NCHRP Project 8-36 (72)
DOT Approaches to Implementing
Cost Estimate Management
Process Improvements

Final Report

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Introduction
The product of the National Cooperative Highway Research Program (NCHRP) study 8-49 Final Report 574: Guidance for Cost Estimation and Management for Highway Projects during Planning, Programming, and Preconstruction, is a guidebook enabling departments of transportation (DOTs) to develop improved cost estimating and management procedures. However, the Guidebook does not sufficiently address implementation; it does not provide a process for effecting organizational and cultural changes necessary to facilitate acceptance of new procedures. Successful adoption of the Guidebook by DOTs requires an implementation strategy, based on the successes and lessons learned. One objective of this study is to document the processes used by DOTs in implementing the Guidebook. Another objective is to develop a technical reference on implementation from a synthesis of information gained from DOT implementation efforts.

1 Cost Estimation in a Challenging Environment

Estimating the cost of highway projects accurately and consistently in the planning and design phases of project development has become a nationwide challenge, receiving attention from an American Association of State Highway Transportation Officials (AASHTO) Task Force on Project Oversight, the AASHTO Subcommittee on Design Cost Estimating Task Force, and a new AASHTO task force on project delivery. DOTs must develop fiscally constrained transportation plans for 20 years in the future, in an environment where budgets, materials costs, and regulatory requirements and expectations are constantly changing. Unforeseen engineering complexities and constructability issues, changes in economic and market conditions, local government and stakeholder pressures, and transformation of community expectations also affect the reliability of cost estimates.

1.1 The Importance of Cost Estimating at DOTs and the Risks of Unsuccessful Estimation

In 1991, Congress added specific requirements for fiscal constraint in transportation plans. The purpose of the fiscal constraint requirements was to ensure that planning and programming are meaningful and based on realistic assumptions about funding all capital, operating, and maintenance costs associated with the surface transportation system. Congress noted that plans and programs developed without regard to realistic funding are unreliable and undermine public participation and coordination with local governments, tribes, and others. In 1993, the Federal Highway Administration (FHWA) amended planning regulations to include fiscal constraint requirements. The most recent transportation funding bill, Safe, Accountable, Flexible, Efficient Transportation Equity Act: a Legacy for Users (SAFETEA-LU), issued in 2005, continued and increased emphasis on fiscal constraint. In the agency’s 2007 guidance on cost estimating, FHWA noted, “Estimates are central to establishing the basis for key project decisions, for establishing the metrics against which project success will be measured and for communicating the status of a project at any given point in time. Logical and reasonable cost estimates are necessary in maintaining public confidence and trust throughout the life of a major project.”

Accurate and reliable project cost estimates are essential at every stage in the project development process for responsible fiscal management and successful project delivery.
Difficulties predicting and controlling costs generate many problems and risks for DOTs. Impacts to financial accountability and accurate project scheduling are among the most serious. When project costs unexpectedly exceed the programmed budget, the result is usually a delay or cancellation of other projects. Unreliable cost estimates can generate severe problems in a DOT’s programming and budgeting in local and regional planning and result in staffing and budgeting decisions that compromise the effective use of resources. In turn, this affects the DOT’s relations with the state’s transportation commission, legislature, local and regional agencies, and the public.

Inaccurate estimation of the costs of construction projects affects agency credibility along with budgets. For example, according to the 2002 audit of the Springfield Interchange project in Northern Virginia, Virginia DOT (VDOT) had to postpone or cancel 166 other projects because the interchange costs were underestimated. In 2001, a Joint Legislative Audit and Review Committee (JLARC) study found that VDOT tended to underestimate construction costs significantly at each phase of project life. The study was a key factor in VDOT developing national model systems for public accountability, especially the agency’s dashboard of performance measures, improved internal information systems, and a revised cost estimation process.

Finally, the purpose of an Engineer’s Estimate is to allot sufficient funds during planning and development of a project so that funds will be available for construction of the project. The accuracy required is directly related to that purpose.

1.2 What is In a Cost Estimate?

FHWA’s 2007 guidance on cost estimating applied mainly to major projects, but it also succinctly covered basic information on cost estimating, creating a standard basis for state DOTs rather than the previous excessive diversity of interpretations and approaches. For example, the guidance states that “the cost of a project is most often interpreted and most easily understood by the public to be dollars that are spent on the project. The program cost estimate should be considered the equivalent of the total project purchase price. As such:

“...the program cost estimate should include all costs and the value of any resources needed to complete the NEPA work, design, right-of-way activities, environmental mitigation, public outreach, construction, overall project management, specific management plans (e.g., transportation management plans), appropriate reserves for unknowns, as well as costs and resources paid to others for work related to the project such as utility adjustments, environmental mitigation, and railroad relocations...Costs that are unknown and costs associated with potential risks can be included in the form of a contingency amount. Contingency estimates should be defined and quantified throughout the project’s development as specific risk elements, which then may be used to create a Risk Management Plan for the project. As the project is refined, the contingency should reflect the shift of contingencies into actual cost categories. Contingencies should be expressed in terms that can be easily presented to and understood by the public. The appearance of false precision must be avoided.”

