estimating procedures, data sources used, documentation of assumptions, estimate tracking and updating. The questionnaire also included questions about the agency's performance expectations for estimate accuracy, actual cost variance from estimates for recent projects, and the agency's level of satisfaction with current practices and level of interest in changing those practices. A copy of this survey instrument is shown in Appendix A.

The questionnaire was distributed to persons responsible for preparing and/or managing transportation capital project estimates at sixty-five cities and counties in California, Oregon, and Washington. Seventeen completed questionnaires were returned, including twelve cities and five counties between San Diego and Seattle. Responses from these agencies were prepared by transportation planners, project engineers, capital program managers, and city engineers.

Demographics of Responding Agencies

The responding agencies represent a broad spectrum of agencies in terms of size, population, and location. The populations of these jurisdictions range from 50,000 to over 3,000,000. These agencies, along with their geographic region and approximate populations, are listed in Table 3 below.

Table 3 Responding Agencies by Population

Agency	State	Region	Population
Redmond	WA	Puget Sound	51,300
Brentwood	CA	Northern CA	52,000
Santa Barbara	CA	Southern CA	90,300
Gresham	OR	Oregon	97,100
Eugene	OR	Oregon	138,000
Escondido	CA	San Diego	144,800
Pasadena	CA	Southern CA	150,000
Irvine	CA	Southern CA	212,800
Anaheim	CA	Southern CA	348,500
Lane County	OR	Oregon	350,000
Sacramento	CA	Northern CA	481,000
Washington County	OR	Oregon	529,200
Seattle	WA	Puget Sound	592,800
Multnomah County	OR	Oregon	715,000
San Diego	CA	San Diego	1,354,000
Orange County	CA	Southern CA	3,140,000
San Diego County	CA	San Diego	3,173,000

Sources: CA Dept. of Finance, WA Office of Financial Management, and United States Census Bureau

The responding agencies also represent a broad group in terms of annual budgets and number of projects delivered. The one-year transportation capital budgets range from $2 million to $234 million. The number of projects delivered over the last five years range from as few as five to as many as 120. This information is shown in Table 4 below to illustrate the range of budgets and corresponding number of projects completed; however, agencies are not identified.

Table 4 Agency Budgets and Projects

One-Year Transportation Capital Budget	Projects over $250,000 in last 5 years
$30,000,000	120
$234,000,000	NA
$62,800,000	28
$55,000,000	35
$50,000,000	88
$45,000,000	15
$40,000,000	25
$21,000,000	25
$18,000,000	20
$16,000,000	27
$14,000,000	20
$10,000,000	37
$10,000,000	50
$8,700,000	8
$4,000,000	75
$2,000,000	5

Source: Agency survey responses

Analysis of Responses

Following receipt of the completed questionnaires, the responses were compiled and evaluated. In the analysis that follows, the survey responses have been grouped for discussion into categories associated with particular aspects of cost estimating practice. The categories include the three basic categories identified in the Metropolitan Transportation Commission study of notable estimating practices: estimate preparation, process documentation, and estimate management (Betlyon 2008). In addition, other categories explore the background and training of estimators, how estimates are presented, the accuracy performance of recent cost estimates, and questions related to estimating polices.

The Cost Estimator

The skills, training, and experience of the person or team preparing the cost estimate have much to do with the quality of the estimate. Estimating requires skills from various disciplines including engineering, accounting, statistics, and economics. Generally, the estimator will have formal training in only one of these areas (Stewart 1982). The survey included several questions regarding the background and training of agency staff who prepare estimates.

EDUCATIONAL BACKGROUND

Agencies primarily rely on civil engineers for preparation of cost estimates at all stages of project development. At the early planning stage of a project, about 70% of cost estimates are prepared by engineers and 30% by transportation planners. Engineers prepare over 90% of estimates used for project programming. From the time a project is budgeted through final design, all estimating is done by engineers. This aligns with the reported educational background of estimating staff. All agencies reported staff with civil engineering degrees. Three agencies used estimators educated in urban planning. One agency reported staff with construction management education and one agency had an estimator who was a civil engineer with an MBA.

IN-HOUSE OR CONSULTANTS

Agencies were also asked whether estimates were prepared by in-house staff or by consultants. Using in-house estimating staff can increase the consistency of estimates and better utilize institutional knowledge. On the other hand, consultants may bring specialized estimating skills or access to estimating resources not available to smaller agencies. Most estimating is performed by agency staff. Two agencies (12%) reported using only consultants, while three other agencies (18%) reported using consultants to supplement in-house staff.

EXPERIENCE

The majority of estimators for the responding agencies have more than five years of experience preparing cost estimates. In addition, about one-third of the agencies have staff with one to five years of experience. Only two agencies reported estimators with less than one year of experience, but both of these agencies also have more experienced estimators on staff.

TRAINING

Five of seventeen agencies (30%) reported that they offer specialized cost estimating training for estimating staff, while the remaining twelve agencies do not.

Cost Estimate Preparation

CONSISTENCY

Eleven agencies (65%) reported that cost estimates were prepared in a consistent manner among all estimating staff in the department. The remaining six agencies indicated that estimators were able to use their judgment to choose the appropriate estimating technique.

DATA SOURCES

All agencies reported using historical cost data from past agency projects. Twelve agencies also use bid data from their state’s Department of Transportation. Eight agencies (about 50%) indicate that they sometimes use cost data from neighboring agencies. Only four agencies reported using published cost data or indices such as *ENR*[6] in preparing cost estimates. One agency remarked that "the traditional method of depending on recent bids is highly inaccurate in economic cycles such as those seen in recent years."

ESTIMATE REVIEW AND VALIDATION

Ten agencies indicated that estimates are reviewed internally by someone other than the estimator or project designer. In most cases this is done by the engineering supervisor or department head, in other cases a peer or designated quality assurance team reviews the estimates. Five of the ten agencies with internal review include multiple layers of review (e.g., peer review and supervisor). Seven agencies (40%) reported that cost estimates are not reviewed internally.

In addition to reviews by peers and managers, independent review reduces the chance of institutional bias or "group think" affecting the estimate. Ten agencies (almost 60%) reported sometimes using consulting engineers to independently verify estimates (nine of these are from the same ten agencies that answered "yes" above to conducting internal reviews). Seventy percent of those agencies that use consultants for independent review believe that it has resulted in improved estimate accuracy.

Ten agencies also reported sometimes asking contractors or construction management firms to perform independent reviews of cost estimates (again, most of these agencies also conduct

[6] Engineering News-Record (ENR) published by McGraw-Hill, Inc.

internal reviews as well as independent reviews by consultants). In this case, eighty percent believe that the practice has improved the accuracy of their cost estimates.

In all but one instance, agencies that did not conduct internal reviews also did not perform independent reviews by outside consultants or contractors. The exception was one agency that did report sometimes using consultants to independently review estimates, but also reported that the independent review did not improve the accuracy of the estimates.

CONTINGENCY AND UNCERTAINTY

Recall that there are a number of ways to determine the contingency percentages for a project. The survey asked agencies to describe how they typically determine design contingency amounts. As depicted in Figure 6 below, nearly all of the agencies surveyed rely on the estimator's judgment in determining the level of contingency to add to the base estimate. About one-third of the agencies base contingency amounts on the size and complexity of the project. Two agencies indicated that contingency is influenced by market conditions (it may be assumed that market conditions are treated as a risk by these agencies, though this is not generally a recommended practice). One agency reported that policy alone is used to determine contingency amounts, and one agency reported using probabilistic determination methods.

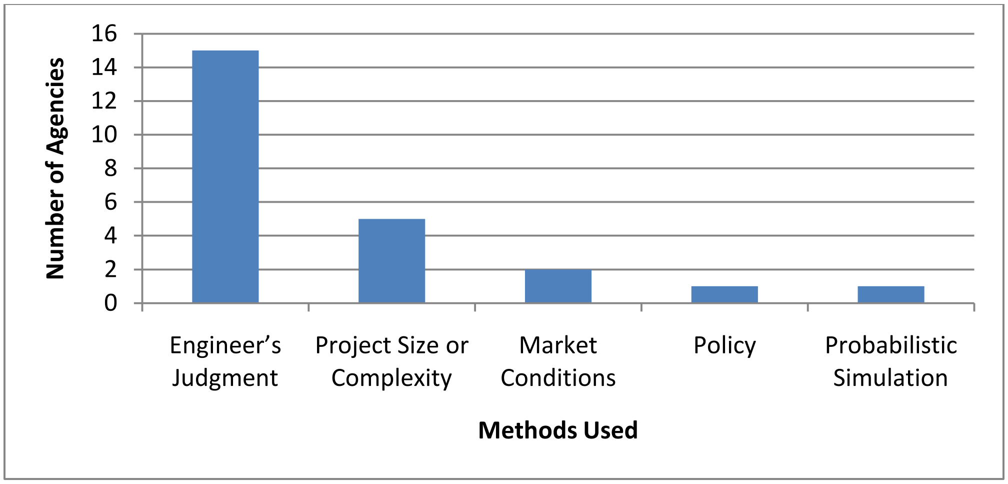

Figure 6 How Contingency Amounts are Determined

It is common to apply different contingency percentages at the different stages of project development. As the design progresses, more becomes known about the project variables and therefore the amount set aside for contingency can be reduced. Agencies were asked what contingency percentages are typically included for four major stages of project development. A fairly wide range of percentages were reported among agencies, especially for the earlier stages. In addition, several agencies reported using a range of contingencies for a particular project stage—this is consistent with the previous responses that contingencies may vary depending on project type and size. Table 5 below shows the full ranges of contingency percentages reported and the average contingency amount reported by project stage, as well as example suggested contingency amounts for these stages. The values reported by most agencies are generally consistent with those commonly suggested in textbooks and guidelines. However, a few agencies reported contingency amounts as high as 60 to 100% for early planning stages and as low as 0% for the final engineer’s estimate. A more detailed table showing the responses to this question is included in the appendices.

