Program Scoping / State of Practice For Washington State

Final Report

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16. ABSTRACT

The overall goal of this research project was to investigate ways to accurately scope projects with an efficient process in a timely manner to align with the critical path development for programming and the legislative cycle. The need for improved cost estimation is an acknowledged essential element in the scoping of a project. Past experiences throughout the world reveal how common and problematic these underestimations of cost and schedules, especially for mega-projects, have become. The accompanying public distrust, lack of confidence in project implementers, and lack of interest in increased funding have generated a great deal of literature, studies, website activity and media attention.

In this research effort, much of the many volumes of material on the subject of scoping and cost escalation were reviewed. Selected findings from selected differing sources formed the core of the review of literature section. These findings were then augmented by a broad survey and review of the activities and efforts of various states, usually by the Departments of Transportation in those states. Those discussions and analyses of those activities allow specific findings and recommendations to be determined.

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EXECUTIVE SUMMARY

The overall goal of this research project was to investigate ways to accurately scope projects with an efficient process in a timely manner to align with the critical path development for programming and the legislative cycle. Identifying the timing needed to develop an adequate scoping process which assumes reasonable risk and compensates for that risk with a budget adjustment prior to legislative considerations and project implementation will set the stage for successful, accurate and reliable scoping documents.

The need for improved cost estimation is an acknowledged essential element in the scoping of a project. Past experiences throughout the world reveal how common and problematic these underestimations of cost and schedules, especially for mega-projects, have become. The accompanying public distrust, lack of confidence in project implementers, and lack of interest in increased funding have generated a great deal of literature, studies, website activity and media attention.

In this research effort, much of the many volumes of material on the subject of scoping and cost escalation were reviewed. Selected findings from selected differing sources formed the core of the review of literature section. These findings were then augmented by a broad survey and review of the activities and efforts of various states, usually by the Departments of Transportation in those states. Those discussions and analyses of those activities allow specific findings to be determined.

Summary Findings

- Cost estimation is only one component of the scoping process but is the component that has been most problematic, both in a budgeting and public trust context. Improvements in cost and schedule estimation and delivery will make the most impact on the overall public trust issue.

- The new political process in the Washington legislature had increased the need for risk management and accurate scoping.

- Scoping starts early, with initial preliminary project estimates for development in the TIB and STIB processes; it is here that the kernel of public mistrust can start with initially generalized project cost estimates becoming “hard numbers” in the minds of planners and the public. Such numbers are difficult to maintain and defend.

- The CEVP and CRA processes developed by Washington State Department of Transportation were well accepted, and even often recommended, in the review of literature and survey of states. The bottom up development of costs of these processes decreases uncertainty compared to the top down generalist approach.

- The public information program of Virginia Department of Transportation was also a model mentioned favorably in the reviews and survey.

- Public awareness is both a problem and a solution. Transparency of the Department’s scoping process will encourage accurate estimates in an ongoing fashion while fostering acceptance of those estimates and project characteristics.

- Adopting an approach of only “designing to bid or cost” is, at best, a short term solution to scoping concerns and may result in suboptimum transportation system performance over time. Such planning approaches increase the need for accurate scoping of the projects.

- Historical data are indeed *history* in a changing market, especially for mega projects that may affect market conditions and competition. Current market prices and trends are necessary to avoid unexpected cost escalation.

- The level and specificity of design produces cost variance. As the design reaches the engineering estimate stage, variance in costs decreases. Public reporting of scoping should increase as project reaches bidding stage.

- It is critical to always present costs in Year of Expenditure (YOE) numbers at all stages from planning to construction. Inflation indices will guide the growth in costs, but even these have risk variance around them and should be noted.

- Reducing the length of project development decreases the uncertainty around the estimate……thereby clearing up the crystal ball of forecasting.

- Dollars invested in early design yield multiples of savings in construction costs.

- The correct comparison for degree of cost escalation is final costs to engineering cost estimates just prior to bid, rather than planning or pre-design estimates.

Recommendations

1) Increased funding for, and application of, CEVP and CRA should be considered. Continued review of cost and schedule estimations should be done in a Continuous Dynamic System (CDS), from planning to production or "concept to concrete" stage. Such continuous monitoring will inform the project managers as well as both the citizenry and political decision makers.

2) Utilize the Virginia Department of Transportation process to monitor source of item errors in cost and schedule estimation and to quantify and measure performance of the cost estimation process.

3) Consider using risk based estimation in a portfolio of projects for the consideration of the Legislature. The total budget may be a "known and hard" figure, but internal variation in individual projects may be acceptable in a portfolio management of risk. This approach should involve consideration of "Risk Reserves" at the total State Transportation budget level, rather than contingencies at the individual level.

4) Incorporate value engineering or analysis into the Project Team's initial budget estimate withinF the CEVP team's analysis so as to increase the CEVP's efficiency in considering the "base" estimates and risk probabilities. Value analysis helps in refining the design considering the cost impacts.

5) Embrace "scope creep" by using a Continuous Dynamic System (CDS) of following, estimating and explaining changes in project scope throughout the process. Any increased costs of scoping will be paid for by the cost saving and value of public transparency.

6) Develop a departmental culture of leadership and pride of accurate estimates to counteract the Flyvbjerg sense of misrepresentation by self interest promoters. This will put a damper on underestimating, no matter what the reason at the time. Disincentives to underestimate and incentives for avoiding underestimation of cost and schedules should be developed at all stages of the scoping process.

7) Combine risk identification and risk management into the same process, using it to learn about the intricacies of the project as it moves forward, again in a CDS approach.

8) Documentation of all changes in scope resulting in schedule and cost items should be constant and continuous.

9) Allow Region offices to choose internal design and costing structure unique to the Region but encourage development of regional item costs, based on local market factors.

INTRODUCTION

The Washington State Department of Transportation (WSDOT) is continually working to preserve its existing infrastructure and improve the transportation system in the state of Washington, with major emphasis over time on the highway system. Those improvements are usually in the form of discrete projects that, when brought together, enhance the highway system that provides the available or desired service to the traveling public and to the freight movements so critical to the state and regional economy.

As each of those projects are developed and constructed, a critical phase in the development is the scoping of the project prior to and during the design or preliminary engineering stage, followed by budget approval by the legislature prior to construction. Scoping begins with the transportation planning process that identifies system deficiencies, assigns conceptual or possible solutions to these deficiencies, finally resulting in a transportation or highway system plan. State procedures, as well as USDOT-FHWA guidelines, usually follow that plan approval with the three primary phases of work: Preliminary Engineering, Right-of-Way Acquisition and Construction.

Scoping is used to identify the purpose and need for the project, the project characteristics, its schedule and budget, and cost of each project phase; because of overriding legislative accountability and timing, the initial scoping budget estimate often becomes the programmed budget for that project. Incomplete scoping of a project often impacts the schedule and budget of projects and provides misleading or incomplete information to decision makers as they allocate constrained funds. Any deviations or underestimates may then affect the success and timing of the project; this is sometimes referred to as the success or failure in delivering a project “on time and on budget”, the identified goal of the Washington State Department of Transportation, Washington State Transportation Commission and the Legislature.

Preparing scopes of work for projects is costly and time consuming. In most cases, a project’s sequential design and construction activity flow from the details and assumptions from the original scope. This is particularly critical in some of the larger more complex projects that often may not have the time, budget or certainty about future events to complete an exact scope of work, resulting in considerable risk from estimating budget and time schedule variances. In recent years the identification of specific projects in the legislative bills, in a legislative budget cycle that does not easily and clearly match the planning and construction cycle of the traditional WSDOT program, can cause conflicts or, at a minimum, a need for a "continuous dynamic scoping" overall process as various projects are moved on and off the contemplated construction list.

These conflicts occur as the WSDOT works to prepare scopes of work that accurately reflect the schedule, budget and risk factors of the individual projects, such as in the 405 corridor, SR 167, US 520 or various HOV lane projects. Timely delivery of a project is hindered if incomplete or inaccurate scoping information is provided in the initial budget estimate for a project. While critical for a larger, more complex project, like the Alaskan Way Viaduct in downtown Seattle, it is still very sensitive for even smaller projects such as Highway 270 between Pullman, Washington and Moscow, Idaho. It is critical that WSDOT properly identifies and communicates the scope of a project along with the risk factors when selecting project funding and communication with the public so projects can be successfully managed, resulting in delivering that project "on time and on budget". Risk factors in several recent projects include the desire for complete and accurate geo-tech information as well as a full investigation of cultural resources at a project site.

Of special consideration is the role of an individual project in a corridor, where some improvements have been undertaken, some are programmed and others may be added by the legislature. This is an example of the need for an ongoing dynamic scoping process, one that can identify the emerging and changing risks and potential problems as they are affected by the changing corridor situation.

STUDY GOAL

The overall goal of this pilot research effort is to describe the state of the art in program scoping in the U.S. The information will identify scoping methods that are accurate (within reason for the typical level of development found in the stages of scoping) and timely (must align with the legislative process for budget development. Such scoping, with adequate time and budget, will include and offer adequate cultural resource assessment, complete geo-tech investigations and other risk factors assessment, along with the traditional environmental and construction determinations as to cost and requirements. Such an effort will improve the initial estimates, thereby enhancing the information provided for legislative consideration and authorization.

PROBLEM STATEMENT / ISSUE

Underlying the desire for continued improvements in scoping of projects is the desire for public confidence in WSDOTs' ability to come in "on time and on budget." The local and state news media continually report on increases in project costs and delays in project schedules, and these reports are generally accurate, revealing the false expectations under which the public has been operating. The items focused on in these discussions are the final cost of the project relative to the initial project cost estimate and the time of completion of the project, again relative to the initial projected time schedule. These issues underlay the overall process within which scoping of projects occur, namely the initial cost estimate, the project management itself and the communication about the project, both with the public and internal to the project or WSDOT management.

In some situations there are plausible/legitimate explanations why projects fail to be completed "on time and on budget." The initial project estimate may have been hurried due to a desire to get the project started, the competition for funds within a constrained state budget, inadequate funds for a complete scoping and design and/or political pressure for a particular project. But, even if the original cost estimate was exactly correct, "scope creep", from both program creep and political creep, can cause the project costs to increase over time. Such scope creep is not always or is seldom part of the public debate or understanding. Thus, the need for the continuing public communication mentioned earlier is evident. As this report will detail, the final engineering estimate is the appropriate value to use in comparing to final cost of the project, not the initial project scope estimate.