FHWA also introduced the requirement to express estimates in year-of-expenditure dollars if there are multiple construction contracts. This can be done by assigning an inflation rate per year to the proposed midpoint of construction, having built in adequate time for project planning, development durations, and construction, as well as inflation rates that may be different for specific cost elements (e.g., construction rather than right-of-way). FHWA’s cost estimating guidance defines what is needed and required in a cost estimate at all phases of the process.
AASHTO has a technical committee on cost estimating, led by Montana and New York State, that is developing recommended policy and guidelines for cost estimating at all stages of project development, based on best practice. Guidance for improving pre-bid, bid review, and evaluation policies and procedures is included. This committee is also involved in reviewing the NCHRP 8-49 study, and may use it to assist its own publication. NCHRP’s 8-60 study, “Risk Analysis Tools and Management Practices to Control Transportation Project Costs” is developing a comprehensive guidebook on risk-related analysis tools and management practices for estimating and controlling transportation project costs; the project is due to be completed in April 2009.

1.3 NCHRP 8-36(72) Research

At each phase of project development, from planning through design and construction, cost estimates influence management decisions about project budgets and schedules. Other research studies, most notably the Transportation Research Board’s (TRB) NCHRP Final Report 574: Guidance for Cost Estimation and Management for Highway Projects during Planning, Programming, and Preconstruction, have looked at the methods and tools DOTs use to estimate and manage costs. NCHRP 8-36(72) focuses on DOT implementation and process improvement.

1.3.1 Research Plan Development

The objective of NCHRP 8-36(72) is to provide insights on how DOTs can implement the strategies to effect the organizational and cultural changes necessary to improve the accuracy and consistency of project estimates. While the Request for Proposal (RFP) initially requested that the selected research team study implementation efforts in three states, the panel asked that the 8-36(72) research study team take a broader perspective, examining efforts in states that reported using the NCHRP 8-49/Report 574 guide as well as states that had other cost estimating and estimate management process improvements underway. The panel expressed interest in learning from the experiences of the broad group of states that are improving their cost estimating and estimate management processes to investigate how they are accomplishing these improvements, what barriers and obstacles they are encountering, and how they are measuring success. Panel priorities for the project were to learn how DOTs are handling issues:

- Recognizing cost estimating and cost estimate management as an agency issue
- Gaining attention and motivation for change
- Managing the change process

In response to the panel’s instructions to, in the constraints of the budget, “be as broad as we can be,” the research team agreed to conduct interviews in as many states as possible.

The research team retained the following initial topic list of questions for the interviews to obtain maximum information in the budget:

- How needed organizational change was identified and what organizational change was identified
- Current status of strategy implementation
- Plans and process of planning for long-term implementation, including how-to information on executing implementation and bringing about the organizational and cultural changes necessary
- Objections or resistance encountered
- Unexpected difficulties encountered
Methods for handling objections and difficulties

Solutions

Lessons learned

Work and accomplishments of multidisciplinary task committees

Methods for estimating staffing and resources needed and assignment of responsibilities

Methods for assessing practice changes and measurement of effectiveness and intended results

Methods for measuring performance and quantifying implementation results

Processes, resources, and implementation steps for controlling scope and schedule changes

Techniques for communications, administration, training, accountability, documentation, and technical support, including implementation templates and resources from lead DOTs, to minimize the effort and cost to other DOTs

Methods and strategies to manage and reduce risks and costs associated with delivery and procurement

Methods for engaging external participants and conditions that influence project costs

Support systems for estimating and ensuring accurate, consistent, and quality documents

Tips and pitfalls

1.3.2 Literature Review

The research conducted a literature review through TRB, state DOTs, conference presentations, and the Internet, focusing on insights garnered through cost estimating and estimate management improvement efforts at state DOTs. Our first interim report in December 2007 summarized our findings on implementation issues, status, and resources in 26 states, shown in Exhibit 1. States Included in the 2007 Interim Literature Review. This report includes best practices and performance measures from all but a few states.

Our review of available resources for DOTs also uncovered numerous tools and templates for individual state DOTs to use (assess, evaluate, and adapt) as a starting place for their own agencies—a leading request from state DOTs in the interview process. DOTs would like the resources to be available in an easily accessible location; consequently, we will provide these resources to TRB’s...
1.3.3 Design of Interview Guide and Identification of Focus States

Through our literature review and discussions among the experts on the team, we identified lead states for in-depth interviews aimed at understanding barriers encountered and solutions developed by DOTs nationwide. We designed the question set in a similar manner; we used the oversight panel’s discussion in the kick-off meeting as a basis for the questions.