Table 5 Contingency Amounts for Various Project Stages

Project Stage	Survey Responses		Typical Contingencies		
	Range of Contingency	Average Contingency	Wideman	Martin	Caltrans PDPM
Early Planning	10-100%	35%	25%	50%	30-50%
Programming	10-60%	30%	20%	30%	20-25%
Budget/Pre-Design	10-60%	25%	15%	20%	15%
Engineer's Estimate	0-20%	10%	10%	10%	5-10%

Cost Estimate Process Documentation

DOCUMENTATION

The importance of documentation for communicating and reviewing the estimate and avoiding misunderstanding or misuse of the estimate has been discussed. Seventy-one percent of agencies report that they document the basis for project cost estimates. Another five percent provide documentation on some projects. The remaining agencies (24%) do not document the assumptions or data used for preparing cost estimates.

TRACKING

Tracking changes in project scope and cost estimates through the life of a project is an essential cost management tool. This documentation is useful for making meaningful comparisons of the final project to the original scope and estimate. Tracking allows managers to monitor the cost impacts of design decisions and can help identify problems before a project overruns its budget. This information can also be used to improve the cost estimating process in order to produce more accurate estimates in the future.

Three-fourths of the agencies report that explanations of significant changes to the project that affect the cost estimate are tracked. The remaining agencies do not document these changes.

Agencies were asked how they track cost estimates through the life of a project. While the value of good documentation and estimate tracking has been discussed, it is also important that this information be stored in a consistent format and be readily accessible. Generally, paper files are less accessible; they are kept in one department (or even one individual's office) and often times are archived when the project is completed. Electronic filing simplifies monitoring and reporting and makes it easier to share information between estimators. This is especially important for larger agencies that have many projects to monitor at any given time and must share information among different departments (e.g., engineering, finance, administration). More than one response was allowed for this question. Fourteen of the responding agencies (88%) indicate that information is tracked in electronic spreadsheets. One-third of the agencies store information on paper in project files. One-third of the agencies use commercially available software (e.g., citywide finance system) to track this information. Two agencies have developed custom databases for tracking estimate information.

Cost Estimate Management

Cost estimate management defines the process and techniques to be used, level of detail required, timing, documentation and approvals required for preparing initial cost estimates as well as updates or other modifications to the cost estimate during project development or until the project is ready to construct.

POLICIES AND GUIDELINES

The survey asked if the agency has policies or guidelines for preparing cost estimates. The response was nearly evenly split; nine agencies have cost estimate management policies and eight do not. Of the nine agencies that reportedly have policies in place, only one agency was able to provide a copy of a written policy (included in appendices). One agency reported that they follow Caltrans' Project Development Procedures Manual guidance in preparing cost estimates. Another agency's policies provide guidance on *when* estimates and updates should be performed, but provide no guidance on *how* those estimates should be prepared. Several agencies reported that their guidelines only address the cost percentages to be used for estimating design and construction management costs or contingency percentages for various stages of project development. One agency reported that cost estimating guidelines were "verbal" rather than written. This particular agency later stated that this unwritten policy includes estimating "on the high side…so you are not short on funds." Essentially, only two of the seventeen agencies (12%) have policies that guide estimators in which techniques or data sources should be used in preparing cost estimates.

ESTIMATE UPDATES

Cost estimates must be updated periodically in order to remain useful for decision making and budgeting purposes. These updates should reflect factors such as inflation, changes in land, material and labor costs, and changes in project scope. There are several approaches to updating cost estimates that vary in terms of effort required and result in varying degrees of accuracy. The least detailed and time-consuming method is to apply a multiplier (e.g., percent inflation) to the total project cost estimate. A slightly more detailed approach would be to apply appropriate multipliers to major elements of the project. For example, if the cost of a particular material (e.g., steel) were to increase disproportionately to the rest of the project. The most detailed approach is to re-perform the estimate from scratch to reflect current unit prices and/or the most recent design information. This approach is appropriate as the project design progresses through major milestones or when a significant amount of time has elapsed from the original estimate.

About half of the agencies (47%) reported using various methods depending on the circumstances for updating estimates. Six agencies (35%) indicated that estimates are always updated by preparing detailed estimates using the latest data and design information. Two agencies reported that estimates are not regularly updated, but only when significant scope changes occur (it is presumed that when this is necessary, the estimates are prepared in detail). One agency reported that estimates were updated only by use of a cost multiplier.

The frequency of cost estimate updates typically varies depending on the stage of project development. Projects that are unfunded or several years from starting design are generally updated less frequently than those currently or soon-to-be in design. Because this paper is primarily concerned with pre-design cost estimates, agencies were asked how frequently estimates are updated for three project stages: planning, programming, and budget approval/pre-design. The agency responses are illustrated in Figure 7 below. For projects in the planning stage (long-range projects that are years away from beginning design), half of the agencies update cost estimates every two to five years, about one-fourth update annually, two agencies update two times per year, and two agencies do not regularly update estimates. During the programming stage (projects that are one to five years away from beginning), most agencies update estimates annually and about one-fourth update less frequently. For projects that are at the budgeting stage (just prior to starting design), over seventy percent of the agencies update cost estimates annually and twenty percent update more frequently.

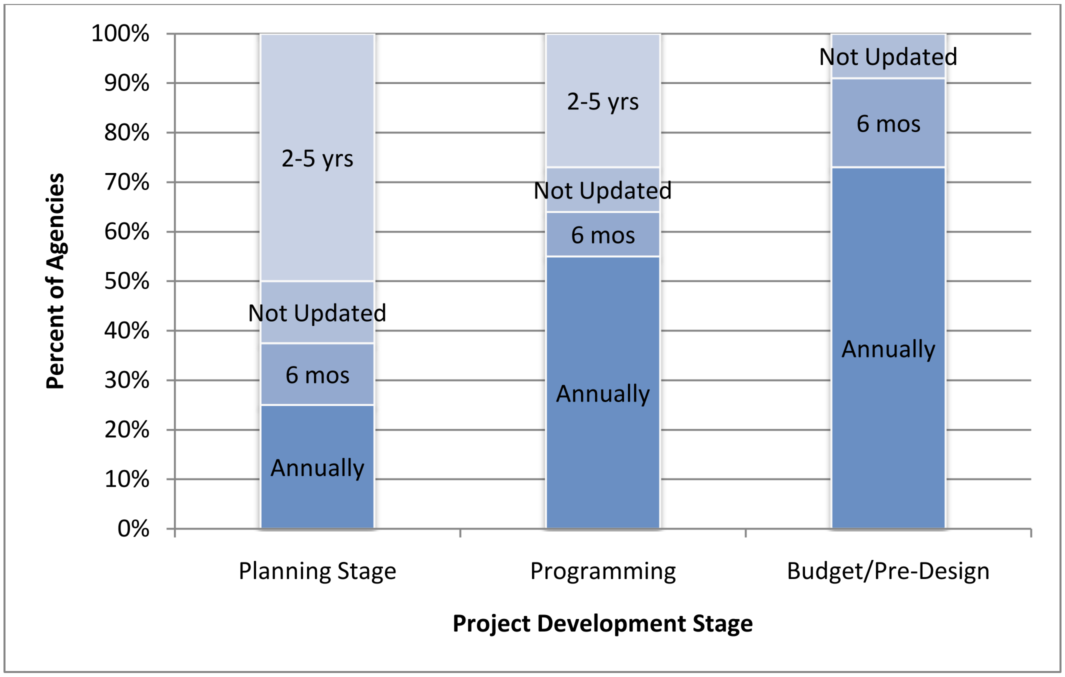

Figure 7 Estimate Update Frequency by Project Stage

Communicating Estimates

USE OF COST ESTIMATE RANGE VS. SINGLE VALUE ESTIMATE

Some larger agencies have moved toward presenting cost estimates as a range of probable values, rather than a single value, in order to demonstrate the confidence level of the estimate (Reilly et al. 2004; FHWA 2007). Most local agencies surveyed indicated that project cost estimates are presented as a single value. Fifteen agencies (88%) use single values for all estimates. Only two of the seventeen agencies reported using estimate ranges for early estimates and for very large projects.

INFLATION: CURRENT YEAR VS. YEAR-OF-EXPENDITURE ESTIMATES

It is common practice to compare projects or alternatives using present value cost estimates even if the project will not begin construction for several years. Adjusting for inflation and communicating estimates in the projected year of expenditure (YOE) can minimize confusion and reduce the appearance of cost growth (Schexnayder 2003). Nine agencies present project cost estimates in current year dollars. Four agencies use current year dollars for unfunded projects that do not have a planned date for construction, but adjust cost estimates to YOE for projects that are scheduled. Three agencies report all estimates in YOE dollars. One agency does not have a set policy for how costs are presented.