REPORT OUTLINE

The report will first review the most cited sources of increases in cost and time frame estimates and provide overall results from a review of studies, reports, academic literature and guidebooks regarding the sources of cost underestimation, the alternatives available to handle the risks associated with point estimates and the performance of those alternatives. The second section will discuss the results of a review of selected states and how scoping is undertaken in each state. Common characteristics will be identified and considered for best practices recommendations.

The third section will draw from the reviews of literature and the states' practices a summary of the major cost/schedule concerns and implementation issues. Alternative changes in reviewing and validating cost estimates, providing public information and improved communication between project managers and the public are then considered. Finally, as potentially productive practices are identified, suggested changes or alternative recommendations for Washington State Department of Transportation's management of scoping will be presented.

SOURCES OF COST ESCALATION

The causes and explanations for these final cost (and time) excesses in project scope estimation are many and they vary from project to project. A common one is, as indicated above, "scope creep" or changes over time from the original scoping. The resulting project built may simply not be the project that was originally under consideration when scoped, due to responses from local community leaders, political decisions or even changes in standards affecting the project size and characteristics. Inflation, by the vary nature of changing prices over time can be the cause of many changes in the magnitude of cost estimates and also time variances as additional investment funds are required. Inflation increases in importance when schedule delays occur, putting more, unexpected pressure on construction cost items.

While handled by the technique of always quoting and identifying costs in the year of expenditure (YOE), inflation is still a projected/forecasted estimate with some measure of risk and uncertainty associated with it. A common source of cost escalation is missed individual items within the cost framework, for example, rock density and amount, needed lighting, administrative costs, right-of-way purchases (ROW), cultural resources discovery, etc.

The sources of escalation, above normal inflation expectations, are even more pronounced recently: localized material shortages for specific construction products, spot shortages of labor, regulatory restrictions, such as environmental permits for plants and quarries, hurricane-related issues increasing non-highway construction demand, downsizing of the local workforce due to instability of transportation funding prior to the "nickel" and other subsequent funding. Construction material prices saw significant increases in the past three years. Concerns about the availability of Portland cement, copper, gypsum and PVC pipe in the short run were evident. Underlying many of these cost increases is the continuing escalation of global fuel prices, which many of these products depend on for processing and shipment to markets.

As a result, total construction costs have been rising ahead of inflation costs for the past several years. WSDOT's Construction Cost Index (CCI), based on recent bids, reflects the prevailing market conditions. The average annual growth in the CCI from 1990 to 2001 was 1.5% per year, but since then, the average growth rate has been 8.0% per year (Measures, Markets and Mileposts, December 31, 2006).

Faced with cost escalation and inflation overall, the WSDOT has worked to evaluate the competition among bidders on the projects, feeling that "a competitive bidding market is WSDOT's best tool in an inflationary market." They found that the percent of WSDOT's contracts bid by at least three firms has held steady at around 67% but that the percent of contracts bid by at least four firms had fallen from 50% to 33% in 2005. The larger number of contracts being let and the overall activity of construction in the area may be part of that change. Also, mergers and consolidations in the construction industry that reduce the number of available contractors to provide the work are also evident.

An often stated source of differences between actual and estimated costs is that the initial cost estimates are highly and systematically misleading. Flyvbjerg and colleagues go so far as to say that underestimation cannot be explained by error and is best explained by strategic misrepresentation or in their terms "lying". Discussed later in this report, this study suggests that the public, media, etc., should not blindly trust cost estimates that are advanced by project promoters or those that do the analysis for them.

The public concern and distrust towards the estimation of costs and expected schedules of completion for these projects is quite evident. The scoping process that produces these cost numbers and schedules is constrained by the fact that these are only estimates, conducted at a time when incomplete information is all that is available and usually completed in a very short time frame. Only upon completion of the project is the final schedule and cost known. The issue in this study is to see if there are practices utilized in other states, regions or countries that could improve Washington's scoping process and how those scoping estimates are utilized in the project management and political process in the state.

PROFESSIONAL AND ACADEMIC LITERATURE REVIEW

Lying or Missing the Mark?

Project cost escalation, as a major problem for Departments of Transportation and other construction agencies, received a great deal of attention in an article by Flyvbjerg, Holm and Buhl, published in the Journal of the American Planning Association, in 2002. Entitled "Underestimating Costs of Public Works Projects- *Error or Lie",* this work represents a significant study of cost escalation completed recently. Other studies have looked at smaller samples or individual projects, often of urban rail, but the size and complexity of this sample sets this study apart.

The authors start out by defining cost inaccuracy or escalation as the difference between actual costs minus estimated costs as a percent of estimated costs. The authors do frankly admit that defining estimated costs as the estimate at the time of the decision to build was made is not without critique. Cost estimates at each successive stage typically become more accurate over time, and the cost estimate at the building decision time is significantly different than the engineers estimate just prior to construction. However, the authors point out that their focus is on how cost estimates are used in decision making, so the expected costs at the time of the decision are relevant for their analysis. They feel they are evaluating the extent of how informed the decisions are at that time.

They also admit that projects can change drastically over time (project or scope creep) such that "apples are compared to oranges". But it is the authors' contention that some of these changes in a project, such as environmental and safety concerns, may have been institutionally left out deliberately in the original estimate to get the project accepted and underway. They use the initial estimates for the 258 projects in North America, Europe and other countries that they were able to compile and develop, according to the authors, defendable data.

The findings of the study support the authors' assertions that "estimation success" is iis rare. Generally, they found that 9 out of 10 projects had underestimated costs of the project, at least under the authors' definitions. Overall the final costs were 28% higher than estimated costs with few projects having overestimated costs, and these were of small magnitude. Rail projects and fixed link (bridges and tunnels) were found statistically to be more prone to underestimation than road (highways and freeways), with underestimations of 44.7%, 38.8% and 20.4%, respectively.

It was found that cost escalation was a concern globally, but with some variation over location. For highways, North America experienced only 8.4% underestimation compared to 22.4% in Europe. Rail and fixed link projects in North America versus Europe had 40.8% versus 34.2%, respectively, cost escalation. Interestingly, the study found that the cost estimates, and associated underestimates, had not improved over the time period of the data, up to1998.

The authors then turn to attempting to explain the reasons for this underestimation, considering if it is an error or a conscious misrepresentation. They find, first, that there was no technical reason for forecasting errors, as indicated by the predominance of errors being in underestimating rather than producing an equal number of overestimations. In the discussion, they point out that risk can and should be accounted for in forecasts of costs, but typically are not. This finding has particular relevance to the current methodology utilized by the State of Washington, discussed later in this report.

The primary explanations of economic self interest and public self interest are also examined. Economic self interest details the situations where, if the project goes forward, work is created and profits are realized. Competition for limited monies is also a form of economic self interest. Public self interest suggests lower cost estimates provide an incentive to cut costs and thereby save taxpayers money. However, the study finds that the argument that taxpayers' money is saved by cost underestimation misses the point that bad benefit-cost ratios misdirect monies to lower value projects and overall societal welfare is compromised.

Appraisal optimism, or the feeling that "it will be all right" is examined in a psychological context as a possible reason for cost escalation. The authors reject this reason as well, saying it would only hold if inexperienced estimators were used. And, since there has been no improvement in the cost estimating over time, as discussed above, it suggests to the authors that this reason for missed estimates isn't appropriate either.

The final explanation examined by the authors was political, in terms of interest and power. This suggests that forecasts are intentionally biased to serve the interests of project promoters in getting projects started. This estimation disregards the risk of delays, accidents, project changes, etc., because it doesn't fit in the goals of the promoters

In summary, the authors find that cost underestimation is highly, systematically and significantly evident, cannot be explained entirely by forecast error and seems to be best explained by strategic misrepresentation. (As will be discussed later in this report, the findings in this study ignore much of the real world of cost estimation, its risks and its complexities.)

Improvement Options

The severity of the scoping cost escalation problem has caused many individuals, institutions and state agencies to search for ways to generate estimates that allow more "on time and on budget" project outcomes.   An academic article by Knight and Fayek, published in the Journal of Construction Engineering and Management, in late 2002, described a model that incorporates ***"fuzzy logic"*** for use in predicting potential cost overruns on engineering designs. Though it focused on design costs rather than construction or full project costs, it offers a general framework of evaluation that is seen in other efforts throughout the literature.

The authors point out that scope definition is a consistent problem and that a good scope estimate is necessary to allow base lines or benchmarks to be set. Design overruns seem to come from the item estimate itself and the loss of control over the project scope. Literature dealing with specific factors contributing to the uncertainty was reviewed, but no tool for predicting the design cost overrun was found in that literature; thus, the rationale for this article.

The model is quite basic, dealing with two main items: characteristics that affect design costs, and the risk or probability of those characteristics occurring and to what degree, expressed as a percentage. These relationships are determined by two "standard strengths" in the model. First, the relationship and sensitivity between project characteristics and the risk events are specified by a panel of experts and then the risk events are related to the expected cost ranges by that same panel of experts. Characteristics-risks and risks-damage amounts are identified as poor to excellent and worst case to best case, respectively. The model then uses fuzzy binary relations to approximate the relationships between the project characteristics and risk events in order to predict the expected cost overrun or under run. The model is dependant on the user or project experts to provide the relationship parameters for the standard strengths.

The model was run on a sample of projects using a collaborating design firm. The model results predicted that the conditions of the project, based on the parameters inserted by the expert panel, would cause a 10.2% to an 11.6% cost overrun above the estimated contract fee. The authors felt the use of fuzzy logic was realistic, capable of being modified as the project design progressed and offers a function as a risk assessment and problem identification tool. But they concede the model is data dependent and parameters have to be estimated by historical experiences and expert estimates, both of which may not accurately represent future realities.

The Washington State Department of Transportation has developed a full project model to review and validate cost estimates for large projects and to include risk assessment and opportunity events in order to better predict these costs. Copyrighted as ***Cost Estimate Validation Process CEVP,*** the process includes validation of the base cost of a project, along with explicit identification of high-cost and schedule risk drivers, according to the authors of the report, "The Development of CEVP-WSDOT"s Cost-Risk Estimating Process", by Reilly and colleagues. Such a process leads to an ability to develop explicit risk management plans early in the project's development. This method was initially applied to a set of large projects in Washington State, estimated to cost about U.S$25 billion, and to many smaller projects. The process is now accepted as the standard business practice by Washington State and has been reviewed and applied in many of the articles in this review of literature, including USDOT agencies.