Appendix A contains relevant DOT contact information and Appendix B includes the phone interview question set. We submitted the questions to the NCHRP project manager before the start of the interview process to provide familiarization with the types of questions that would be asked. Of the 19 agencies we corresponded with to arrange interviews, 14 states provided more specific information about useful approaches, challenges, and lessons learned about cost estimating and cost management processes.

In April and May 2008, we conducted in-depth interviews with cost estimating and estimate management process leaders at state transportation agencies, representing a diversity of geography, agency sizes, budgets, and information systems, shown in Exhibit 2. States That Participated in In-Depth Interviews.

In addition to the literature review and in-depth interviews, we obtained information from presentations and conversations with many other DOTs at the November 2007 and the April 2008 Cost Estimating and Cost Management in the Design and Project Development Process Capacity Building workshops in Minneapolis. We include implementation highlights and insights from 39 DOTs in this NCHRP 8-36(72) report and guidance, along with discussion of relevant associated systems. Following compilation of this information, including all available performance metrics, we contacted all 50 state DOTs as well as that of the District of Columbia and Puerto Rico to solicit a review and any corrections to the performance measures in use.

The literature review and phone interviews provided many useful insights; however, the interviews also highlighted what DOTs felt to be limited standard procedures and guidelines for cost estimating. This project (NCHRP 8-36-72) provides strategies to address practitioners’ most commonly expressed challenges in integrating process improvements in the organizations’ culture. As with any practice in
general, no “one size fits all” methodology for cost estimating and cost management emerges, and, to some extent, the process is unique for every project. Still, many of the organizational and project management strategies described in this report can benefit most DOTs.

In the past decade or more, state DOTs, the public, and state legislatures and others planning organizations have placed increased emphasis on delivering projects on time and in budget. The practices offered in this report can provide DOT executive managers, middle managers, and supervising practitioners with a toolbox of effective strategies for planning and executing implementation of the cost estimating improvements presented in NCHRP 8-49. By implementing methods, practices, and procedures to eliminate or mitigate cost and schedule overruns, agencies can more effectively deliver needed transportation projects.

1.4 Organization of the Remainder of the Report

The remainder of the report is organized as follows.

Section 2 – Identifying the Change Needed and Developing Improvement Strategies discusses the impetus for changes in the cost estimating and cost management process and how State DOTs structured a strategy for process improvements.

Implementing process changes is discussed in the following three sections.

Section 3 – Implementing Change at the Organizational Level discusses the role of management in organizational changes and the development of an organizational vision and setting performance measures.

Section 4 – Implementing Change at the Program Level discusses staffing, communication, and tools used at the program level to improve the process.

Section 5 – Implementing Change at the Project Level discusses risk management, cost management, schedule management and scope management to improve cost estimates and manage project costs.

Section 6 - Current Status of Strategy Implementation and Plan for Long Term Implementation summarizes the status of implementation of improvement processes for select states.

Section 7 – Further Research provides suggestions for additional research.
2 Identifying Needed Changes and Developing Improvement Strategies

DOTs face internal and external pressures to plan, design, construct, and maintain transportation projects on time and in budget despite continually decreasing funds, loss of experienced staff, and rapidly increasing construction costs. The cost of fuel, asphalt, concrete, and other construction materials is beyond the control of the DOTs, but many agencies took a hard look at their internal processes and identified a wide range of major to simple changes to help them begin to get better control of the cost estimating and cost management processes.

2.1 Understanding the Problem: Why Do Cost Overruns Occur?

In most states, DOT management indicated a strong and clear need for more accurate estimating, estimate management, and easily accessible information for decisionmaking—for engineers, DOT leaders, state legislatures, and local partners. For example, in 2007, MaineDOT determined that cash flow challenges hindered its ability to identify the actual amount of money available for project development, and therefore, the DOT was uncertain about the number of projects that could be advertised for construction. It became apparent to the agency that it needed more accurate cost estimates to predict a realistic schedule and cash flow. Without a clear understanding of cash flow, MaineDOT had fewer projects to bid and implement. Another problem identified by the agency was poor quality data due to an overall lack of priority for maintaining and updating historical project cost data.

A small number of states undertook intensive investigation into how and why their estimates were falling short. The Virginia Transportation Research Council (VTRC) study was the most in-depth and revealing. In internal surveys and interviews exploring reasons behind the problem of cost overruns, the Virginia DOT team found many reasons why final project costs can exceed initial estimates. Other Virginia studies agreed with VDOT’s results. In one study, JLARC examined data from 297 projects beyond the design or construction phase. In July 2002, another study by the Virginia Commonwealth’s Auditor of Public Accounts (APA) examined VDOT’s budgeting and cash management practices. The JLARC review found that early project estimates were much lower than estimates made later in project development and design, and that final construction costs tended to be greater than the award amount due to overlooked, complicating, and troublesome field conditions and unforeseen contract administration costs. The JLARC study concluded that, “Transportation should develop and employ a more rigorous cost estimation process and allocate more resources (front loading) to the development of cost estimates during the planning process, thereby yielding more refined and more accurate project concepts.”