Performance of Agency Estimates

PERFORMANCE EXPECTATIONS

The relationship between estimates and the project budget has been discussed. If the low construction bid exceeds the budget, agency management and possibly elected officials may need to authorize the use of additional funds, or if no additional funds are available, it may be necessary to redesign and re-advertise or even delay the project. Many DOTs have established performance expectations for the maximum difference between the estimate and the low bid (Schexnayder 2003). In this survey, agencies were asked if they had adopted expectations for estimate accuracy. Of the responses, thirteen reported that they have no expectation (Table 6). One agency in California, with a $10 million capital budget, commented that “cost estimates are really not significant.”

Table 6 Performance Expectation of Estimate

Percent difference between Engineer’s Estimate and Actual Cost	No. of Agencies
Within 5%	1
Within 10%	1
Within 15%	1
No Expectation	13

ACTUAL PERFORMANCE

To gauge the accuracy of their estimating practices, agencies were asked to provide estimate performance data for projects completed within the last five years. Agencies reported the number of projects completed in this time frame and the performance results in three ranges: within 5%, between 5% and 10%, and in excess of 10%. Twelve agencies responded to this question covering a total of 468 projects over the last five years. Overall, most projects fell within 5-10% of the engineer's estimate (44%), while the percentage of projects less than 5% or more than 10% of the engineer's estimate were about equal (Table 7).

Table 7 Comparison of Engineer's Estimate to Actual Costs

	Percentage of Projects		
No. of Reported Projects	Actual Cost <u>within 5%</u> of Estimate	Actual Cost within 5 to 10% of Estimate	Actual Cost <u>more than 10%</u> over/under Estimate
120	54%	29%	17%
20	60%	30%	10%
37	24%	14%	62%
25	20%	72%	8%
35	20%	30%	50%
88	23%	68%	9%
27	30%	11%	59%
50	0%	70%	30%
8	0%	50%	50%
5	0%	100%	0%
25	0%	80%	20%
28	25%	21%	54%
Overall: 468	28%	44%	27%

CAUSES OF INACCURACY

Based on feedback from the agencies surveyed, Table 8 below identifies significant impacts on estimate accuracy in the order of their significance, from most to least significant:

Table 8 Primary Influences on Cost Estimate Accuracy

Overall Rank	Response
1	Significant scope change(s) during design development
2	Unforeseen conditions discovered during design
3	Material, land, or labor costs change greater than normal inflation
4	Limited staff time or budget to prepare detailed preliminary estimates
5	Inexperienced estimators
6	Lack of estimating policies & guidelines
7	Desire to use optimistic, or “best case”, estimates

Satisfaction with Policies and Practices

All seventeen agencies indicated that staff and elected officials were satisfied with current levels of accuracy and reliability of cost estimates. Only three agencies indicated that they were considering making changes to their estimating practices.

Ten agencies (59%) indicated that they viewed policies and procedures “helpful” in terms of producing accurate cost estimates. Three agencies (18%) believe them to be “essential”, while four agencies (23%) view them as “unnecessary”.

Two survey questions dealt with estimating guidelines and consistency among different agencies. Most agencies (88%) were not concerned with a lack of consistent estimating practices with neighboring agencies. However, as shown in Table 9 below, approximately half of the agencies expressed interest in estimating guidance from their area Metropolitan Planning Organization (MPO), DOT, or the FHWA.

Table 9 Perceived Value of Estimating Guidelines

	No. Agencies		
Response	FHWA	State DOT	MPO
Beneficial	7	8	7
Unnecessary	9	8	9

Summary of Findings

- Nearly all estimates are prepared by experienced, in-house civil engineers.
- Most agencies do not offer specialized training to their estimating staff.
- Most agencies do not have written guidelines for preparation of cost estimates.
- One-third of surveyed agencies lack consistency in how estimates are prepared.
- Estimates are typically prepared using historic bid data and are updated more frequently as the project design is developed.
- Sixty percent of respondents perform internal reviews of estimates and conduct independent reviews using consultants and/or construction experts. Two-thirds of this group believes that independent review improves accuracy.
- Forty percent of agencies do not review or validate estimates.
- Nearly all agencies rely on the engineer's judgment to determine the amount of contingency to add to the project. Reported contingency amounts vary widely, but on average are consistent with industry standard.
- One-fourth of responding agencies do not document the assumptions used in developing cost estimates.
- Almost all agencies communicate their estimates as a single value, not as a range of probable costs.
- Most agencies present cost estimates in current year dollars rather than adjusting for inflation to the year of planned construction.
- Most agencies have no performance expectation for the accuracy of estimates in relation to construction costs. Despite this, over seventy percent of projects completed in the past five years were within ten percent of the engineer's estimate.

- The top reported influences on cost estimate accuracy are significant scope changes or unforeseen site conditions encountered during design and unexpected increases in material, land or labor costs.
- All agencies surveyed indicated that they are generally satisfied with the accuracy and reliability of their estimates; thus, there is little interest in making changes to their estimating practices.
- About half of the respondents expressed some interest in estimating guidance from their MPO, state DOT, or the FHWA.

CONCLUSIONS AND RECOMMENDATIONS

A Case for Improvement

Many aspects of how local agencies prepare their estimates appear to generally follow the best practices of the industry. Most agencies surveyed reported that actual costs were usually within ten percent of the estimate. Most are generally satisfied with the accuracy and reliability of their estimates, and few plan to make any changes to their estimating practices. However, the survey revealed that there are several areas that could be improved by implementing guidelines and process improvements.

Most agencies do not have adopted policies or written procedures for cost estimating and most do not offer or require specialized training in cost estimating to their staff. Though only one-third of the agencies reported a lack of consistency in estimate preparation, without written policies or procedures, the consistency of the other two-thirds is questionable.

Cost estimates are used to make critical decisions about project initiation, funding, design, and project management. Good decision-making requires good information. Bad information affects the success of the project, the fate of competing projects, and the reputation of the agency. The literature suggests that public scrutiny of large scale cost overruns is the impetus for some agencies to change their estimating practices. However, recognizing the financial and organizational advantages of high quality estimates, organizations such as the TRB and some state DOTs have proactively developed guidelines to improve estimating. The benefits of consistent, reliable, and accurate cost estimates—in planning, programming, budgeting, and performance measurement—make a compelling case for developing guidelines and policies. Below are some additional considerations for making such improvements.

Public Confidence

AbouRizk states that, “the motivation for an accurate capital cost estimate in a municipal environment results from the need for stewardship of resources” (AbouRizk et al. 2002). Deserved or not, as evidenced by Flyvbjerg’s work and contemporary newspaper editorials, there appears to be a general lack of public confidence in agencies’ ability to act as good stewards of their resources (i.e., tax dollars). Though the media and public are not typically interested in the average public works project, the public also doesn’t necessarily distinguish between local, state, and federal government—which means that errors made by one agency tarnishes the image of other agencies (“*they’re all the same*”). Forty percent of the agencies surveyed reported inaccuracies of 10% or more on more than half of their projects. Eighty percent of the agencies reported that they have no minimum expectation for accuracy. These figures do little to assuage the negative public perception of accountability in government—at all levels. In a climate of mistrust, agencies and professionals should do all that they can to build and maintain the confidence of the public and elected officials. Better estimates will improve budgeting process. Better estimates will restore public confidence. Public confidence is essential for future support of agency projects and funding requests.

Efficient Use of Limited Resources

In the current economic situation, it is tempting to say that greater accuracy is needed now more than ever. The GAO states that "as resources become scarce, competition for them will increase" (GAO 2009). The need for new facilities to provide increased capacity and the need to repair and replace aging infrastructure comes at a time when funding for transportation is especially low. The recent economic downturn that has impacted revenue for all local agencies is compounded by the fact that the federal Highway Trust Fund is nearly out of money. The studies cited in this paper date back more than forty years, but the concerns are the same today. The fact is, there are never enough resources to build the projects that the public wants or needs and, therefore, it is always important to make the most efficient use of those resources. Reliable and accurate estimates are critical to effective project management, capital improvement programming, and good financial planning at the local agency level.

Ethics and Professional Integrity

Flyvbjerg's studies present persuasive evidence that optimism bias and willful deception have played a role in some project cost forecasts. His studies have gained the attention of large agencies who have taken steps to minimize or eliminate these factors. As agencies like WSDOT and Caltrans look for ways to improve their estimates, so too must the individuals who prepare the estimates—especially Professional Engineers. The American Society of Civil Engineers (ASCE) Code of Ethics[7] calls on engineer's to "uphold and advance the integrity, honor and dignity of the engineering profession by being honest and impartial and serving with fidelity the public, their employers and clients." The ASCE's Fundamental Canons include the following:

- Engineers shall issue public statements only in an objective and truthful manner.
- Engineers shall act in professional matters for each employer or client as faithful agents or trustees, and shall avoid conflicts of interest.
- Engineers shall act in such a manner as to uphold and enhance the honor, integrity, and dignity of the engineering profession and shall act with zero-tolerance for bribery, fraud, and corruption.