The Reilly article covers once again the problem of both schedule and cost overruns that have been common (internationally and nationally), documenting the core issues regarding cost estimating for complex projects and briefly addressing how traditional approaches, using "best case" estimates, are badly suited to public forums and communication. Without public confidence WSDOT knew some of the urgently needed projects would not receive funding required to move forward.

The paper details the development of the CEVP methodology, including as it evolved from a cost validation and risk assessment tool into a process that integrated management strategies with process requirements. Several key issues set the stage for usage:

- Avoid single number estimates to reflect the variability of the estimates over time.
- Use a collaborative assessment, combining external peer review with internal project team estimates.
- Acknowledge that both cost uncertainty and schedule uncertainty are major contributors to the estimation variance.
- Be practical and use common sense notions of risk descriptions and quantification.
- Produce project output that can be understood by the ultimate audience, the public.

These authors then go on to outline in detail the Cost Estimate Validation Process (CEVP) and discuss the current developments, as of 2004, in the usage of the tool. At that time CEVP had been used on 15 projects, costing about 0.006% of the projected project costs. Close collaboration between the Project Team and the CEVP team members was noted, with significant and early emphasis on cost and schedule risks by the team members.

Cost Risk Assessments (CRA), a modified and scaled down version of CEVP, for smaller projects has also been implemented, generally relying on WSDOT personnel, with acceptable results. WSDOT was working on just when in the life of the project it was most useful to conduct a CEVP or a CRA.

The CEVP model will not be discussed further in this review because it receives more specific attention as one of the alternative models for further usage in the State.

The National Highway Cooperative Research Program also spent time and effort in looking at the cost estimating process**.** , NCHRP Report 574 (an output of Project 8-49), available at **http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_574.pdf,** analyzed procedures for cost estimation and management for highway projects during planning, programming and preconstruction. Websites are replete with information on the project and some of its results, including the problem statement. Over the time span between the initiation of a project and the completion of construction many factors influence a project's final costs. This report details the challenges related to cost estimation management and development of accurate early project estimates:

- Difficulty in evaluating the quality and completeness of early project cost estimates.
- Difficulty in describing scope solutions for all issues early in project development.
- Difficulty in identifying major areas of variability and uncertainty in project scope and costs.
- Difficulty in tracking the cost impact of design development that occurs between major cost estimates.

The first phase of NCHRP 8-49 focused on state of practice, an extensive review of the literature supported by interviews of transportation agencies, which detailed the major factors causing project cost escalation and strategies, methods, and tools available. Twenty three states collaborated via state of the practice interviews, peer exchange or both. Eleven cost escalation factors internal to the highway departments were identified with emphasis put on poor estimating and inconsistent application of contingencies.

Seven external factors were also identified, including scope creep and inflation as being more common.

The second phase focused on developing a guidebook based on the strategies, methods and tools identified in the first phase. The book was presented to and critiqued by 10 state highway agencies. It was found that to consistently achieve accurate cost estimates and to effectively manage project cost, state highway agencies must adopt strategic approaches that address the interdependence of cost estimating and cost estimating management problems. The guidebook links eight different strategies to over 30 implementation methods that are supported by over 90 tool applications. These strategies, methods and tools are identified in relation to four generic project development phases: planning, programming preliminary design and final design.

The guidebook, as outlined in the literature, is designed to be a step by step outline to success by describing each proposed method and tool. For example, in the method structure questions are: Why use the method? What step is the method used? How is the method impacted by project complexity? What makes the use of the method successful? How is the method applied?

Similar to other studies, and useful in this current study, the developers of the guidebook identify their key principles in cost estimation management and practice:

<u>Cost estimating management</u>

- Make estimating a priority by allocating time and staff resources.
- Set a project baseline cost estimate early in the preliminary design and manage to it throughout project development.
- Create cost containment mechanisms for timely decision making that indicate when projects deviate from the baseline.
- Create estimate transparency with disciplined communication of the estimate uncertainty and importance.

- Protect estimators from internal and external pressure to provide low cost estimates.

Cost estimating practice

- Complete every step in the estimate process during all phases of project development.
- Document estimate basis, assumptions and back-up calculations thoroughly.
- Identify project risks and uncertainties early and use these identified risks to establish appropriate contingencies.
- Anticipate external cost influences and incorporate them into the estimate.
- Perform estimate review to confirm the estimate is accurate and fully reflects project scope.

The material (NCHRP Report 574) produced by NCHRP Project 8-49 included challenges that underlie the implementation of these strategies. State highway agencies management must demand adherence to a strategic approach and require that all steps in the cost estimating management and cost estimating practices be performed. Further, implementation should be approached from a systems perspective, not only integrating cost estimating and cost estimating management but these processes must be integrated with the agency project development process. Finally, full implementation of the Guidebook requires time. The implementation effort will require time to determine how the Guidebook strategies, methods and tools are best integrated into current state transportation agency practice.

Managing capital costs was also the focus of a public transportation study done by Booz Allen Hamilton, Inc. for the Transit Cooperative Research Program of the Transportation Research Board. The report, *"Managing Capital Costs of Major Federally Funded Public Transportation Projects*", was completed in November 2005 and used qualitative and quantitative approaches in its research. The goal of the research was to develop an ability to estimate at the planning and engineering developmental stages, with some desired degree of accuracy, the resulting as-built costs for major federally funded public transportation projects.

This study performed a literature search and data collection from existing sources. The objectives of the literature search were to document the current state of the industry in responding to the challenges of cost increases in all of the transportation modes, as well as to identify sources of data to support the cost and schedule analysis to size the extent of the cost issues. An initial set of over 30 candidate projects were reduced to 28 and then to 14 for more detailed study of the strategies, tools and techniques used to estimate, manage and control capital costs. The researchers developed a database structure to guide the collection of project capital cost data and an approach for analyzing cost changes by major cost drivers through each phase of project development. The major cost drivers identified were initial inflation adjustment, scope changes (including unit cost and quantity), and schedule changes (including the inflationary impact of project delays). The phases of project development utilized in the analysis were:

1. Alternative analyses/draft environmental impact statement
2. Preliminary engineering/final environmental impact statement
3. Final design
4. Construction/operations.

The study findings from this research effort were quite broad. Project definition requires clear prioritization criteria to be established early in project development since they are important to both cost and schedule performance. Some of the most volatile risks to capital costs and schedule are time to achieve political consensus and the acquisition of private property. The tradeoffs between scope, cost and schedule must be communicated in order to control scope creep. Outreach to the community and business is important to minimize project redefinition and maximize support. While engineering issues were encountered in these transit projects, these were felt to be controllable. The larger impacts were the stakeholder, third-party and real estate acquisition issues and their impacts upon the project definition.

Other strategies that contributed to the control of cost and schedule were value engineering and design-to-budget, by refining the design in consideration of project cost factors, even a fixed budget. In addition, a transparent development process and a reasonable project development schedule that reflects sufficient time for stakeholder outreach contributed to the most success in project definition.

Procurement strategies varied from design-build to construction management at risk to traditional design-bid-build. The first two alternatives allow consolidation of construction and installation contracts without the project definition concerns of design-build. Other procurement strategies evaluated favorably in this research included prequalification of contractors and industry review of contract documents.

Change orders and claims management can be minimized by defining them early, and then estimating, negotiating and settled them in an expeditious manner. Alternative dispute resolution provisions were found to minimize cost variance due to scope or schedule changes. Timeliness of responses to proposed changes was essential. Resolving all claims at the lowest possible level can be done by empowering the filed staff while maintaining adequate financial authorization.

Addressing quality issues at an early state helped avoid unnecessary complications. Several innovative quality approaches were identified in the study, including application of a QA/QC manual, a just-in-time training program, preparatory phase inspections, an independent testing program, and use of specific metrics to monitor and recognize contractor's effort on quality.

Risk management, according to the authors, entails the comprehensive identification, assessment and mitigation of risks and responsibilities to the parties involved at early states of project development, and the subsequent monitoring of these identified risks throughout the project development process. Risk mitigation is aided through the assignment of individual risks to the party best able to manage it. Assignment of blind risks to the contractor does little to minimize cost risk and much to increase bid premiums.

The report finishes by answering questions relating to the research goals. Local project sponsors can estimate costs and schedules reliably if they use reasonable starting assumptions, improve estimation quality and increase estimation transparency. The same local project sponsors can contain project costs and schedules at each phase by optimizing project parameters by using design-to-build, value planning, value engineering and risk assessment approaches. Further they can apply a broad range of project management controls such as problem resolution, efficient processing and appropriate incentive structures, accompanied by an effective organization.

Completion of projects on cost and on schedule can be aided by selecting the appropriate delivery method, even including public-private partnerships. Recognizing the tradeoffs in contracting such as one major contractor versus multiple smaller ones and the effect on competition and management complexity is necessary.

Changes outside of the direct control of the project sponsors that could aid performance include improving estimation consistency by use of standard procedures (use of Year of Expenditure, for example), and always communicating uncertainties and limitation in estimates. A detailed, probabilistic risk assessment is becoming a more common and accepted method of identifying risk factors and quantifying their potential impact on project development.

Finally, this excellent report points out that more effective public outreach and stakeholder engagement will help control schedules and costs. Improved funding mechanisms may also aid in controlling schedules and costs; such mechanisms could include local, state, private funding in addition to federal funding.

In ***"**Accounting for Mega-project Dollars**"**,* found in Public Roads, published by the FHWA, USDOT, the author Jim Sinnette looks at the efforts that are underway to improve cost estimating for major highway projects over $1 billion, his mega projects. He reminds the reader that the importance of an accurate mega project estimate cannot be overstated because it sets the stage for sound public decision making. Estimates are a key component in establishing accurate performance expectation at each step of the project's development.

Scope change sometimes occurs because large projects are perceived as opportunities for piggybacking additional projects, completing multiple projects or producing prominent public symbols such as a "signature bridge". But, as the project process progresses, the more accurate and less risky estimates should become. By analyzing project risks and using appropriate contingencies, the goal is to create an initial estimate that will not change significantly throughout the project's life. But the difficulty in anticipating all cost elements early in the project often results in a low initial estimate, especially when combing with a dose of management team over optimism.