The above-referenced studies concluded that VDOT lacked the necessary practices in place to foster accurate project estimates, accountability for a project, and communication among the multiple divisions involved in the projects. Agency staff inconsistently and sometimes inappropriately applied inflation and contingencies. Collectively, the investigations offered the following explanations:

- Insufficient resources for planning level estimating
- Insufficiently detailed project scoping, leaving out items such as sound walls and lighting
- Insufficient communication across divisions and functional areas
- Scope changes—potentially costly items such as traffic management devices, crossovers, turn lanes, and others are added as time goes by
Accountability and incentive structures that did not work to support accurate estimating
- Unforeseen environmental issues arise that require amelioration
- Method used to estimate costs is incompletely or inconsistently applied
- Failure to account for inflation

Caltrans identified the following in their review of internal and consultant estimates and practices:

Caltrans listed the following reasons for poor estimates:
- Estimate not updated, or old and out of date
- Based on historic, not forecasted information
- Prepared by staff with limited estimating expertise
- Based upon low quality or high risk plans and specifications
- Not tailored to project construction schedule
- Prepared without quality control/assurance
- Constrained by programmed funding level.
- Number of bidders available to bid on a project, and the other projects advertised for bid at the same time.

These same issues have been encountered by many other DOTs and came up repeatedly in the in-depth interviews conducted with 14 state DOTs for the NCHRP 8-36-(72) research.

2.2 Understanding the Barriers and Challenges

DOTs face many barriers to cost estimating and estimate management improvement efforts. Some, such as acquiring the necessary resources, accompany any change effort. Other barriers, such as the differences in planning and design estimates, are more fundamental. As one representative at Ohio DOT (ODOT) noted, the reasons for developing the final Engineer’s estimate is completely different the budgeting estimate. For budgeting, the DOT needs to fit a certain number of projects into the budget cycle so that all funds are expended without going over or being under available funds. The final Engineer’s estimate is developed so the estimator has a benchmark to compare and analyze the bids and ensure contractors’ estimates are accurate.16

DOTs commonly conducted brainstorming meetings and, in some cases, internal surveys to better identify the issues, challenges, and barriers to implementing a cost estimating and cost management improvement process. For example, ODOT’s Jobs in Progress program identified $5 billion for new projects over the next 10 years. With increasing inflation, the governor and ODOT’s director wanted assurance that the construction cost estimates were as accurate as possible. First, the director wanted to verify that districts consistently applied cost estimating methods. To that end, ODOT conducted an internal survey to understand how each district performed budget estimating. Because 80 to 85 percent of ODOT’s projects are designed through consultants, the survey also included 80 to 90 consulting firms. The survey found virtually no consistency between the districts and many times not even within a district; the consultants’ methods were not much better.

Similarly, Minnesota DOT (Mn/DOT) began its internal investigation and data gathering with an interview of eight districts to help identify the barriers and challenges to implementation of an
improved cost estimating process. Consistent with many other DOTs, Mn/DOT identified the following issues in its agency:

- **Lack of awareness** about the importance of a sound, comprehensive estimate by other specialties in the agency.
- **Department support** was needed to provide the necessary resources.
- **Cost estimating needs to be a priority** both for the agency and for those with a broad spectrum of other responsibilities.
- **High staff workloads need to be balanced**, particularly in the absence of dedicated estimators.
- **Avoid a one-size-fits-all approach**—estimators need flexibility to adjust the process to match the complexity of the projects and the size of the organization’s program.
- **Organizational change** such as restructuring the organization or changes to individual’s responsibilities can have its own challenges.

A number of DOTs cited the escalation of the cost of construction materials as the #1 reason for cost overruns. **Exhibit 3. Percent Increase in the Cost of Construction Materials** provides an example of how construction costs have risen. DOTs are caught at the crossroads of rising materials and construction costs and flat budgets, with scoping processes generally too limited to produce highly accurate estimates.

AASHTO’s 2007 Update Survey on Construction Cost Increases and Competition found that two-thirds of the responding 38 state DOTs were experiencing significant cost increases in construction bids relative to similar previous projects. Of those, all but one saw overall percentage increases in construction bids between 6 percent (Illinois and Mississippi) and 30 to 35 percent (Georgia and Washington) in 2006, over the previous year. Earthwork costs increased 30 to 100 percent in several states from Wyoming to the Midwest and Southeast, while asphalt prices commonly jumped between 15 to 35 percent in 1 year, in states from coast to coast.