The code of ethics for civil engineer's is especially relevant, as all agencies reported that estimates are prepared by civil engineers at some stage of project development. The ASCE's Code was adopted in 1914. In 2000, the International Cost Engineering Council adopted a code of ethics that follows the same framework as ASCE, calling for estimators to practice with "honesty, integrity, [and] impartiality" (Humphreys 2005).

Recommendations

Local agencies can improve the accuracy and reliability of project cost estimates and reduce the risk of cost overruns by adopting some of the process improvements being used by state DOTs and recommended by organizations such as the Transportation Research Board and the US Government Accountability Office.

[7] https://www.asce.org/inside/codeofethics.cfm

Develop standard procedures. Documented estimating procedures are necessary for an agency to consistently produce reliable and accurate estimates. Guidelines ensure continuity among different estimating staff as well as help in training new staff. With consistent practices and procedures, agencies are able to monitor and evaluate the performance of their estimates over time and make adjustments where necessary in order to continually improve performance.

Train staff. "To ensure all estimators have current estimating knowledge, a training program is vital" (Schexnayder 2003). Estimators should be trained not only in agency estimating policies and procedures, but also recognized industry best practices. Specialized training in cost estimating is offered through the National Highway Institute and organizations such as the American Society of Civil Engineers (ASCE) and the Association for the Advancement of Cost Engineering (AACE).

Adequately account for risk & uncertainty. When possible, avoid a one-size-fits-all approach to risk management (e.g., policy-based contingency percentages) and instead identify and quantify the specific risks for each project. For large or complex projects, consider the use of probabilistic risk analysis such as the WSDOT CEVP methodology.

Avoid misunderstandings and misuse of estimates. Communicate the basis of the estimates and the cost impacts of possible risks so that decision makers and the public understand the meaning of the estimate and its limitations. This can be done through presenting the estimate as a range of possible costs or as a "probability mass diagram", rather than a single value.

Validate estimates through independent external reviews. Enlisting outside experts such as engineering consultants or contractors in reviewing cost estimates can help identify possible errors or omissions in the estimate and reduces the risk of agency bias affecting the estimate.

Share information among agencies. Agencies can benefit by sharing information with other agencies in their region. This could include project bid tabulations, estimating practices, or "lessons learned". There is great value in learning from the lessons of previous projects and incorporating that information into future estimates. This includes learning from the mistakes as well as the successes. For smaller agencies, it can be beneficial to share information with other agencies in their region. For example, the public works and transportation departments for the cities of Los Angeles, Oakland, San Diego, San Francisco, San José, Long Beach, and Sacramento participate in an annual study of project delivery methods, costs, and performance. The objective of this study is to reduce costs and delivery time for projects by sharing information and identifying best management practices. In the seven years since the first *California Multi-Agency CIP Benchmarking Study*, the agencies report "significant enhancements in both Capital Project delivery process and efficiency" (Los Angeles 2008). Another example of information sharing is the WSDOT Lessons Learned database. This online, searchable database is intended to help communicate information about past projects that may be helpful for others to consider on future projects. The lessons include a brief description of the project and the particular situation or event experienced on the project, what knowledge was gained from the experience, and recommendations from the project manager on how this knowledge could be applied in the future. A list of similar resources is included in Appendix G.

Adapt to Changing Market Conditions. For decades, the primary concern with inaccurate cost estimates has been centered on the pattern of underestimating costs. The recent economic downturn has resulted in increased competition for construction contracts with more contractors bidding on projects at far lower prices than in previous years. As of early 2009, many agencies are reporting low bids that are 20% to 50% lower than the pre-bid engineer's estimate. Appendix E includes a sample of bid results from several west coast transportation agency projects between December 2008 and May 2009. These data were obtained from agency websites and selected at random to demonstrate the bidding climate at the time of this writing for projects of all sizes. It is likely that the agency estimates represent fair and reasonable costs for the work based on historical data from prior to the recent economic slowdown, and that the low bid prices represent efforts by contractors to trim or even eliminate profits in order to remain in business. This pattern may be short-lived as the economy rebounds or, if as some fear, contractors begin going out of business. Michael McNally, president of contractor Skanska USA, calls these "silly bids" and expresses concern that the bidding wars are causing some contractors to make unrealistically low bids (Tulacz 2009). In the meantime, agencies may consider relying more heavily on the most recent cost data in order to minimize the variance between estimates and low bids. Compared to the criticism that accompanies underestimated costs, there is general enthusiasm in media reports and from elected officials when bids received are far below the estimated cost. Nonetheless, an overestimate is still an inaccurate estimate and ties up resources that could be allocated to other projects. A pattern of overestimating may eventually lead to the same criticism as underestimating.

—-

"*An entity that wants to continue operating successfully must continually improve its cost estimating methods*" (Stewart 1982).

APPENDIX A: SURVEY INSTRUMENT

These questions pertain to cost estimates for transportation capital projects over $250,000 prepared from early planning through construction bidding. Transportation projects may include new roadways, bridges, street widening, streetscape enhancements, signals, pedestrian or bicycle facilities.

Please return completed questionnaire as Word file or scanned PDF to dgrilley@gmail.com ***by April 3, 2009****.*

NOTE: Agency names will NOT be associated with survey responses presented in the report.

1. **Does your agency have policies or guidelines for preparation of cost estimates?** Yes___

   No___

a. If yes, please describe:

b. If there is a written policy or guide, would you provide a copy?

2. **Please answer the following questions, for each stage of project development, using the table shown below**:

a. Who prepares cost estimates for each stage of development? *(e.g., consultants, transportation planners, CIP manager, project engineers, management analysts)*

b. What contingency percentages are typically included for each stage of project development?

c. How often are the estimates for each stage updated?

Project Development Stage	2(a). Prepared by	2(b). Typical Contingency Percentage	2(c). Frequency of Updates
Early Planning (10-20 yrs out)			
Programming (3-6 yrs out)			
Budget Estimate (1-2 yrs out)			
Detailed Engineer's Estimate (pre-bid)			

3. **Please describe your agency's method(s) for determining contingency amounts** *(set by policy, based on engineer's judgment, probabilistic simulation, other)*

4. **What is the process for updating estimates?** *(adjust using inflation factor, re-perform estimate, other)*

5. **Does your cost estimation process include formal review and validation?** Yes___ No___ If yes, please briefly describe the process and composition of review team:

6. **Do you sometimes use consulting engineers to independently verify estimates?** Yes___ No___ If yes, do you believe that this has improved cost estimate accuracy? Yes___ No___

7. **Are contractors or construction management firms ever asked to review preliminary cost estimates?** Yes___ No___ If yes, do you believe that this has improved cost estimate accuracy? Yes___ No___

8. **Are the assumptions used for estimating (design basis, cost basis, etc) documented for all project cost estimates?** Yes___ No___ Comment:

9. **Are estimates presented as a single value, or as a range of probable costs?**

10. **Are <u>early</u> estimates presented in current year dollars, or adjusted for year of planned construction?**

11. **What data sources are most often used for estimating? Please indicate if different sources are used for different types of estimates**.

____ Agency historical data (bid tabulations) from similar projects

____ ENR or other cost indices

____ State DOT bid data

____ Neighboring agency data

____ Other:______________________

12. **How are projects cost estimates tracked through the life of the project**?

____ Commercial software. Please indicate title:______________________

____ Custom database (using Access or similar)

____ Spreadsheet

____ Paper files

____ Other:______________________

13. **Are estimates and the explanation for significant changes tracked through the life of the project?** *(versus simply replacing the old early estimate with an updated value)* Yes___ No___ Comment:

14. **Are cost estimates prepared in a consistent manner among all staff in your agency?** *(e.g., different project engineers, consultants, departments)* Yes___ No___ Comment:

15. **What is the typical educational background of agency staff who prepare <u>early</u> estimates?** *(e.g., civil engineering, construction management, urban planning, accounting)*

16. **What is the typical cost estimating experience of agency staff who prepare <u>early</u> estimates**?

Less than 1 year___ 1 to 5 years___ Over 5 yrs___ Comment:

17. **Is specialized training provided for agency staff who prepare estimates?** Yes___ No___

18. **How much is your agency's one-year transportation capital project budget this fiscal year?** $__________________________________

19. **Approximately how many transportation projects over $250,000 has your agency completed in the last five years?** ________

20. **On how many of these projects was the low bid …**

a. within 5% over/under Engineer's Estimate? _____

b. between 5% & 10% over/under Engineer's Estimate? _____

c. more than 10% over/under Engineer's Estimate? _____

21. **Does your agency have a performance expectation for estimate accuracy, such as +/- 10% of Engineer's Estimate?** Yes___ No___ If yes, please describe:

22. **Disregarding recent declines due to economic downturn, based on projects completed in the last 5 years, have you observed a trend of...**

a. estimates exceeding actual costs _____

b. actual costs exceeding estimates _____

c. no clear trend observed _____

23. **What do you believe are the primary reasons for <u>early</u> cost estimate inaccuracy in your agency?** (*Rank in order up from 1, with 1 being most significant cause; or N/A if not applicable)*

____Unforeseen conditions discovered during design
____Material, land, or labor costs change greater than normal inflation
____Significant scope change(s) during development
____Inexperienced estimators
____Lack of estimating policies & guidelines
____Limited staff time or budget to prepare detailed preliminary estimates
____Desire to use optimistic, or "best case", estimates
___ Other:____

24. **Is your agency (including staff & elected officials) satisfied with the level of accuracy and reliability provided by current cost estimating practices?** Yes___ No___ Comment:

25. **Do you anticipate making changes to your agencies cost estimating practices**?