During the design stage, costs are affected as the engineering efforts discover issues or constraints unknown during the planning phase. The final engineer's estimate is the basis for putting the project out to bid and should be very specific. Sinnette points out that forecasting is still required to estimate the impact of a mega project on the construction environment. Even with a good engineering estimate, uncertainties, risks and cost increases occur. He identifies cost factors of inflation, additional mileage and upgraded standards to meet safely, operational and environmental needs.

Underlying the impact of these cost factors is a need for improved communication, and using Virginia Department of Transportation's Project Details screen on VDOT's dashboard Website as an example, the need for the public to view the status of a project is fulfilled. A full description of WSDOT's CEVP process is presented as an appropriate model to improve cost estimating. (Both of these models are discussed in detail later in this report.) The paper then summarizes other sources of tools available to the public, ranging from the Major Projects Team of FHWA to NCHRP Report 574, discussed earlier, to other sources from AASHTO, and the departments from Maryland, California, New Jersey, Florida, as well as The transportation Estimators Association, Trns●port User Group, NCHRP Report 20-7, etc.

Another comprehensive study was the June 2003 *"Project Cost Estimating-A Synthesis of Highway Practice"*, by Schexnayder and colleagues, prepared as part of NCHRP Project 20-7. A solid literature review of books and technical articles forms the core of this work. The authors find that although numerous books have been published on the subject of construction estimating, most of them are directed to the building and homebuilding segments of the construction industry. The procedures for producing heavy construction estimates are the subject of a limited number of books. Special attention is paid to the Parker book, and the Bartholomew book among others.

More material and information is found in technical articles in the categories of policies and procedures of estimating entities and the technology for estimating. The design to cost strategy involves constantly managing the design to insure that the construction documents reflect a design that can be constructed for the budgeted amount. It encourages the design team to put more emphasis on the budget than the polished design. Another discussion suggests that the personnel performing the estimate possess both a strong knowledge of costs as well as implicit design knowledge. These personnel can be guided by the Construction Specifications Institute (CSI) Master Format whose sixteen categories allow for easy organization of all aspects of the contract and estimate. This approach is similar to the format used by AASHTO in its guide, especially for specification writing and payment monitoring.

Production of bid estimates receives some attention with several alternative methodologies reviewed. Market forces are favored over historical data by several of the articles.

Technology in estimating is constantly evolving and developing. Desired specifications in an estimating program include (1) clear definitions of all terms and actions, (2) ease of use, and (3) some method of tracking each and every part of the estimate, as well as option lists for each portion of the estimate, such as altering pavement type or thickness.

Three specific techniques to be used in computer analyses are offered. *Regression analysis* in one reviewed study produced estimates within 20% of the low bid amount. *Neural Networks* have the capacity to perform a large number of calculations and make decisions with a minimal amount of user input. Historical data allow the network to learn cost relationships. A small test of a neural model produced estimates within 9% of a panel of experts. *Monte Carlo Simulation* is a probabilistic cost estimation system to handle variability involved with cost estimates. Tests indicate that an accurate model can predict the cost of line items that generally have the most variability. This model generated correlated random numbers from the data, and then applied those numbers to user-defined quantities in order to develop an estimate.

The article summarizes by stating departments must: (1) avoid false precision, created by early optimism as to knowledge of actual or perceived costs, (2) relate contingency to the layman's everyday experiences with uncertainty and (3) invest in continuous and transparent QA/QC of the estimating processes. Further cautions include the need for institutional and management maturity, sufficient funds to complete the proposed work, and realization that the actual cost of a project is subject to many variables which will influence the range of probable projected cost.

The interest in this critical scoping and cost estimation issue has resulted in many "guidelines" for strengthening bidding and contracts or overall scoping. AASHTO recently produced *"Suggested Guidelines for Strengthening Bidding and Contract Procedures"* which walks the reader or project manager through the elements desired at the pre-bid stage, bidding stage and post award stage. In the pre-bid stage attention is paid to prequalification of bidders and subcontractors to determine job experience and to estimate from which the agency might be receiving a bid. Then specifications should include antitrust language and expectations. The detailed engineers estimate should be kept secret to generate open competition. Policies about competition and debarment should be set and made evident.

In the bidding stage attention should be paid to the mechanics of the proposal documents, the estimate, submission of the proposal, location of the bid depository, opening and reading of the bids, analysis of the bids, reporting of suspected antirust activities and, finally, the award. The post award stage requires internal agency audits, review by state antitrust investigation units, and attempts to increase competition and exchange of information among states which have experienced antirust activities. The guideline concludes with examples of how to identify bidding patterns and irregularities.

FHWA produced *"Guidelines on Preparing Engineer's Estimate, Bid Review and Evaluation"* in January 2004.This report is similar to the AASHTO guideline but has more detail and cautions. Its purpose is to outline recommended procedures for preparing engineer's estimates and reviewing bids prior to award, to provide guidance for improving pre-bid, bid review and evaluation policies and procedures and to improve competitive bidding procedures.

Of particular use is the discussion on estimating methods which include the actual cost approach, the historic data approach and the combination of both. All three methods have strengths and weaknesses and receive full discussion. Another point of interest is the emphasis put on the confidentiality and accuracy of the engineer's estimate because the estimate must have credibility if the bid review process is to be effective. Finally, specific detail is offered on an approach to evaluating bids for completeness and competitiveness.

Check lists have been developed for various agencies for scoping of highway projects. The U.S. Forest Service's check list is used as part of its early coordination and data gathering process. Besides describing the project need and scope of proposed highway grading, the checklist contains an initial estimate of environmental resources, potential impacts and related issues in the project study area. Focused on the NEPA process the list helps determine the type of project classification and the scope of the environmental document, whether it is to be a Categorical Exclusion, Environmental Assessment or Environmental Impact Statement. The National Park Service and the National Marine Fisheries use similar scoping documents under Sec. 1501.7 again focusing on the material necessary for environmental impact statement. It details the steps in the scoping process to be followed by the lead agency.

Construction Cost Increases, Competition

As discussed throughout this report, project scoping has fallen short of accurately predicting the final cost of projects. States have responded in many ways, including examining the relationship of construction cost increases to competition. First, Washington State, in its Measures, Markers and Mileposts provides the Highway Construction Costs by quarter, recapping prices bid in the most recent quarter and comparing it to the previous quarter. Units covered are roadway excavation, crushed surfacing, hot mix asphalt, concrete pavement, structural concrete, steel reinforcing bar and structural steel.

The Florida Department of Transportation experienced dramatic increases in project construction costs in late 2005 and 2006. This resulted in an informal email survey of all state DOT Construction Engineers regarding cost increases, with eighteen states responding. The survey focused on any cost increases in the bids and initiatives implemented by the states to address those issues. All of the states had experienced increases, ranging from 2.7% in Minnesota to 66% in Colorado (Washington reported 8-9% and Oregon saw increases of 6-18%).

The initiatives adopted by the states to address these increases varied widely. Many states simply rejected all bids exceeding a given percentage, 10-15%, or with less than three bidders. Some states split projects into two phases while some deferred some projects and canceled others. Competition was a concern for most of the states and attempts were made to increase the number of bidders on projects. Washington State had implemented its Cost Estimate Validation Process and Cost Risk Assessment Programs and used a “materials on hand” provision to pay for materials ordered early to lock in prices. A common response was to simply update the scoped construction costs to reflect current market conditions.

In February, 2006 the FDOT saw a continued increase in construction cost and an increase in non-competitive contracts where the Department eight received no/single bids or received two bids. FDOT then convened a one-day summit which was attended by Florida DOT personnel, Florida Transportation Builders Association member contractors, consultant firms and FHWA representatives. FDOT identified a number of local/global factors contributing to cost increases:

Local factors

- Construction market saturation
- Labor material shortage within the state
- Project requirements in terms of hours of work, night work, delayed start, and asphalt warranties
- Hurricane disrupted petroleum supplies

Global factors

- Fuel cost increases affect on hauling, excavation, paving and fuel related work
- Major increase in cost of construction using steel affects bridge, guardrail and steel related materials

The FHWA briefing paper then summarizes the findings of the Workshop relative to strategies to reduce the cost increases and thereby improve the accuracy of any scoping done on the project. The strategies were broken into short term and long term approaches and the FDOT was to establish a committee to evaluate those strategies and determine which should move forward.

The FDOT informal survey was followed by a formal AASHTO and FHWA survey to determine issues also associated with cost increases and competition. Seventy-seven percent of the states indicated that they had experienced a decrease in the number of competitive bids per project over the previous 2-3 years. Washington's number of three firm bids had held steady but the 4 or more bids had decreased from 50% to 35% recently; however, the state felt that 3 or more bidders indicates good competition.

About 57% of the states identified industry consolidation and increased work with the same number of contractors as reasons for the change. Other responses, about 10% per state, suggested downsizing of workforce due to instability of transportation funding, regulatory restrictions, such as environmental permits for plant and quarries, and increased technical requirements in contracts.

Forty percent had not experienced an increase in the number of single bids or 2 bid projects over the previous 2-3 years, including the states of Washington and Oregon. Single bids occurred most commonly in major bridge and specialty projects. Asphalt resurfacing also received noticeable number of single bids. About 80% of the states published bidders list for proposal and plans in some form or another, including Washington and Oregon.

Over 90% of the states had experienced significant cost increases in construction bids relative to similar pervious projects, including Washington and Oregon. The size of the increases over 2003-2005 ranged from 1-21% in 2003, 1-46% in 2004 and 1-70% in 2005. Average increases identified in the survey for those respective years were 5.8%, 12.7% and 17.1%. Looking specifically at alternative materials and their costs over the previous year, earthwork had increased an average of 26.6%, asphalt increased 17.1%, PCC increased 21% and steel increased 24.2%. The highest increases in any states were for earthwork and PCC, 100% and 80%, respectively.

The most common initiative to fostering competition and controlling costs was rejecting non-competitive bids and re-advertising, followed by balancing work type in each letting. Washington's approach was to revise "payment for stockpiled material" provisions and to conduct additional pre-bid meetings/advertising. To constantly monitor bids Washington compares the low bid to the estimate, with a plus or minus 10% threshold. Beyond the 10% threshold, WSDOT compares the number of bidders and the cluster of bid prices submitted.