The same materials (e.g., oil, copper, steel, concrete) are in demand worldwide, with uncertain supply growth in some areas; producer price index increases are expected in the range of 6 to 8 percent annually over the next 1 to 5 years, with even higher price spikes for some materials. At the same time, industry consolidation (e.g., contractors, quarries) and increased work with the same number of contractors add to the pressure.
2.2.1 Funding

The lack of funding is another barrier. The practice of consultants constraining estimates to the DOT’s programmed project funding levels is culturally engrained due to lack of confidence in DOT estimates, and therefore reluctance to timely inform state transportation commissions.

Many states put a priority on improving the cost estimating and cost management processes, but most DOTs lack the funding to provide the necessary resources and staff to wholly integrate all the necessary process improvements and organizational changes. The majority of states had to make do with existing resources, although most pointed out that the improvement process could benefit from additional funding for staff, training, and tools. Utah and Minnesota were notable exceptions. Utah DOT generated funding internally through cost savings, vacant positions, and in the internal operating budget. The total amount was less than $300,000 and that included contractor support and tools for training courses. Utah noted that while it was not a large outlay, it was a lot of effort.

2.2.2 Staff Time and Resources

Finding the time and resources to implement necessary process improvements is a continual challenge for DOTs, despite the creativity and deep process knowledge and commitment of the public servants who make up the ranks of DOT practitioners. In the majority of states, a number of staff assumed additional estimating and estimate management responsibilities, adding to their existing duties. New full-time equivalent staff positions were rarely available, so DOTs sometimes redefined the roles of current individuals on staff. For example, ODOT and Montana DOT did not receive funding for additional staff; however, they were able to reallocate vacant positions or reorganize to identify positions for dedicated estimators without needing to go to the legislature for additional positions. Only a few states dedicated staff solely to their cost estimating and estimate management improvement processes.

Staff turnover and the loss of technical expertise and historical knowledge is a major issue facing most DOTs, compounding the shortage of experienced estimators. In addition to attrition, a common concern is that personnel with little or no experience will gain the necessary skills at the DOT and then leave for higher paying positions in industry or consulting. Hiring freezes and budget constraints add to the problem.

2.2.3 Other External Factors and Internal Organizational Challenges

Other external factors and internal organizational aspects are important challenges in cost estimating and cost management (cost estimating and cost management) process improvement efforts:

- Shortage of experienced estimators
- Political changes in the middle of projects
- Inadequate tools for cost estimating, inflation forecasting, and data tracking and management
- Lack of consistent policy and guidance
- Limited project and risk management skills
- Inadequate early engagement of internal and external stakeholders who ultimately influence costs
- Shortage of contractors
2.3 Building Recognition of Estimating and Cost Estimate Management as an Issue: Change Drivers

In addition to the common pressures and complicating factors described in the preceding section, the DOT representatives interviewed for NCHRP 8-36(72) pointed to a number of major change drivers. The impetus resulted in increased recognition of a number of estimating and cost estimate management issues at DOTs.

2.3.1 Cost Overruns, Work Program Adjustments, and Undesired Agency Attention

A big or influential project cost overrun or a pattern of overruns creates ripples and waves in programming and budgeting. Ultimately, such failures attract the attention of the media and state legislature, with negative impacts to agency credibility and budgets.

Notable cost overruns typically cause adjustments to the statewide transportation improvement program (STIP) and generate executive attention when the DOT drops or delays other projects to keep the program in budget. For example, since the initial estimates, costs tripled on State Route 167 in Washington State, a primary highway connecting south King and north Pierce counties to the Seattle/Bellevue metropolitan area. As a result, WSDOT concluded the agency needed a better way to estimate and plan for risk associated with proposed projects.

Whether due to a large project overrun, a pattern of consistent underestimating, inflation in materials costs, or a decline in the number of bidders, DOTs frequently adjusted the number of projects included in their rolling 5-year improvement program. For example, Mn/DOT described how the agency repeatedly had to adjust downward the number of projects delivered in a given year of the 4-year STIP.

In a number of states, escalating construction costs—compounded by a process that used only historical data (i.e., no inflation projections)—helped create a perfect storm of problems in accurate cost estimating. The shortfalls highlighted process inefficiencies. External demand in the housing construction market and clustering in the timing of DOT lettings significantly reduced the number of competitive bids received in California, Florida, Utah, Ohio, and other states, further driving up contractor prices. At Caltrans, tracking of engineering estimates versus low bids revealed the difficulty the agency encountered getting low bids; Caltrans was underestimating the bids it received by 20 percent or more, and the trend got worse during the peak of the local housing and infrastructure boom. Even with cooling in the residential construction sector, the demand for heavy equipment operators and construction remains strong, with labor cost increases estimated in the 5 to 6 percent range for the next few years. 21