Yes___ No___ If so, please describe:

26. **Are you concerned by a lack of consistency in how estimates are prepared among neighboring agencies?** *(for instance when cost estimates which are prepared differently are used to compare projects at regional level)* Yes___ No___ Comment:

27. **How do (or would) you view the implementation of policies and procedures for cost estimating in your agency**:

____ *Essential* to producing accurate and reliable cost estimates

____*Helpful* in producing accurate and reliable cost estimates

____Unnecessary

28. **Do you see a benefit in local agency cost estimate preparation guidelines specified**…

a. by the FHWA? Yes___ No___ Comment:

b. by State DOT Yes___ No___ Comment:

c. by MPO/RTPA? Yes___ No___ Comment:

Additional Comments:

# # #

Thank you for your time!

APPENDIX B: SURVEY DATA

1. Does your agency have policies or guidelines for preparation of cost estimates?

No. Agencies	Response
9	**Yes**
8	No

2a. Who prepares cost estimates at various stages of development?

Project Stage	In-House Engineers	Consulting Engineers	Transportation Planners
Planning	56%	13%	31%
Programming	82%	12%	6%
Budget	88%	12%	0%
Final Design	88%	12%	0%

2b. What contingency percentages are typically included for each stage of project development?

Planning		**Programming**		**Budget**		**Final Design**	
No. of Agencies	Response	No. of Agencies	Response	No. of Agencies	Response	No. of Agencies	Response
0	<10%	0	<10%	0	<10%	2	0%
4	10-20%	5	10-20%	6	10-20%	2	5%
4	25-30%	6	**25-30%**	7	**25-30%**	6	**10%**
5	**30-40%**	1	30-40%	1	30-40%	2	15%
2	>40%	2	>40%	1	>40%	3	>15%

2c. How often are the estimates for each stage updated?

Planning		Programming		Budget	
% Agencies	Response	% Agencies	Response	% Agencies	Response
50%	**2-5 yrs**	27%	2-5 yrs	%	2-5 yrs
25%	Annually	**55%**	**Annually**	**73%**	**Annually**
12.5%	6 mos	9%	6 mos	18%	6 mos
12.5%	Not Updated	9%	Not Updated	9%	Not Updated

3. How are contingency amounts typically determined? *(more than one response possible)*

% Agencies	Response
94%	Engineer's Judgment
31%	Project Size or Complexity
12.5%	Market Conditions
6%	Policy
6%	Probabilistic Simulation

4. What is the process for updating estimates?

No. Agencies	% Agencies	Response
8	47%	Either re-perform or adjust using multiplier, depending on situation
6	35%	Always re-perform detailed estimate using latest data
2	12%	No periodic updates; only if significant scope change
1	6%	Adjust prior estimate using multiplier (inflation or cost index)

5. Does your cost estimation process include formal review and validation?

% Agencies	Response
59%	**Yes**
41%	No

6a. Do you sometimes use consulting engineers to independently verify estimates?

% Agencies	Response
59%	**Yes**
41%	No

6b. If yes, do you believe that this has improved cost estimate accuracy?

% Agencies	Response
70%	**Yes**
30%	No

7a. Do contractors or construction management firms ever review preliminary cost estimates?

% Agencies	Response
59%	**Yes**
41%	No

7b. If yes, do you believe that this has improved cost estimate accuracy?

% Agencies	Response
80%	**<u>Yes</u>**
20%	No

8. Are the assumptions used for estimating (design basis, cost basis, etc) documented for all project cost estimates?

% Agencies	Response
71%	**<u>Yes</u>**
24%	No
5%	Sometimes

9. Are estimates presented as a single dollar value, or an expected range of values?

No. Agencies	Response
15	**<u>Single Value</u>**
2	Range

10. Are early estimates presented in current year dollars or year of planned expenditure (YOE)?

No. Agencies	Response
9	**<u>Current Year</u>**
4	Current Year for Unfunded Projects & YOE for Funded
3	YOE
1	Varies

11. What data sources are most often used for estimating? Please indicate if different sources are used for different types of estimates. *(NOTE: more than one response possible)*

No. Agencies	Response
17	Agency historical data
12	State DOT bid data
8	Neighboring agency data
4	ENR or other cost indices

12. How are projects cost estimates tracked through the life of the project? *(NOTE: more than one response possible)*

No. Agencies	Response
14	Spreadsheets/Electronic files
5	Paper files
5	Commercial software (e.g. agency finance system)
2	Custom database

13. Are explanations for significant changes tracked through the life of the project?

% Agencies	Response
77%	**Yes**
23%	No

14. Are cost estimates prepared in a consistent manner among all staff in your agency?

% Agencies	Response
65%	**Yes**
35%	No

15. What is the typical educational background of agency staff who prepare early estimates? *(NOTE: more than one response per agency allowed; 16 agencies responded to this question)*

No. Agencies	Response
16	**Civil Engineering**
1	Construction Management
3	Urban Planning
1	MBA

16. What is the typical cost estimating experience of agency staff who prepare early estimates? *(NOTE: more than one response per agency allowed; 16 agencies responded to this question)*

No. Agencies	Response
3	Less than 1 year
5	1 to 5 years
14	**Over 5 years**

17. Is specialized training provided for agency staff who prepare estimates?

% Agencies	Response
30%	Yes
70%	**No**

18. How much is your agency's one-year transportation capital project budget this fiscal year?
-and-
19. How many projects over $250,000 has your agency completed in the last five years?

18. Agency One Year Transportation Capital Budgets	19. Agency Projects over $250,000 over last 5 years
$ 30,000,000	120
$ 14,000,000	20
$ 10,000,000	37
$ 21,000,000	25
$ 55,000,000	35
$ 18,000,000	20
$ 45,000,000	15
$ 50,000,000	88

$ 16,000,000	27
$ 10,000,000	50
$ 8,700,000	8
$ 4,000,000	75
$ 2,000,000	5
$ 40,000,000	25
$ 62,800,000	28
$ 234,000,000	NA
Average* = $25.8M *excludes highest budget	Average = 39 Projects

20. Accuracy of estimates for transportation capital projects completed in last five years?

	Percentage of Projects		
No. of Reported Projects (12 Agencies)	Actual Cost within 5% of Estimate	Actual Cost within 5 to 10% of Estimate	Actual Cost more than 10% over/under Estimate
120	54%	29%	17%
20	60%	30%	10%
37	24%	14%	62%
25	20%	72%	8%
35	20%	30%	50%
88	23%	68%	9%
27	30%	11%	59%
50	0%	70%	30%
8	0%	50%	50%
5	0%	100%	0%
25	0%	80%	20%
28	25%	21%	54%
Overall 468	28%	44%	27%

21. Does your agency have a performance expectation for estimate accuracy, such as +/-10% of Engineer's Estimate?

No. Agencies	Response
1	Within 5%
1	Within 10%
1	Within 15%
13	**No Expectation**

22. Disregarding recent declines in costs due to economic downturn, based on projects completed in the last 5 years, have you observed a trend of...

No. Agencies	Response
5	Estimates exceeding actual costs
6	Actual costs exceeding estimates
6	No clear trend observed

23. What do you believe are the primary reasons for early cost estimate inaccuracy in your agency? *(Ranked 1-7, with 1 being most significant)*

Overall Rank	Response
1	Significant scope change(s) during development
2	Unforeseen conditions discovered during design
3	Material, land, or labor costs change greater than normal inflation
4	Limited staff time or budget to prepare detailed preliminary estimates
5	Inexperienced estimators
6	Lack of estimating policies & guidelines
7	Desire to use optimistic, or “best case”, estimates

24. Is your agency (including staff & elected officials) satisfied with the level of accuracy and reliability provided by current cost estimating practices?

% Agencies	Response
100%	**<u>Yes</u>**
0%	No

25. Do you anticipate making changes to your agencies cost estimating practices?

No. Agencies	Response
3	Yes
14	**<u>No</u>**

26. Are you concerned by a lack of consistency in how estimates are prepared among neighboring agencies?

No. Agencies	Response
2	Yes
15	**No**

27. In terms of producing accurate and reliable cost estimates, how do you view the implementation of policies and procedures for cost estimating in your agency?

No. Agencies	Response
3	Essential
10	**Helpful**
4	Unnecessary

28. Do you see a benefit in local agency cost estimate preparation guidelines from the FHWA, State DOT, or your local Metropolitan Planning Organization (MPO)?

	No. Agencies		
Response	FHWA	State DOT	MPO
Yes	7	8	7
No	9	8	9

Additional Comments:

(General)

- It is the policy of the department to estimate on the high side. The cost estimates are really not significant except for budgeting or getting grants. In either case you want to be on the high side so you are not short on funds. It is better to return the money than to go back and ask for more.

(Regarding Question #24)

- A codified range/probability based system would be better. The traditional method of depending on recent bids is highly inaccurate in economic cycles such as those seen in recent years.