SURVEY OF STATES

The following information was developed from selected states through interviews and materials produced in the literature review. Specific effort was made to determine how scoping was done, the extent of cost escalation and the strategies used to handle scoping cost escalation. Selected items of interest to this project are summarized below and discussed in more detail following the table.

Table 1: State Process, Cost Escalation Estimates and Strategies

State	Scoping Process	Extent of Recent Cost Escalation	Strategies
California	Utilizes a project development procedures manual, referred to as Appendix AA. Cost estimating is more than one step in the process. Initial estimates are developed and then specific information on the project is developed.	20-28%	Use previous projects and historical data for initial estimates. Then a current analysis of production rates, labor costs and material costs is included. Project cost estimates are reviewed frequently.
Florida	Develop each project as part of a five year work program. Long Range Estimating Program (LRE) was launched in 2003 and is web based. This LRE will generate reliable internal data, such as earthwork quantities, based on minimal user input.	16-20% due mainly to fuel price increase and shortage of labor	Allow each district to use its own method of defining the scope. Each “concept report” scopes the project. Often 25% is added to the estimated cost as a contingency. Little reliance is made of actual cost data.
Maine	If a cost overrun is identified, supplemental funds are used, as available.	NA	A project is dropped if there is not significant state or local interest.

Table 1: -continued- State Process, Cost Escalation Estimates and Strategies			
Missouri	Scoping process has seven steps: timeline, preliminary plan, project scoping checklist, cost estimates for project parts, public involvement, environmental issues, and management approval. An Accountability Report details any project that is +/- 10% deviation from the original estimate.	15-20%	A 10% contingency is added to the entire project's original estimate. The final cost is made the same as the original cost estimate by changing the project scope as necessary. If not possible to do so, the project is not moved forward.
Montana	Cost estimation procedure uses seven steps; preliminary cost estimate by designer, review by specialists, addition of traffic control and contingencies/inflation, updating of cost estimate at all key stages, documentation of all assumptions , Cost Estimate Review Team of projects over $15 million, and use of regional rather than district prices.	5-15%	Attempt to restrain preliminary engineering costs, currently running about 20-30% of the project. Estimates from previous projects are used, searching for similar projects.
New York	Utilizes a specific manual with a given procedure: 1) Assign project manager with similar experience. 2) Determine complexity of project. 3) Create interdisciplinary team. 4) Develop a Public Involvement Plan. 5) Utilize a checklist, flowchart and alternatives evaluation. 6) Document project scope. 7) Approve, and modify if necessary, final project scope	20-29% on fuel and steel	Follow manual on project scoping and construction process. Resolve issues at the lowest and earliest possible opportunity.
Texas	An AASHTO cost estimating program called Estimator is used as a general manual for all districts. A preliminary Design Conference establishes concepts and design criteria. Alternative routes are examined, followed by a full NEPA assessment.	10-15%	Consultants are often used, about $450 million per year. No centralized scoping procedure is used for the districts and the 254 counties in the state. Historical numbers are developed at the district level for both the preliminary and final engineering cost estimates. If there is an over or under run of 25%, the change must be specified and supported.

Table 1: -continued- State Process, Cost Escalation Estimates and Strategies			
Virginia	The department uses its Project Cost Estimating System. Information is developed by the project manager in three steps: funding and time estimates, perceived problems, and any changes that are made. Milestone meetings are held throughout the project covering scope, preliminary field inspection, public interaction, field inspection and pre-advertisement conference.	NA	The Department requires early input from all functional areas, based on the year of anticipated construction, including an inflation rate. The scope development is being centrally controlled currently, using a planning estimate, a scoping estimate and the final estimate. Detailed cost estimates can be adjusted by the Districts.
New Mexico	Design teams are given the assignment of scoping and cost estimation. The General Office builds and maintains the data base, using Trns●port, for the estimator on each project. Individual projects fluctuate but smaller projects, especially those under $20 million	12-20%	Normal projects run between $5-15 million but a recent $1 billion bonding has several mega projects. The Department constantly considers the Legislature and accountability since they provide the funding and the direction from the public. Overall, yearly efforts, as a package, are delivered within 1% of scoping efforts.
North Carolina	An extensive detailed examination of the proposed projects is done even before being entered into the TIP. Scope definition and maintenance of that definition is critical since the project cycle in the state is 10 years, time for significant scope creep or corrections to the original cost estimate.	15-23%	An early public distrust issue now has the DOT continually reporting on the progress and status of the projects. The DOT forces credible scoping initially and updates as necessary over the project cycle in the state. Recent projects have been in at around 4% overrun of the original estimate.
Pennsylvania	Parametric values are used in determining cost estimates in the planning and early design stages. Engineering and Construction Management System (ESMS) is used to manage projects during the design and construction phases.	8-14%	Estimation of scope and costs heavily considers environmental issues, wetlands, cultural resource mitigation and right-of-way purchases. The concept of lump sum designs and construction projects has recently been utilized.

Table 1: -continued- State Process, Cost Escalation Estimates and Strategies			
Oregon	Significant resources are now going to outsourcing due to a shortage of in house personnel. Estimates include inflation factors and now supply and demand factors are being considered.	15-20%	Effort/interest in producing regional supply and demand factors for the Pacific Northwest is underway. Time lines are being reduced, allowing minimization of inflation impacts and less uncertain projections being necessary.
South Dakota	The DOT has imposed controls in recent years and scope and cost estimates have been more accurate for both the 5 and 10 year TIP.	8-12%	Environmental issues are greatest concerns but recently right-of-way and ITS costs have increased the uncertainty of cost estimates. Performance under the new controls has decreased over runs form 10-20% to 1-2%.
Utah	The Department now controls what goes into the TIP and forces fiscal constraints. The list is shortened and projects more tightly scoped. Their project management system establishes costs at each level of activity, e.g. right-of-way, environmental, cultural, etc.	8-15%	Utility relocation is done at DOT expense with little control available to the Department. Right-of-way is now emphasized since it can be up to 50% of total project costs.

California

California has developed a project development procedures manual. Appendix AA of that manual was identified by Caltrans personnel as the current approach to the issue. Cost estimating is not a one step process in the Caltrans approach. Estimating costs is to be done throughout the whole construction process. Caltrans tries to get as many people as possible involved in the estimating process, including functional units such as Division of Structures, Right-of-Way, Traffic Operations, Materials, Maintenance, Construction, Environmental, and Landscape Architecture. They also scope alternative methods instead of one method by using a technique called "walking the job". If they notice a high cost item then they use a "worst probable case" approach to determine the cost.

Additional information is then sought about the project. Some of the points included: “existing and forecasted traffic; geotechnical design information (particularly where foundation and slope stability problems can be anticipated); materials and pavement structural section design information; advance planning cost estimates for new structures and modifying existing structures; hazardous waste assessment; potential environmental issues and mitigation; right-of-way and utilities data sheets; traffic handling and transportation management plans; utilization of existing resources (recycling), etc."

Two general methods are used in cost pricing estimation. The first is to use previous projects and historical data. The other is to make a complete current analysis of production rates, labor costs, and material costs. Project cost estimates are to be reviewed frequently, given the recent experience of cost escalation.

There is a general format that Caltrans uses in estimating costs. It is as follows:

1. Cover Sheet

2. Roadway Items
    a. Earthwork - estimated by developing typical cross sections, profiles, contour maps and then using electronic calculations.
    b. Pavement Structural Section - calculated by determining width, depth and length.
    c. Drainage - estimated by determining extensions to existing culverts and the number of other features, such as inlets, and overside drains, that will be affected.
    d. Specialty Items - retaining walls, noise barriers, reconstruction of irrigation facilities, erosion control, hazardous wastes, and environmental mitigation.
    e. Traffic Items - signing, stripping and other traffic items.
    f. Minor Items - fencing, curbs, sidewalks, access ramps, etc.
    g. Mobilization - 10% of the total of the main construction items plus minor items.
    h. Roadway additions - provide funds for construction work that can not be predicted or calculated beforehand because of an uncertain nature or amount and therefore it is not done on a contract item basis.

3. Structure Items
    a. Bridges
    b. Railroads

4. Right-of-Way Items - costs to relocate fencing, reconstruct gates, reconstruction road approaches

Florida

Each project in Florida is part of a five year work program. Lately there has been 16-20% inflation in labor and materials. Not only is there inflation because of the increase in fuel prices, but Florida DOT has experienced a shortage of labor, thus increasing the wages cost item in the scope. A conference, “Commitments Made, Commitments Kept" focused particular attention on the need to clearly and tightly define the project scope.

FDOT has developed a new program called Long Range Estimating Program (LRE), launched in 2003. The new LRE is web based and replaces the prior mainframe system that was originally installed and written in 1986. The new LRE is designed to be intuitive and user friendly and to provide for improved accuracy in estimating. Lump sum projects under the old system are not comprised of anticipated cost items, quantities and unit prices. The new LRE is expected to generate reliable internal data, such as earthwork quantities, based on minimal user input.

The personnel from the project management office also revealed that each district had a somewhat different method when defining the scope, and that some districts were more efficient than others in producing that scope. Each district has its own "concept report" that scopes the project. One of those districts that were successful, Turnpike District, was interviewed. For every project, they simply add 25% to the estimated cost as a contingency. The agency reports that they make limited use of actual cost data.

Maine

If there is an overrun on a particular project Maine attempts to use supplemental funds. That is, they seek extra funds from a private/non-state donation or take funds from a future project. In several cases the project has been dropped if there is not enough local or state interest.

Missouri

The project scoping process utilized by the state of Missouri has seven steps:

1. Determine a timeline. Scoping projects should not be pushed by time.
2. A preliminary plan is required. A formal document of this plan is accessible.
3. There is a project scoping checklist which is also accessible.
4. Estimates for the parts of the projects are formulated.
5. The public becomes involved in the scoping process.
6. The environmental issues are considered.
7. Management then has to concur with the project and give approval.

For scope changes (scope creep) MODOT breaks it into two sections, non-major scope changes or major scope changes. Based on the size of the scope creep, determination will be made as to whether formal requests for more funds will be required.