DOT interviewees reported increased media pressure and pointed questions from their state legislatures. In some cases, the pressure followed on agency failure to deliver the 5-year transportation program and questions arose on why they could not manage projections or deliver the projects agreed to in the STIP. Negative press attention extends beyond the mega projects when construction costs exceed original estimates. VDOT related how the agency faced an increasingly skeptical public and a Virginia legislature confounded by project delays and escalating costs; the agency battled the public’s impression that VDOT could not manage its work. In response, the governor and new VDOT commissioner initiated a cost estimating and cost management improvement effort. In Missouri, the legislature passed an accountability bill requiring the agency to provide an annual performance report relative to the ability of the Missouri DOT (MoDOT) to deliver its program. Among other things, the statute requires MoDOT to report to a 14-member Joint Committee on Transportation any cost increases over 10 percent (STIP estimates versus final completed costs) or $5 million and explain the reasons for
the discrepancy including inflation, department-wide design changes, changes in project scope, federal mandates, or other factors. Avoiding the unpleasant task of going before the Joint Committee is a strong motivator to improve the accuracy of cost estimates.

2.3.2 Desire to Build Credibility

Credibility and trust translate to more confidence and funds from state legislatures and the public, as well as being a preferred customer of contractors. Concerned about its ability to complete projects and meet expectations of the public and officials, Utah DOT began to make improvements as it struggled to be able to award projects. As one DOT commented, “stakeholders don’t care if the reason for a delay was inaccurate revenue forecasting or an inaccurate cost estimate. The problem is the project not being there when they expect it.”

DOTs also experienced the ramifications of limited contractor availability, few bids, and higher prices when the DOT is low on contractors’ priority lists. Utah explained how the Association of General Contractors had the DOT as third on its list of popular customers, but when the economy slowed down in 2004–2005, contractors did not have incentive to work with the DOT because they had higher profit margins elsewhere.

In New Mexico, the governor wanted a way to showcase the agency to the public and used the Compass Document to introduce the DOT’s cost estimating and estimate management improvement process. Now the New Mexico Department of Transportation (NMDOT) uses the “Good to Great” report to show the results of its continuous improvement efforts. Many other states also make the results of their performance measures publicly available on the DOT Web site to increase agency accountability for delivering projects on time and on budget. Maine and Virginia DOTs are among those maintaining public Web dashboards and quarterly reports. WSDOT implemented the goal of communicating uncertainty regarding the expected range of project costs to the public in a graphic, one-page format, and it issued a quarterly “Gray Notebook” to keep the public informed. To maintain agency transparency with the public, Utah DOT reports a so-called “batting average” using a weekly updated graph of how many year-to-date projects have been bid in 110 percent of the engineer’s estimate.

In Virginia, the governor asked the DOT’s new Commissioner to fix consistent overspending; the agency needed the credibility to deliver the program as promised. Subsequently, the commissioner asked VTRC to assemble an interdisciplinary team to look at the cost estimating process. In a 90-day intensive effort, including all the operating divisions. That effort initiated development of VDOT’s Project Cost Estimating System (PCES), an adaptation from an Excel spreadsheet tool used in one of VDOT’s regions.

2.3.3 Proactive and Continual Improvement Efforts: Responding to Process Shortfalls

Frequently DOTs mobilized a preventive approach, beginning with an internal evaluation of the process. Ten years ago, MoDOT’s Director of Program Delivery, Dave Nichols, acknowledged a performance gap and re-engineered the scoping and project development processes to reduce “chaos at the end of the process.” MoDOT’s re-engineering consulted with other agencies...
involved and entailed internal changes, to produce a process that was both more streamlined and more reliable.

Mn/DOT had several reports documenting the impact of cost escalations and need for improvement. A Cost Management Measures report documented the reasons for delays related to increased costs. Another report from Mn/DOT included project case studies to identify best practices. Virginia could point to executive and legislative audits as well as internal reviews, documenting problems to make a case for process improvements. In analyzing their process, South Dakota Department of Transportation (SDDOT) found a large blackout period between the initial planning estimate and the Plans, Specifications, and Estimates (PS&E), and the agency took action to connect the beginning of the estimating process to the end of project development, from scope to bid. In Montana, the Montana Department of Transportation (MDT) began to identify inconsistencies across its five districts in the development of estimates, nomination of projects, and project letting.

At Pennsylvania DOT (PennDOT), MaineDOT, and others, an executive-level committee monitored substantial cost increases late in the process and called for improvements in cost estimating and management. The committees and DOT chief executive officers (CEOs) now must approve all cost increases after a certain threshold.

In the course of examining where their issues lay, some DOTs discovered a need for formal guidance and training to produce consistent estimates and compensate for high staff turnover. For example, PennDOT was experiencing up to 10 percent turnover with an associated loss of historical knowledge and experience. Other DOTs expect a large number of retirements in the next few years and do not yet have a strategy for replacing seasoned staff.