(Regarding Question #28)

- MPO is most available and aware of local issues.

- Local agency guidelines are more beneficial than outside agencies because they are local and tend to be more accurate.

- FHWA guidelines if required as condition of federal funds; Currently use Caltrans cost data; would use MPO guidelines if applicable to our projects.

- FHWA's "global view" is important.

- Estimate preparation guidelines need to be consistently applied to all agencies.

APPENDIX C: RESPONDING AGENCIES

Agency	State	Region	Population
Redmond	WA	Puget Sound	51,300
Brentwood	CA	Northern CA	52,000
Santa Barbara	CA	Southern CA	90,300
Gresham	OR	Oregon	97,100
Eugene	OR	Oregon	138,000
Escondido	CA	San Diego	144,800
Pasadena	CA	Southern CA	150,000
Irvine	CA	Southern CA	212,800
Anaheim	CA	Southern CA	348,500
Lane County	OR	Oregon	350,000
Sacramento	CA	Northern CA	481,000
Washington County	OR	Oregon	529,200
Seattle	WA	Puget Sound	592,800
Multnomah County	OR	Oregon	715,000
San Diego	CA	San Diego	1,354,000
Orange County	CA	Southern CA	3,140,000
San Diego County	CA	San Diego	3,173,000

Geographic Distribution of Responding Agencies

APPENDIX D: SURVEY CONTACTS

Rudy Emami..City of Anaheim, CA

Anthony Salam..City of Brentwood, CA

Samuel Cottrell and Robert Zaino......................City of Escondido, CA

Paul Klope..City of Eugene, OR

Katherine Kelly..City of Gresham, OR

Kal Lambaz..City of Irvine, CA

Mike Bagheri..City of Pasadena, CA

Steve Gibbs..City of Redmond, WA

Ryan Moore..City of Sacramento, CA

Jerry McKee...City of San Diego, CA

Brian D'Amour and Pat Kelly............................City of Santa Barbara, CA

Lorelei Williams...City of Seattle, WA

Kerry Werner..Lane County, OR

Brian Vincent and Jane McFarland....................Multnomah County, OR

Ted Rigoni and Ignacio Ochoa...........................Orange County, CA

Antonio Dos Santos and Terrence Rayback.......San Diego County, CA

Russell Knoebel..Washington County, OR

APPENDIX E: OVERESTIMATING

The table below is a very small, non-statistical sample of bid results from western US transportation agency projects between December 2008 and May 2009. This is included to illustrate how the current economic downturn has created a highly competitive bidding market which has resulted in bid prices significantly lower than agency estimates.

Table 10 Sample Bid Results, December 2008 - May 2009

Agency	Project	Bid Date	Engineer's Estimate	Low Bid	% Under Estimate
Sound Transit (Seattle)	University light rail extension	3/25/2009	$395,354,000	$309,175,274	22%
City of Redmond, WA	36th Street bridge	12/9/2008	$31,400,000	$21,400,000	32%
City of Edmonds, WA	76th Ave walkway	4/16/2009	$2,000,000	$1,600,000	20%
City of SeaTac, WA	192nd St/37th Ave sidewalks	5/15/2009	$1,360,000	$867,129	36%
Clackamas County, OR	Fields & Stafford Road Bridges	1/13/2009	$13,600,000	$10,400,000	24%
Sacramento County, CA	Bradshaw/ Gerber intersection	3/12/2009	$3,200,000	$1,100,000	66%
Caltrans	I-80 resurfacing near Fairfield	4/21/2009	$22,000,000	$13,400,000	39%
Caltrans	I-105 retaining wall near Athens	4/14/2009	$731,675	$178,807	76%
Caltrans	I-15 bridge deck rehabilitation	4/30/2009	$821,841	$453,300	45%
City of Costa Mesa, CA	18th Street reconstruction	4/13/2009	$835,095	$477,744	43%

Source: Agency websites.

APPENDIX F: SAMPLE COST ESTIMATING POLICIES & GUIDELINES

City of San José

City of San José, California

COUNCIL POLICY

TITLE ESTIMATING CONSTRUCTION COSTS AND DEVELOPMENT OF PROJECT BUDGET	PAGE 1 of 3	POLICY NUMBER 8-12
EFFECTIVE DATE August 22, 2000	REVISED DATE	
APPROVED BY COUNCIL ACTION		August 22, 2000, Item 11a.

PURPOSE

To improve the quality and effectiveness of the City Public Capital Budget Process and accuracy of subsequent capital project construction by assuring that:

1. Capital projects have realistic budgets.
2. The City Council has enough information and data to establish the budget once a project is approved.
3. The Public is clearly informed about project "budgets".

BACKGROUND

Approval of a Council Policy for the Redevelopment Agency and City that will improve the Capital planning and budgeting process by setting definitions of project estimation relative to the degree of project design definition and level of completion. The policy will establish a consistent and uniform approach for estimating and reporting construction project costs and establishing realistic construction project budgets.

As a general guideline, the City and Agency should use no less than a "budget" estimate associated with the Schematic Design Phase when establishing final project budgets. Relying on "program" and/or "preliminary" level estimates for setting a final project construction budget is far too early in the project's planning, its definition or design. Until the time where a budget estimate can be made, the project is too conceptual in terms of scope and program size to accurately predict final costs. After the Schematic Design Phase, the project's scope of work is more defined and schematic design has been completed to the extent that a realistic budget estimate can be made to impose effective discipline and direction on the project. At this stage the budget becomes the control for project scope and construction.

POLICY

"Program" and "Preliminary" level estimates are useful tools in a long-term capital budget planning process. However, an estimate must have a level of certainty provided by a "Budget" level estimate to realistically establish a final project.

From project initiation as a concept through the award of a construction contract, there are six essential milestones or steps in the development of a project. These steps are shown below.

At various points within these steps, there are four different kinds of estimates that are prepared as the project progresses from start to finish. As more detail, specificity and definition are developed through the stages of design, these estimates become more certain and realistic as noted below.

The six milestones or steps in a project and the point at which these estimates are prepared, are defined in Attachment "A" and are as follows:

City of San José, continued

TITLE ESTIMATING CONSTRUCTION COSTS AND DEVELOPMENT OF PROJECT BUDGET	PAGE 2 of 3	POLICY NUMBER 8-12

Project Milestone/Phase	Type of Estimate
1. Project Initiation	Program Estimate
2. Planning/Programming	Preliminary Estimate
3. Design	
Conceptual Design	
Schematic Design	Budget Estimate
4. Construction Documents/Bidding/Contract Award	Engineers Estimate
5. Construction	
6. Occupancy/Opening	

The four estimates are defined by this policy as follows:

- The "Program Estimate" is created in the Project Initiation Phase for the long-term, multi-year planning and for initial feasibility studies. It is based on a general description of the project as a concept and does not include any design, architectural work or detailed scope. It may typically include components for land acquisition, design, construction and construction management.

Level of Certainty: ± 35%

- The "Preliminary Estimate" is prepared during the Planning/Programming Phase and is based on an initial program containing building and site square footages and general site work. It is typically not based on any formal engineering or architectural work, which usually has not yet occurred. The Preliminary Estimate is most commonly used to develop the next year's budget or to add a project a current year budget to allow for further design development. For smaller projects of shorter duration and minimal complexity, the Program Estimate step may be eliminated in favor of the Preliminary Estimate.

Level of Certainty: ± 20%

- The "Budget Estimate" is prepared during the Schematic Design Phase and is based on a defined scope and schematic design work. It is prepared using estimated material quantities and unit prices taken from the plans and applying a general unit cost to each item. This estimate includes all changes in definition and scope that have been identified and incorporated into the project design since the Preliminary Estimate. Items associated with the commencement of construction such as bonds, insurance, mobilization and overhead costs are also included. This estimate is used for evaluating project alternatives, value engineering, and evaluation of the project budget established by the Preliminary Estimate in the Planning/Programming Phase. For projects of a multi-year duration, the Budget Estimate should include an inflationary factor that escalates the cost to the dollar value at the mid-point of the construction schedule.

Level of Certainty: ± 10%

- The "Engineers Estimate" is a detailed estimate prepared using the final construction documents prior to bidding and contract award. It is prepared using unit prices for exact quantities of materials and labor taken from the plans. The Engineer's estimate is used to establish the final funding within the budget and to evaluate bids received.

City of San José, continued

TITLE ESTIMATING CONSTRUCTION COSTS AND DEVELOPMENT OF PROJECT BUDGET	PAGE 3 of 3	POLICY NUMBER 8-12

Level of Certainty: ± 5%

Smaller projects of shorter duration may not require all four levels of estimates. In most cases, however, a larger project would require as a minimum a "Preliminary", "Budget" and "Engineer's" Estimate.

To support the establishment and implementation of this policy, a set of detailed administrative procedures to be followed for project managers and staff engaged in capital construction projects will be developed. These procedures are to provide specific and detailed instructions and guidelines on how and when estimates are prepared, reviewed and approved in accordance with this Council Policy.