Discussions with personnel indicate a strict adherence to making the final cost the same as the estimated cost. If major differences arise between the two the new changes are not incorporated into the project or the project is not moved forward at all. If a project is estimated to be completed at 3-10% of the original estimate, it must be approved by a higher authority. If it is greater than 10%, another level of authority examines and gives the approval. By law, an "Accountability Report "must be published every year which detail every project that has a +/- 10% deviation from the engineering estimate. MODOT attempts to follow a "Practical Design", similar to that used in New Jersey. One of the current rules is to add a 10% contingency to the entire project's original estimate.

MODOT states it has delivered over $2 billion of construction work and had been within 0.33% of the original estimate up to 2005. Subsequent cost increases have made it difficult to maintain that performance. The management process that MSDOT uses allows, for each project, a 3% inflation factor. The original scope document has to be approved at several levels within the Department.

Montana

Montana has a seven step general cost estimation procedure, as follows:

1. The designer or consultant gathers as much information as possible for a preliminary cost estimate.
2. The PDM, Design Supervisor or Lead Worker, and CE Specialist reviews and revises the estimate using tools, training, and judgment.
3. Traffic control, mobilization, contingencies/risk, inflation are added as appropriate to scope of project and design stage.
4. The cost estimate is updated at all key stages of design using current price information, and then the cost estimate is again discussed with the design team and Construction at the plan review meetings; a continual caution is to be aware of project budget constraints.
5. All steps and assumptions used in determining cost estimates are to be documented.
6. For projects with construction estimates over $15 Million, a Cost Estimate Review team is convened to further refine the cost estimate at key stages.
7. District Prices are no longer required from District personnel – regional prices will be determined by the design team and the Project Design Manager.

When estimating costs, MDOT does use estimates from previous projects, searching for similar projects. If a road needs to be built they will look at previous costs of a road that was built in the same area and with similar characteristics.

A critical current problem is inflation. Formally, they expect 3% every year, but recent experiences indicate the increase in gas prices is even more dramatic. A similar issue is the need to restrain preliminary engineering costs. These costs are currently running between 20 and 30% of the total program, much of it dealing with overall project planning, environmental permitting and cost escalation.

New York

NYDOT has a specific manual that outlines and develops the entire construction process. The section on scoping details the seven steps for the project scope, as follows:

1. A project manager is usually assigned that has previous experience in similar projects. A consultant and/or an outside agency in project scope development activities will also be added to the scoping process.
2. The complexity of the problem, the environmental issues, and appropriate documentation are determined. Explicit determination of the needs of the project scoping, specifically the project issues, elements, and initiatives, is the next step. Then, the required amount of staffing is specified.
3. A broad based inter-disciplinary project team is created to consider all the needs, identify critical issues, and develop solutions that are based on a desired consensus.
4. The public and the stakeholders are then involved, after they develop a Public Involvement Plan.
5. The group will have a project scope development checklist. In summary, the checklist covers the existing conditions, considerations, and real estate cost estimates. There is also a flowchart that describes the process for the development of the project scope. Also, there is a list of technical activities that need to be examined, as well as a brief examination of any possible alternatives to the current plan as formulated.
6. The project scope will then be documented making certain that problems, needs, objectives, design, alternatives, costs, and considerations are discussed.
7. Finally any problems have to be resolved, approval of the project scope received, and final modification of the scope done.

Texas

The state of Texas operates a very decentralized scoping procedure. There is no centralized scoping procedure of the districts and the 254 counties in the state. Estimates are usually generated from historical numbers with the districts developing both the preliminary and final engineering cost estimates. The personnel felt the engineering was generally accurate, with few overruns and under runs. However, the planning estimates do cause the state problems since good parameters are difficult to determine because of the varied specification and processes used among the districts.

The state of Texas spends $450 million a year on consultants, who are usually contract managers outside of DOT. The DOT personnel oversee the progress to make sure the contract managers being complete in there reviews. If there is an overrun or under run of 25%, a form is needed to specify and support the change.

- TXDOT uses an AASHTO cost estimating program called *Estimator* that is available for preparing estimates. This serves as the general manual for all Districts, from which the differences among Districts becomes evident.
- A Preliminary Design Conference is held to establish and agree on fundamental aspects, concepts, and preliminary design criteria of a project.
- Public meetings are then held.
- Alternative routes are examined.
- Environmental issues are then considered and a NEPA assessment completed.
- The project manager physically surveys the area, as well undertaking a topographic survey.

Virginia

In Virginia, a project manager is chosen for each project. Once the project manager is chosen for a particular job, he/she will answer questions regarding what needs to be done. There are three parts to the overall report. Part A asks about the funding, time, etc. At the end of Part A the project manager seeks approval from the District Consultant Engineer, District Administrator, Programming Division Director, Assistant Local & Design Engineer, and the Local Assistance Division Director. Part B asks if there will be any problems with the project. Part C asks if there were any changes that were made from Part A, and second signatures are required from those that were mentioned before.

The project manager has five milestone meetings in order to complete a project. The first one covers the scoping process. This includes "examining the context of the project and potential opportunities for public input, defining/refining the preliminary project scope developed during programming, including concepts of constructability, confirming that the estimated advertisement date is attainable, and confirming that the initial construction cost estimate is reasonable." The four others are the Preliminary Field Inspection, Public Hearing Meeting, Field Inspection, and the Pre-Advertisement Conference. The milestone meetings will be held on "Project Day". This allows for everyone in the district to give input at the different stages of each project.

Currently, the VDOT manages a budget around $3.5 billion. Projects over $100 million in size are required to have a detailed financial and programming plan. The Department uses its Project Cost Estimating System. It requires early input form all functional areas to develop estimates based on the year of anticipated construction, including an inflation rate. Using the System, the scope development is being centrally controlled now. The System has a planning estimate, a scoping estimate and a final estimate. Detailed cost estimates are developed for all major cost areas, including right-of-way, but these can be adjusted by the Districts.

New Mexico

New Mexico's program is about $270-300 million per year but a recent $1 billion bonding program is covering several mega projects included in that request. Normal projects for the Department run between $5-15 million.

Design teams are given the assignments for scoping and cost estimation. Currently using Trns●port as the costing program and procedure, the General Office builds and maintains the data base for the estimator on each project. The Department finds that projects in total for the overall program each year are delivered within 1% of the estimated costs developed during scoping. However, the individual projects fluctuate considerable with significant cost overruns in some instances, especially for projects under $20 million.

Personnel identified the consideration that, irrespective of the size of a project or program, the Department needs to be accountable to the Legislature; they are the source of the funding and the direction from the public.

North Carolina

North Carolina early on experienced a public distrust issue. In 1989, the Legislature passed a highway program that included a loop program around the key cities in the state. Under time pressure the DOT created a project list and produced individual scoping and cost estimates very quickly. The initial estimates were extremely under stated and the DOT felt it lost a great deal of credibility. Key factors identified as contributing to these under estimated costs were inflation, ITS needs, environmental issues, overall permitting and a need for substantial traffic control around the cities. As a result, the DOT is required to continually report on the progress and status of the projects on the original list.

In the actual construction phase, projects experienced about an 11% overrun initially but recent projects were being brought in at around 4% overrun. Recent construction costs increases, as in other parts of the nation, may have increased this overrun on recent projects.

The DOT has reacted by conducting a more intensive detailed examination of the proposed projects before they are even entered into the TIP. Scope definition and maintenance of that definition overtime is critical but difficult because the project cycle in the state is 10 years, time for significant scope creep or corrections to the original cost estimate. The personnel acknowledge tremendous pressure from local promoters and sponsors to get projects into the TIP, which generates pressure to reduce the scope and cost the projects accordingly. The DOT has responded by scoping the projects credibly and making the rationale for the scope estimates transparent to the public, including the local promoters.

Pennsylvania

The Pennsylvania Department of Transportation uses parametric values in determining cost estimates in the planning and early design stages. As in many other states, people in the state, especially the MPOs and the RPOs would like to list as many projects as possible during the TIP development stage.

The DOT uses Engineering and Construction Management System (ESMS) for managing all of their projects during both the design and construction phases. This System is used to procure consultant services, manage consultant contracts, bid and award construction contracts, and manage the entire project during final construction, and to do so electronically to the extent possible. Other AASHTO products are used quite extensively at different phases and issues in the scoping process.

Estimation of scope and costs is heavily affected by the environmental issues, wetlands, cultural resource mitigation and, to an increasing degree, right-of-way purchases. Construction costs have come in within 3% of the bid amount with some upward pressure in recent years. The DOT has explored using the concept of lump sum designs and lump sum construction projects and has used a consultant utilizing that concept in a $170 million new highway alignment project.

Oregon

The Oregon Department of Transportation has undergone some significant organization changes over time, the most significant of which is an increase in outsourcing due to a shortage of resources "in house". This comes at a time when the consulting community is not as wed to the new system as the DOT. Preliminary Engineering costs have increased from a little under 12% to 20% with some identified decrease in overall quality.

Bond work is a major financing alternative and the schedule pushes construction cost estimating, with early estimates often being locked in by the state. Estimates include a factor for inflation, but only recently had industry supply and demand factors been considered to any degree. Interest was expressed in developing regional supply and demand factors for the Pacific Northwest to improve the accuracy of estimates prior to bid.

The Department is working on reducing the project development time lines. A reduction is exposure time means inflation impacts are minimized and less of a crystal ball is needed for projecting cost levels.

South Dakota

South Dakota feels they have similar costing issues as most states. Actual bid experience has been generally 10-20% higher than planning estimates. The difficulty in controlling the STIP process contributes to that difficulty. The DOT has imposed some controls in recent years and is doing a better job of identifying the scope of work and cost estimates in both the 5 and 10 year TIP. This has reduced the overall state annual bid differences from the planning estimates from the 10-20% now to 1; however, significant variation is evident in individual project performance. The State feels the largest issue is environmental concerns but right-of-way and ITS are also issues impacting the uncertainty of cost estimates.

Utah

Personnel in the DOT express their frustration with the cost estimation process by suggesting that traffic and planning had similarities---- develop an estimate and double it. Three elements are developed together in their process: scope, schedule and budget.

The DOT has gone through an evolution to where we now control what goes into the STIP with the Department exercising more fiscal constraints. Historically the DOT inserted three times as many projects as could be realistically delivered. This causes the original estimates, because of the time delay, to be seriously unrealistic when the project finally surfaces.