2.4 Focus Areas Targeted for Improvement

Looking at the big picture, DOTs undertaking cost estimation and estimate management improvement processes identified the following changes or actions needed for process improvements. These can be categorized at the organizational level, the program level, and the project level.

**Organization Level**
- Provide agency support and resources for staff positions or consultant support (or both) for the change initiative.
- Raise awareness across the agency about the importance and need for more accurate cost estimates.
- Direct department-wide priority on estimating, managing, and controlling costs.
- Develop an organizational vision and set performance measures.

**Program Level**
- Assessing staffing needs.
- Assign clear accountability for delivering projects on time and on budget, and give project managers the authority to control scope and cost.
- Break down silos so that planners, project managers, designers, and cost estimators work together to integrate the process with other parts of the organization including right-of-way, utilities, and traffic.
- Developing or obtaining the necessary tools.
Project Level

- Strategies for improving project management - risk management, cost management, schedule management, and scope management, to improve cost estimates and cost management.

2.5 Structured Improvement Processes with Research/Consultant Support

DOTs identified and undertook the changes and related improvement strategies in a variety of different ways, some simple and streamlined and some very involved. Virginia and Minnesota DOTs’ efforts drew on assistance from consultants. VDOT structured its cost estimating improvement process into the following eight tasks:

- Formation of a project task force
- Review of the literature on project cost estimation
- Survey of VDOT districts to determine their methods of cost estimation
- Review of methods used outside Virginia
- Recommendations to improve project scoping processes
- Selection and necessary modification of the selected cost estimation tool
- Testing and statistical analysis of the tool’s performance
- Further refinement and statewide implementation of the tool

The Virginia Transportation Research Council, a 60-year old research arm of VDOT, supported VDOT in the task force facilitation and tool development effort.

Mn/DOT drew on the consultants from the NCHRP 8-49 research effort to evaluate the organization’s business practices for cost estimating and estimate management. Mn/DOT developed a four-phase process that can provide a model for how other DOTs can begin to identify their respective issues and bring about needed organizational change. The four phases include: (1) data gathering and practice assessment, (2) defining desirable process improvements, (3) developing a reference manual, and (4) providing training on the new processes. Georgia’s process likewise employed the NCHRP Report 574 researchers and consultants.

However, 12 of the 14 states interviewed for this study implemented the cost estimating and estimate management improvement process almost entirely through their own internal efforts, with little or no consultant support, highlighting the importance of the exchange of resources and best practices among practitioners.

2.6 Use of Multidisciplinary Task Forces

While many state DOTs implemented process improvements to cost estimating and estimate management without convening multidisciplinary task forces, a few notably drew on such committees.

In perhaps the most extensive collaborative effort, Mn/DOT drew on a cross-section of managers in the agency and partners such as FHWA and a metropolitan planning organization (MPO). Working groups helped define the cost estimating and cost management models and approaches for planning, scoping, design, and letting; these teams included front line workers, program directors, and project managers in pre-design, design, planning, right-of-way, agreements, materials, hydraulics, traffic & maintenance, and construction, bridge, estimating, environmental,
investment management, program management, and finance. The effort also received input from Mn/DOT and FHWA staff members of three working groups involved in the process model for CE/CM, interviews with Mn/DOT program managers, meetings and discussions with the CE/CM project team, and direction from Mn/DOT leadership, including the Policy and Oversight Group. The agency designed the bottom-up process to generate buy-in. The process was supported by the consultants who wrote NCHRP Report 574, and leaders of the Mn/DOT effort commented that despite their support, “Mn/DOT employees wrote a lot of the policy and guidance” and “people questioned the cost of the consultants for the project.”

VDOT established a multidisciplinary task force, grounded in technical expertise and knowledge of VDOT’s project development process, to identify and lead the specific changes. The team included leaders in cost estimating and estimate management practice at VDOT, others whose input and leadership would be necessary to inform and bring about the change, the VTRC, and an MPO. The task force met extensively in the summer of 2002 and presented its findings to the DOT commissioner at the end of its 90-day charge. VDOT’s participants illustrate the range of positions necessary for and involved in the effort:

- Chief of Technology, Research & Innovation, Task Force Chair
- Director, Information Technology Applications Division, VDOT
- Asst. Division Administrator, Scheduling & Contract Development Division
- Asst. State Construction Engineer, Construction Management Division
- Senior Design Engineer, Fredericksburg District, VDOT
- State Transportation Planning Engineer, Transportation & Mobility Planning Division
- Transportation Engineer Program Supervisor, Transportation & Mobility Planning Division
- Division Administrator, Financial Planning Division
- Fredericksburg District Location & Design Engineer
- Location & Design Division
- State Location & Design Engineer
- Members of the Commonwealth Transportation Board

MaineDOT involved the following functional areas and leaders to identify problems and develop new procedures: safety, environment, finance, maintenance and operations, and multimodal and passenger transport, with co-chairs from planning and project development.