City of San José - Proposed Revisions to Policy 8-12 (April 2008)

b. Cost Estimating for Capital Improvement Projects (PW) – Deferred from March

Director of Public Works, Katy Allen and Assistant Director, Dave Sykes presented the report on cost estimating for capital improvement projects. In accordance with Council Policy 8-12: Estimating Construction Costs and Development of Project Budget, staff developed and put into practice sound cost estimating techniques which include the following:

- Examination of historical bid data for commonly-used materials and labor,
- Market research for current pricing of specialized materials and labor, and
- Employment of cost-estimating consultants for complex projects.

While these estimating techniques are in-line with industry standard practices, difficulties in accurately estimating construction costs have been encountered as the market becomes increasingly more uncertain. On the average, staff has done a good job of estimating costs but believes that modifications to the current policy will improve the accuracy and effectiveness of cost estimating and budgeting. Staff is considering incorporation of the following measures into the revised policy:

- Increased review and quality assurance of cost estimates.
- Structural contingencies of various project stages to contend with uncertainties, including the use of a bid contingency to absorb the cost of unexpected bid results.
- More formal use of add-alternates to ensure that project scope is not unnecessarily removed.

Staff has prepared a draft revision to Council Policy 8-12 titled, "Estimating Capital Improvement Project Costs and Development of Project Budgets." This draft will be circulated to staff and stakeholders for their input. Upon the motion of Vice Chair Sam Liccardo, and seconded by Councilmember Judy Chirco, the Committee voted to accept the report.

Source: www.sanjoseca.gov

Government Accountability Office (GAO)

Excerpt from Cost Estimating and Assessment Guide (2009):

Table 2: The Twelve Steps of a High-Quality Cost Estimating Process

Step	Description	Associated task	Chapter
1	Define estimate's purpose	▪ Determine estimate's purpose, required level of detail, and overall scope; ▪ Determine who will receive the estimate	5
2	Develop estimating plan	▪ Determine the cost estimating team and develop its master schedule; ▪ Determine who will do the independent cost estimate; ▪ Outline the cost estimating approach; ▪ Develop the estimate timeline	5 and 6
3	Define program characteristics	▪ In a technical baseline description document, identify the program's purpose and its system and performance characteristics and all system configurations; ▪ Any technology implications; ▪ Its program acquisition schedule and acquisition strategy; ▪ Its relationship to other existing systems, including predecessor or similar legacy systems; ▪ Support (manpower, training, etc.) and security needs and risk items; ▪ System quantities for development, test, and production; ▪ Deployment and maintenance plans	7
4	Determine estimating structure	▪ Define a work breakdown structure (WBS) and describe each element in a WBS dictionary (a major automated information system may have only a cost element structure); ▪ Choose the best estimating method for each WBS element; ▪ Identify potential cross-checks for likely cost and schedule drivers; ▪ Develop a cost estimating checklist	8
5	Identify ground rules and assumptions	▪ Clearly define what the estimate includes and excludes; ▪ Identify global and program-specific assumptions, such as ▪ the estimate's base year, including time-phasing and life cycle; ▪ Identify program schedule information by phase and program acquisition strategy; ▪ Identify any schedule or budget constraints, inflation assumptions, and travel costs; ▪ Specify equipment the government is to furnish as well as the use of existing facilities or new modification or development; ▪ Identify prime contractor and major subcontractors; ▪ Determine technology refresh cycles, technology assumptions, and new technology to be developed; ▪ Define commonality with legacy systems and assumed heritage savings; ▪ Describe effects of new ways of doing business	9

GAO, continued

Step	Description	Associated task	Chapter
10	Document the estimate	▪ Document all steps used to develop the estimate so that a cost analyst unfamiliar with the program can recreate it quickly and produce the same result; ▪ Document the purpose of the estimate, the team that prepared it, and who approved the estimate and on what date; ▪ Describe the program, its schedule, and the technical baseline used to create the estimate; ▪ Present the program's time-phased life-cycle cost; ▪ Discuss all ground rules and assumptions; ▪ Include auditable and traceable data sources for each cost element and document for all data sources how the data were normalized; ▪ Describe in detail the estimating methodology and rationale used to derive each WBS element's cost (prefer more detail over less); ▪ Describe the results of the risk, uncertainty, and sensitivity analyses and whether any contingency funds were identified; ▪ Document how the estimate compares to the funding profile; ▪ Track how this estimate compares to any previous estimates	16
11	Present estimate to management for approval	▪ Develop a briefing that presents the documented life-cycle cost estimate; ▪ Include an explanation of the technical and programmatic baseline and any uncertainties; ▪ Compare the estimate to an independent cost estimate (ICE) and explain any differences; ▪ Compare the estimate (life-cycle cost estimate (LCCE)) or independent cost estimate to the budget with enough detail to easily defend it by showing how it is accurate, complete, and high in quality; ▪ Focus in a logical manner on the largest cost elements and cost drivers; ▪ Make the content clear and complete so that those who are unfamiliar with it can easily comprehend the competence that underlies the estimate results; ▪ Make backup slides available for more probing questions; ▪ Act on and document feedback from management; ▪ Request acceptance of the estimate	17
12	Update the estimate to reflect actual costs and changes	▪ Update the estimate to reflect changes in technical or program assumptions or keep it current as the program passes through new phases or milestones; ▪ Replace estimates with EVM EAC and Independent estimate at completion (EAC) from the integrated EVM system; ▪ Report progress on meeting cost and schedule estimates; ▪ Perform a post mortem and document lessons learned for elements whose actual costs or schedules differ from the estimate; ▪ Document all changes to the program and how they affect the cost estimate	16, 18, 19, and 20

Source: GAO, DHS, DOD, DOE, NASA, SCEA, and industry.

APPENDIX G: OTHER RESOURCES

Cost Estimating Guidance

Caltrans (http://www.dot.ca.gov/hq/oppd/costest/costest.htm)
This website is a collection of policies, tools, guidance, training, best practices and lessons learned being made available to assist in the development of cost estimates that are complete and accurate, reflecting the true scope of work to be performed and reflecting current market trends. This is a dynamic collection and in no way reflects a complete universe of material that is available for use.

CCTA Cost Estimating Guide (http://www.ccta.net/EN/main/state/tools.html)
The Contra Costa Transportation Authority Cost Estimating Guide sets out a consistent framework for estimating project costs at the conceptual level. Project proponents are encouraged to use the Guide when preparing cost estimates for Measure C or J funded projects. Sound financial programming requires consistent and reasonable cost estimates. Accurate cost estimates help project proponents establish reliable funding plans for their projects and allow the Authority to program sufficient funding to deliver the projects.

Mn/DOT (http://www.dot.state.mn.us/cost-estimating/costmgmt/index.html)
The Minnesota Department of Transportation site includes information on Mn/DOT cost management guidelines, cost estimating policies and procedures, guidance for determining uncertainty, risk and contingency, and cost estimate communications.

Oregon Department of Transportation (www.oregon.gov/ODOT/HWY/OPL)
The ODOT website provides access to average bid item prices by region, summary of current construction cost trends, and quarterly cost indices.

WSDOT Strategic Analysis & Estimating Office (http://www.wsdot.wa.gov/Design/SAEO/)
The Strategic Analysis and Estimating Office is part of the Washington State Department of Transportation Design Office, providing technical support in the disciplines of Estimating, Risk Analysis, Value Engineering, and Project development. This site provides links to information on the WSDOT cost estimating guidelines, the CEVP approach to estimating, standard construction item bid data, and cost trends.

Sharing Best Practices & Lessons Learned

California Multi-Agency CIP Benchmarking Study (http://eng.lacity.org/techdocs/cabm/)
For the 7th consecutive year, the California Multi-Agency CIP Benchmarking Study (Study) has continued its unparalleled effort to share the collective Capital Improvement Project

implementation experiences of the seven largest cities in California. This year, a substantial amount of effort was expended to improve the quality of the regression analysis methods and the statistical significance of the modeled relationships. Through a modification of the statistical methods employed, measures for goodness-of-fit for regression models have typically improved tenfold, increasing the value of the Study for the participants.

WSDOT Lessons Learned (http://www.wsdot.wa.gov/Projects/delivery/LessonsLearned/)
The Washington State Department of Transportation Lessons Learned system is an on-line, automated database designed to capture, present, and track lessons learned from the department's project delivery program. This system enables users to apply knowledge from past experiences to current and future projects. Its intent is to share best practices and avoid the repetition of past failures.

ABBREVIATIONS AND ACRONYMS

AACE	Association for the Advancement of Cost Engineering
AASHTO	American Association of State Highway and Transportation Officials
CAD	Canadian dollars
CCTA	Contra Costa Transportation Authority
CEVP	WSDOT’s Cost Estimate Validation Process
CIP	Capital Improvement Program
DOT	Department of Transportation
FHWA	Federal Highway Administration
GAAP	Generally Accepted Accounting Principles
GAO	Government Accountability Office
Mn/DOT	Minnesota Department of Transportation
MPO	Metropolitan Planning Organization
MTA	Metropolitan Transit Authority (Los Angeles)
NCHRP	National Cooperative Highway Research Program
ODOT	Oregon Department of Transportation
OMB	Office of Management and Budget
PDPM	Project Development Procedures Manual (Caltrans)
PS & E	Plans, Specifications and Estimate
RTPA	Regional Transportation Planning Agency
STIP	State Transportation Improvement Program
TIP	Transportation Improvement Program
TRB	Transportation Research Board
WBS	Work Breakdown Structure
WSDOT	Washington State Department of Transportation

BIBLIOGRAPHY

AbouRizk, S.M., G.M. Babey, and G. Karumanasseri. "Estimating the cost of capital projects: an empirical study of accuracy levels for municipal government projects." Canadian Journal of Civil Engineering (National Research Council Canada) 29 (August 2002): 653-661.