The Utah Department of Transportation utilizes a project management system that incorporates a project level budgeting process in the initial development. The process calls for establishing costs at each level of activity, e.g. ROW, Environmental, Cultural, etc. They note that once a project is identified the right-of-way can be as much as 50% of the project cost and is a major contributor to the cost overruns.

Personnel also pointed out that utility relocation is done at DOT expense and, since it is usually done and billed by the public utility, there is no real way to control the cost. "Whatever it costs, it costs". Similarly, it was felt that environmental cost controls were relatively non-existent, hence another outside determined cost that has to be projected and then experienced.

ALTERNATIVE SCOPING MODELS

Throughout the review of literature and reports, and the survey of selected states for this pilot study, several models were continually being offered or recommended as appropriate in improving the scoping process. The Washington State Department of Transportation's **Cost Estimation Validation Process (CEVP**) and the Virginia Department of Transportation's **Project Cost Estimation System (PCES)** and especially its pubic interactive board, **Dashboard,** were both born from a realization that the public trust required a more accurate, reliable and transparent scoping process. Too many major projects had come in "behind time and over budget", generating project prioritization difficulties and creating reluctance on the part of the public to support any further funding in the state. As detailed below, both of these models offer the ability to consider project characteristics, assign risk effects in a full scoping effort and then to submit them to public review, scrutiny and consideration, hopefully leading to understanding and public support.

Virginia's Project Cost Estimation System (PCES) and Dashboard

PCES has been developed and used by the Virginia Department of Transportation over the past four years. A task force was formed in 2002 to develop a definitive, consistent, and well documented approach for estimating the cost of delivering construction projects. The problem of keeping transportation programs in line with available funding had become larger and was capturing the attention of agency leadership, the pubic, the media and Virginia's General Assembly. While certainly not unique to Virginia, improvement in cost estimation accuracy from a statewide approach was deemed necessary. The task force's assigned objectives were to improve the project scoping process, and to develop a cost estimation system useful for the state. The Virginia Research Council was tasked to develop that method and was the convener of the task force. The resultant system is now under the supervision of the Virginia's Scheduling and Contract development Division. VDOT is currently conducting a review and assessment of the process VDOT employs in project scoping.

The task force engaged in a review of the literature, surveyed the VDOT Districts, reviewed methods outside of Virginia and then worked on the improvement of project scoping. The development and statistical testing of the performance of the project cost estimation method was the final task.

Recommendations on project scoping included best practices for the structure of the scoping team, preparation for the scoping meeting, communication among staff, documentation of the process, definition and control of scope creep and re-scoping of the projects when they change significantly. A formal Project Development Website now serves as a repository for project information. Continually updated, the site provides estimates, plans, maps, documents, video, project cross sections, the name of project contacts, etc. Individual projects are also available with intimate detail in real time.

The task force decided that the system used by the Fredericksburg District, with necessary adjustments, was the base to be used in the new model. Essentially an Excel spreadsheet, it was simple to use, understand and modify.

The spreadsheet estimated construction costs for primary, secondary, and urban projects and for bridges, including an annually compounded inflation rate and a method to estimate preliminary engineering costs. This template was designed to develop cost estimates very early in the project development cycle it was broader that the detailed unit price and quantity approaches used historically by VDOT estimators. In building the template Fredericksburg staff determined the costs "common" to most projects and those that were "unique" or specific to a project. The length of the alignment was related to the common costs while the unique costs were those most often overlooked in the scoping process. These costs were determined from a sample of 40 construction projects. The spreadsheet contains common cost factors (CCF), quantities of specific unique items (turn lanes and traffic signals, for example), and unique or unusual items requiring a specific dollar input (such as large drain fields or other lump sum costs).

The first step in deriving CCF is to place similar projects into groups, used to build data tables. The base estimate does consider construction engineering, size of the project, two versus four lane projects, annual compounded inflation rates and low volume roads. Appropriate multipliers are in the model to reflect these characteristics. Over time the Fredericksburg District had added bridge estimation costs and PE costs for roads and bridges.

The template developed by the task force, and now comprising the PCES, was developed as a statewide process by modifying the original Excel model by including statewide construction costs and PE costs, as well as bridge costs. Statewide variation was accounted for by determining average CCFs and then modifying for each project as needed. Improvements in coverage of bridge costs, PE costs and construction engineering and inspection costs were incorporated into the system. Right-of-way and Utilities worksheets were added to the model as development proceeded. A summary page in the model brings all three modules (construction, utilities and right-of-way) together. Each cost component is sensitive to the District name on the first page, automatically adjusting the costs to reflect the District.

The task force did rigorously test the performance of the model. A majority (61%) of the errors fell within +/- 30% with 48% of the errors falling between+/-20%. The weighted average error was 22 percent, significantly better than previous cost estimate performance VDOT had achieved earlier. The task force then tested for over and under estimation and project characteristics that are related to percentage errors. For underestimations the only significant variable was urban systems, suggesting that the complexities of the urban projects make caused underestimation. For the overestimations, project size tended to increase the amount of overestimation. Similarly, small projects in some districts were typically overestimated. These findings were incorporated into the current PCES via refinements to the model.

A Final Report on the project, by Kyte and associates offer conclusions and recommendations that have apparently been incorporated into the continued usage of

PECS. Many of them related to project planning and how to improve the data for the PECS model.

A related effort to involve the public in the project management process was the development of Dashboard, VDOT's solution to managing information more effectively and improving cost estimation. Dashboard is a centralized, Web-based system that documents 16 critical steps in the four phases of project development and completion: advertising, contract deadlines, contract awards and work orders. The public can access the information from Dashboard online anytime and send questions via e-mail directly to project managers. This process was originally developed to improve internal processes and communication but has now metamorphosed into a tool for transparency with the public. VDOT also uses community drop-in centers as an enhanced communication opportunity with the public.

Washington's Cost Estimation Validation Process (CEVP) and Cost Risk Assessment (CRA)

In early 2002 the WSDOT began a new process to improve on cost estimation procedures for complex transportation projects. This effort resulted in the Cost Estimation Validation Process (CEVP) and, later, the Cost Risk Assessment used for less complex projects. In 2003 the first round of 12 mega-projects in the state under went the CEVP Process. In the same year a one day due diligence review of smaller projects was conducted, under a process initially referred to as Schedule Cost Risk Evaluation or Score, a name no longer used and now referred to as CRA. The workshops were used statewide on projects not large or complex enough to warrant a full CEVP. At the end of the year the WSDOT Cost Risk Estimating Management Office was formed.

The evolution of this new tool continued with CEVPs of major projects updated in 2004 and the entire process and culture of Risk Management Planning becoming common within the Project Management process. In the same year a Policy for Cost Risk Management, including the use of CRAs and/or CEVPs, was established statewide. In the summer of 2005 a Project Management on-Line Guide was deployed via an Executive Order, a Policy for CRA and CEVP established and in the fall a Risk Management Plan (RMP) spreadsheet tool was made available. Currently the Department is exploring the development of a portfolio risk modeling tool, a risk data base and metrics for performance for the program and exploring ways to increase the efficiency and effectiveness of CEV. The heart of this process is that “an estimate is not an actual number, but a range”.

This process starts early in the project development cycle to identify, assess and evaluate the risks and opportunities that may affect project cost or schedules. Knowing that point estimates of cost and schedule are only one outcome from the interaction of many variables, the process used in CRA and CEVP relies on probabilistic assessment of events occurring, both in costing and scheduling. This process of cost estimation under risk occurs under overall project risk management where the logical steps of (1) initiate and align the project, (2) plan the work, (3) endorse and accept the plan, (4) work and implement the plan and (5) transition and close the project and plan. The first part of the sequence is essentially risk planning and assessment and the last part is the active management of risks.

The heart of the process is the workshop collaboration of the Project Team, the independent internal and external Subject Matter Experts (SMEs) of the CEVP team and the CREM administrative team. The CREM has produced a set of Common Assumptions to be used in the workshops (the workshops are the cost workshop and the risk elicitation workshop), offering inflation factors, indices and item current costs. After determining project assumptions, scope and strategy, the cost and scheduling is broken down to “base cost”, considering if the project were to go forth “exactly as planned without any problems”. This is done for the significant individual project activities, which vary from project to project. Then the workshop participants “build” contingencies in the form of risk and uncertainty estimates from the bottom up rather than a gross estimate of overall risk.

Problems and opportunities that could affect project cost and schedule are then identified, followed by an assessment (quantification) of the impact of such an occurrence. Then, critically, the probability, likelihood or chance of such event occurring is assessed in a peer review by the workshop teams, relying heavily on the SMEs, who vary from project to project depending on project characteristics. Then Monte Carlo estimation is used to identify the final probability estimates, yielding a probability range for costs and schedule timing. For example, there may be a 90% chance that the cost will be under $50 million and a 50% chance that it will come in under $47 million, or there is an 80% chance that the project will be done by June, 2009 and a 30% chance it will be completed by June, 2008.

A key output of the process is the ranked listings of the risk and opportunity factors contributing to the uncertainty, with the factors identified as to the contribution to the total risk. This information offers a strong opportunity for risk management as the project moves forward from "concept to concrete".

Thus far the WSDOT has found that CEVP and CRA are efficient and relatively simple while being far more accurate than lumping contingencies and escalation. Tests have shown that the process is remarkably scalable, especially for the CRA approach. When the project outcome had been agreed upon and the process is complete, a detailed report is created. A one page summary of the project is then made available to interested personnel and the public. Reaction to these one page summaries has been very positive from both internal and external to the Department.

Principles underlying this process and the entire project management effort include, according to WSDOT personnel, *validating*-avoiding false precision, *communicating*-relate words in fashion all can understand, *improve*-always involve QA and QC in cost estimation. This deals directly with the problems of scope creep and self interest promotion often ascribed to project cost estimation.

From these applications of the CEVP and CRA techniques the WSDOT has developed various management strategies reflecting the goals and rationale for this process. Single numbers should be avoided all events, especially with media or public events. The process serves to cause expert peer panel evaluation of activities, items, costs, risks and costs of events. The correct timing of the CEVP is still uncertain but benefits of doing it prior to working with the Legislature with the project list, allowing probability statements to accompany what the legislators consider a hard number. Finally, it felt the process can aid a new culture of engagement with the tax paying public, one based on the common sense understanding by all that “an estimate is an estimate”.