Anderson, Stuart, Keith Molenaar, and Cliff Schexnayder. Final Report for NCHRP Report 574: Guidance for Cost Estimation and Management for Highway Projects During Planning, Programming, and Preconstruction. NCHRP Project 8-49, Washington D.C.: Transportation Research Board, 2006.

—. NCHRP Report 574: Guidance for Cost Estimation and Management for Highway Projects During Planning, Programming, and Preconstruction. Washington, D.C.: Transportation Research Board, 2007.

Association for the Advancement of Cost Engineering (AACE). "AACE International Recommended Practice No. 10S-90, Cost Engineering Terminology." January 26, 2009. Retrieved from www.aacei.org/technical/rps/10s-90.pdf (accessed April 12, 2009).

—. "AACE International Recommended Practice No. 17R-97, Cost Estimate Classification System." August 12, 1997. Retrieved from www.aacei.org/technical/rps/17r-97.pdf (accessed April 14, 2009).

—. "AACE International Recommended Practice No. 40R-08, Contingency Estimating General Principles." June 25, 2008. Retrieved from www.aacei.org/technical/rps/40R-08.pdf (accessed May 18, 2009).

Betlyon, Brian, and Lisa Randall. "Cost Estimation Resources, Tools and Notable Practices." Resource Paper, Planning Technical Service Team, Metropolitan Transportation Commission, Oakland , 2008.

Caltrans. "Planning Cost Estimates: Project Report." Sacramento, CA, October 31, 2008.

—. "Project Development Procedures Manual." Sacramento, CA, 2006.

Carr, Robert. "Cost Estimating Principles." Journal of Construction Engineering and Management (American Society of Civil Engineers) 115, no. 4 (December 1989): 545-551.

Contra Costa Transportation Authority. “Cost Estimating Guide.” Pleasant Hill, CA, October 2008. Retrieved from http://www.ccta.net/EN/main/state/tools.html (accessed February 12, 2009).

Doyle, Sue. "MTA Questions Caltrans' Budgeting: Price tags keep rising on freeway projects." LA Daily News, December 7, 2006.

Federal Highway Administration (FHWA). "Guidelines on Preparing Engineer's Estimate, Bid Reviews and Evaluation." January 2004. Retrieved from http://www.fhwa.dot.gov/programadmin/contracts/ta508046.cfm (accessed April 23, 2009).

—. "Major Project Program Cost Estimating Guidance." January 2007. Retrieved from http://www.fhwa.dot.gov/programadmin/mega/cefinal.cfm (accessed February 12, 2009).

Flyvberg, Bent, Holm Mette Skamris, and Buhl Soren. "Underestimating Costs in Public Works Projects: Error or Lie?" Journal of the American Planning Association 68, no. 3 (Summer 2002): 279-295.

Flyvbjerg, Bent. "From Nobel Prize to Project Management: Getting Risks Right." Project Management Journal, August 2006: 5-15.

Flyvbjerg, Bent, and COWI. "Procedures for Dealing with Optimism Bias in Transport Planning: Guidance Document." London: British Department for Transport, June 2004.

Flyvbjerg, Bent, Massimo Garbuio, and Dan Lovallo. "Delusion and Deception in Large Infrastructure Projects: Two Models for Explaining and Preventing Executive Disaster." California Management Review 51, no. 2, 2009: 170-194.

Gray, Clifford, and Erik Larson. Project Management: The Managerial Process. 4th. New York, NY: McGraw Hill, 2008.

Hecker, JayEtta Z. Federal-Aid Highways Cost and Oversight of Major Highway and Bridge Project – Issues and Options. Report No. GAO-03-764T. Washington, D.C.: United States, May 8, 2003.

Hendrickson, Chris. Project Management for Construction: Fundamental Concepts for Owners, Engineers, Architects, and Builders. Vers. 2.2. Department of Civil and Environmental Engineering, Carnegie Mellon University. Summer 2008. Retrieved from http://pmbook.ce.cmu.edu/ (accessed April 4, 2009).

Hufschmidt, Maynard M., and Jacques Gerin. "Systematic Errors in Cost Estimates for Public Investment Projects." Edited by J Margolis. The Analysis of Public Output. New York: The National Bureau of Economic Research, 1970. 267-315.

Humphreys, Kenneth. Project and Cost Engineers' Handbook. New York: Marcel Dekker, Inc., 2005.

Humphreys, Kenneth, and Paul Wellman. Basic Cost Engineering. 3rd. New York: Marcel Dekker, Inc., 1996.

Los Angeles, City of. "California Multi-Agency CIP Benchmarking Study Annual Report." Los Angeles, 2008.

Martin, James L. Management of Public Works Construction Projects. Kansas City, MO: American Public Works Association, 1999.

Merewitz, Leonard. Cost Overruns in Public Works, with Special Reference to Urban Rapid Transit Projects. Berkeley, CA: Institute of Urban Regional Development, University of California, 1972.

Minnesota Department of Transportation. “Cost Estimation and Cost Management Technical Reference Manual.” Saint Paul, MN, 2008. Retrieved from http://www.dot.state.mn.us/cost-estimating/tools/index.html (accessed February 19, 2009).

Molenaar, Keith. "Programmatic Cost Risk Analysis for Highway Megaprojects." Journal of Construction Engineering and Management (American Society of Civil Engineers) 131, no. 3 (March 2005): 343-353.

Oberlender, Garold, and Steven Trost. "Predicting Accuracy of Early Cost Estimates Based on Estimate Quality." Journal of Construction Engineering and Management (American Society of Civil Engineers) 127, no. 3 (May/June 2001): 173-182.

Pryne, Eric. "Washington State Cost Estimates for Highway Projects Skyrocket." Seattle Times. June 4, 2002. Newspaper Source Plus, EBSCOhost (accessed May 24, 2009).

Reilly, John, Michael McBride, Dwight Sangrey, Douglas MacDonald, and Jennifer Brown. "The Development of CEVP: WSDOT's Cost-Risk Estimating Process." WSDOT Cost Risk Assessment. Feb 22, 2004. Retrieved from http://www.wsdot.wa.gov/NR/rdonlyres/F3C8DCB6-08B4-4CCF-B7A0-2A8494D28466/0/040223BSCEfinalpapersubmitted.pdf (accessed May 19, 2008).

Sacramento, City of. “Project Delivery Manual.” Sacramento, CA, January 31, 2007. Retrieved from http://www.cityofsacramento.org/transportation/engineering/project-delivery-manual.html (accessed April 23, 2009).

Schexnayder, Cliff, Sandra Weber, and Christine Fiori. Project Cost Estimating: A Synthesis of Highway Practice. NCHRP Project 20-07, Task 152, Webb School of Construction, Arizona State University, Tempe, AZ: American Association of State Highway and Transportation Officials, 2003.

Seattle Post-Intelligencer Editorial Board. "Highway costs aren't what's shocking." *Seattle Post-Intelligencer*, June 9, 2002.

Stewart, Rodney D. Cost Estimating. New York: Wiley, 1982.

Sundaram, Venkataramani. "Essentials of Design Phase Cost Management and Budget Control." Cost Engineering (Association for the Advancement of Cost Engineering) 50, no. 2 (February 2008): 24-28.

Taylor, Sam. "Ferndale approves roundabout: Some think the $2.4M price tag is disappointing." Bellingham Herald (Bellingham, WA), April 17, 2007. Newspaper Source Plus, EBSCOhost (accessed May 24, 2009).

United States Government Accountability Office (GAO). GAO Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Capital Program Costs. Washington, D.C.: United States, 2009.

Washington State Department of Transportation. "Cost Estimating Manual for WSDOT Projects." Olympia, WA, November 2008.

Westneat, Danny. "Tunnel's cost may fool us all." Seattle Times. April 26, 2009. Retrieved from http://seattletimes.nwsource.com/html/dannywestneat/2009123442_danny26.html (accessed May 3, 2009).

Westney, Richard. Managing the Engineering and Construction of Small Projects: Practical Techniques for Planning, Estimating, Project Control and Computer Applications. New York: Marcel Dekker, Inc., 1985.

Wideman, R. Max. Cost Control of Capital Projects and the Project Cost Management System Requirement. Vancouver, British Columbia: AEW Services, 1983.

ABOUT THE AUTHOR

DAREN T. GRILLEY, P.E.

Daren Grilley is a licensed Professional Engineer in California and Washington and is currently the Assistant City Engineer at the City of SeaTac, Washington. He holds a Bachelor of Science in Civil Engineering from the University of Washington in Seattle. Prior to joining the City of SeaTac, Mr. Grilley was a Senior Civil Engineer for the City of Rancho Cordova, California (2007-2008) and the City of Galt, California (2006-2007), and a Project Engineer with the City of Kirkland, Washington (1999-2006). He resides in Edmonds, Washington with his wife, Anne, and their two children.