Current efforts by WSDOT in refining the costing techniques, within CEVP and CRA and outside, include trying to fit the detail/degree of investigation and analysis to the risk element of the projects. Low risk projects, such as simply asphalt overlays, might receive just normal evaluation. Moderate risk projects might entail at least some field investigation and high risk projects, especially with large budgets such as capacity adding projects for example, would receive the full scoping and cost analysis before getting the signal to proceed.

Other Examples of Risk Management or Cost Estimation

The studies, literature and states survey reveal that many other states, if not all, have found this issue critical enough to focus their attention to. Although the Washington and Virginia models are most commonly mentioned, many other sources are developing partial models at least.

- Maryland has Dot State Highway Administration’s Consolidated Transportation Program Cost Estimate Program.

- California utilizes its Project Development Procedures Manual, including a detailed Risk Management Process.

- New Jersey relies on its Construction Cost Estimation Manual.

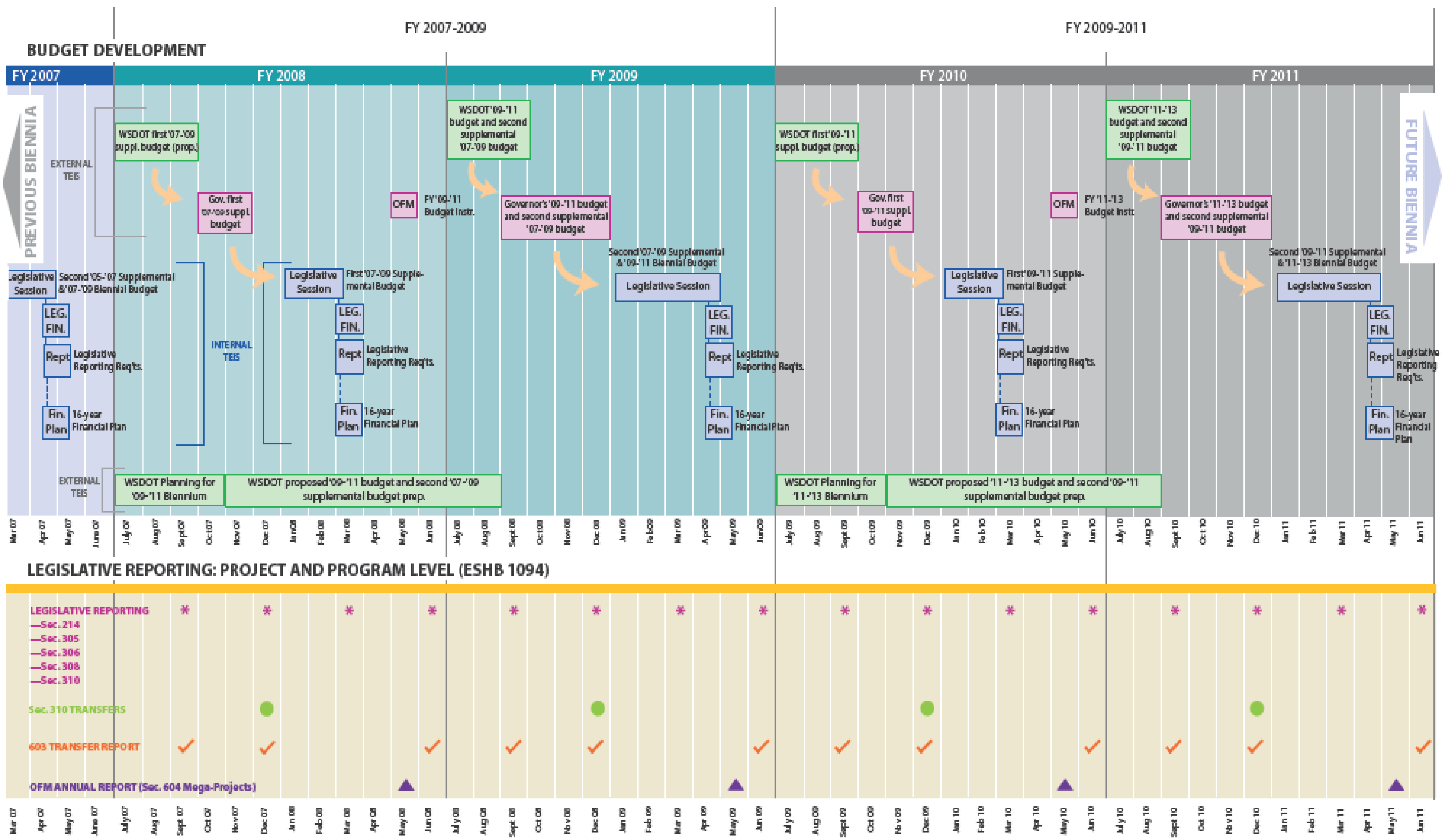
- Florida produces its annual Transportation Costs for all districts.

- TRB and FHWA produce various information and survey reports.

- Cost estimates are available from The Transportation Estimators Association, the Trns●port User Group (TEA/TUG).

The usefulness of these techniques can be enhanced by the timing of the evaluation in the budget cycle. The figure below identifies the current Washington State Legislative budget cycle. Early infusion of the chosen technique, with appropriate follow up, will inform each stage of the process and the resultant reports.

TRANSPORTATION CAPITAL BUDGET DEVELOPMENT PROCESS



Source: Lund Consulting, Inc.

SUMMARY AND RECOMMENDATIONS

The overall goal of this research project was to investigate ways to accurately scope projects with an efficient process in a timely manner to align with the critical path development for programming and the legislative cycle. Identifying the timing needed to develop an adequate scoping process which assumes reasonable risk and compensates for that risk with a budget adjustment prior to legislative considerations and project implementation will set the stage for successful, accurate and reliable scoping documents.

The need for improved cost estimation is an acknowledged essential element in the scoping of a project. Past experiences throughout the world reveal how common and problematic these underestimations of cost and schedules, especially for mega-projects, have become. The accompanying public distrust, lack of confidence in project implementers, and lack of interest in increased funding have generated a great deal of literature, studies, website activity and media attention.

In this research effort, much of the many volumes of material on the subject of scoping and cost escalation were reviewed. Selected findings from selected differing sources formed the core of the review of literature section. These findings were then augmented by a broad survey and review of the activities and efforts of various states, usually by the Departments of Transportation in those states. Those discussions and analyses of those activities allow specific findings to be determined.

Summary Findings

- Cost estimation is only one component of the scoping process but is the component that has been most problematic, both in a budgeting and public trust context, becoming essentially the 800 pound gorilla in the project delivery process. Improvements in cost and schedule estimation and delivery will make the most impact on the overall public trust issue.

- The new political process in the Washington legislature had increased the need for risk management and accurate scoping.

- Scoping starts early, with initial preliminary project estimates for development in the TIB and STIB processes; it is here that the kernel of public mistrust can start with much generalized project cost estimates becoming "hard numbers" in the minds of planners and the public. Such numbers are difficult to maintain and defend.

- The CEVP and CRA processes developed by Washington State Department of Transportation were well accepted, and often recommended, in the review of literature and survey of states.

- The public information program of Virginia Department of Transportation was also a model mentioned favorably in the reviews and survey.

- Public awareness is both a problem and a solution. Transparency of the Department's scoping process will encourage accurate estimates in an ongoing fashion while fostering acceptance of those estimates and project characteristics.

- Adopting an approach of only "designing to bid or cost" is, at best, a short term solution to scoping concerns and may result in suboptimum transportation system performance over time. Such planning approaches increase the need for accurate scoping of the projects.

- Historical data are indeed *history* in a changing market, especially for mega projects that may affect market conditions and competition. Current market prices and trends are necessary to avoid unexpected cost escalation.

- The level and specificity of design produces cost variance. As the design reaches the engineering estimate stage, variance in costs decreases. Public reporting of scoping should increase as project reaches bidding stage.

- It is critical to always present costs in Year of Expenditure (YOE) numbers at all stages from planning to construction. Inflation indices will guide the growth in costs, but even these have risk variance around them and should be noted.

- Reducing the length of project development decreases the uncertainty around the estimate……thereby clearing up the crystal ball of forecasting.

- Dollars invested in early design yield multiples of savings in construction costs.

- The correct comparison for degree of cost escalation is final costs to engineering cost estimates just prior to bid, rather than planning or pre-design estimates.

Recommendations

1. Increased funding for, and application of, CEVP and CRA should be considered. Continued review of cost and schedule estimations should be done in a Continuous Dynamic System (CDS), from planning to production or "concept to concrete" stage. Such continuous monitoring will inform the project managers as well as both the citizenry and political decision makers.

2. Utilize the Virginia Department of Transportation process to monitor source of item errors in cost and schedule estimation and to quantify and measure performance of the cost estimation process.

3. Consider using risk based estimation in a portfolio of projects for the consideration of the Legislature. The total budget may be a "known and hard" figure, but internal variation in individual projects may be acceptable in a

portfolio management of risk. This approach should involve consideration of "Risk Reserves" at the total State Transportation budget level, rather than contingencies at the individual level. Such Risk Reserves could be used to "incentive-ize" accurate estimation at various levels in the Department.

4. Incorporate value engineering or analysis at the end of the Project Team's initial budget estimate and prior to the CEVP team's analysis so as to increase the CEVP's efficiency in considering the "base" estimates and risk probabilities. Value analysis helps in refining the design considering the cost impacts.

5. Embrace "scope creep" by using a Continuous Dynamic System (CDS) of following, estimating and explaining changes in project scope throughout the process. Any increased costs of scoping will be paid for by the cost saving and value of public transparency.

6. Develop a departmental culture of leadership and pride of accurate estimates to counteract the Flyvbjerg sense of misrepresentation by self interest promoters. This will put a damper on underestimating, no matter what the reason at the time. Disincentives to underestimate and incentives for avoiding underestimation of cost and schedules should be developed at all stages of the scoping process.

7. Combine risk identification and risk management into the same process, using it to learn about the intricacies of the project as it moves forward, again in a CDS approach.

8. Documentation of all changes in scope resulting in schedule and cost items should be constant and continuous.

9. Allow Region offices to choose internal design and costing structure unique to the Region but encourage development of regional item costs, based on local market factors.

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