Most state DOTs managed the change process without adding multidisciplinary teams or noting the existence of such teams. In California, the division of design chief held quarterly board meetings with the district design deputies to brainstorm ideas. For a long time, the agenda included the topic of improvements to the cost estimating process. People from the various districts would speak at the meetings and, in turn, they were able to learn about best practices from other estimators around the state.

With a considerably less structured process and no multidisciplinary teams, MoDOT posted the most spectacular results in accurate cost estimating and estimate management. Instead, MoDOT focused on raising expectations and standards, as communicated through performance measures and new agency expectations emphasizing cost awareness and control. MoDOT staff interviewed for NCHRP 8-36(72) said the “focus is on making the system better” and improving performance. While the state doesn’t have a detailed process, its continuous improvement process roughly follows a Plan-Do-Check-Act format, familiar to those who work in quality improvement or ISO
9001 or 14001 processes; goals and targets are set (Plan), staff attempt to meet them (Do), results and performance are assessed (Check), and modifications occur as needed (Act).
3 Implementing Change

Deciding what change is desired is one thing. Implementing it is a complex and challenging issue of its own. After understanding the problem, barriers, and challenges, building recognition for the issue, and identifying focus areas for improvement, often with the assistance of internal teams, State DOTs begin to implement the change, tackling issues at the organizational, program, and project level.

Organizational Level

It takes vision and leadership support to effect a cultural change and overcome the established mindset found in any organization. Without the support of management, cultural change becomes a barrier. Traditionally, Departments of Transportation (DOTs) function with a top-down management structure; it is very difficult to create change from the bottom up in such a structure. Critical factors in achieving a change in organizational culture are (1) a vision, (2) performance measurement, (3) executive leadership, and (4) resource requisition. Also important are increased emphasis on the importance of cost estimating and estimate management, day-to-day leadership of the change effort, and policies and processes to standardize or centralize the organization. DOTs find it particularly challenging to establish standardized policies and processes, which usually entails centralized District goals.

3.1 Executive Leadership and Requisitioning Resources

DOT cost estimating and estimate management improvement efforts garnered attention and support from the highest levels of management. Better estimates make it easier for executives to do their jobs and report to governors and state legislatures. Management contributes to these efforts by giving staff across the organization a clear message that high quality cost estimating is a priority. Almost without exception, the most commonly stated reason for success in advancing the cost estimating process is the support of leadership. For example, Virginia DOT’s CEO called for an inclusive, definitive, consistent, well-documented, accurate approach to estimating the cost of delivering construction projects at the various stages of development and delivery, to deliver projects in budget limits, and improve VDOT’s credibility with the state legislature and the public.

Montana (MDT) reported “a lot of support from upper management.” At Caltrans, cost estimating and estimate management process leaders said the agency’s realization that “we need to fix this” went “way beyond just support.” It was not difficult to get the buy in and support from upper management, although “any resources (funds and staff time) spent on this were redirected from other areas.” Other DOT leaders drew additional resources to the effort, including consultant support, or helped procure additional staff. Such resources included funding, tools, training, guidance, and experienced staff.

As interviewees noted, everyone needs to buy in to the process—the philosophy has to be sold. Support from the chief engineer, the DOT director, and design leadership greatly facilitate this philosophy and are absolutely essential to the change effort.
3.2 Increasing Emphasis on the Importance of Cost Estimating and Estimate Management

The notable increase in importance of cost estimating and estimate management was the most common reason DOTs gave for process improvements. As a Utah DOT representative commented, “it was always a function, but then it became the most important function.” Utah DOT’s lead estimating staff went on to say, “When resources are tight, you focus on what needs help.... Now everyone on the project team looks at estimates, although the project manager is responsible for making sure estimates fit with all the outlays.”

Michigan DOT reports that a new sense of urgency in delivering the program in scope, in budget, and on schedule has allowed the agency to consistently let over 90 percent of its programs in the first 6 months of the year and let nearly 95 percent of programmed projects on schedule. In addition, the programs have been delivered with cost overruns of 3 percent or lower for the past 5 years. In 2005, the percentage difference for extras and overruns was actually a negative number (i.e., final contract costs were actually just under original cost estimates).

States coast to coast, from California to Maine, reported increased emphasis on cost estimating, estimate management, and accountability—raising the agency-wide profile of the issue and directing attention to an improvement process. As one PennDOT representative noted, “more than anything (the agency’s cost estimating and estimate management improvement process) raised awareness and now PennDOT is better at updating cost estimates as it goes through project development. It is not enough to look at the most recent similar-type project and use those base costs.” MoDOT made cost estimates and lower project costs an agency-wide priority, with high accountability and visibility of individual, district, team, and agency performance.

In 2005, Caltrans set out to develop new instructions and performance expectations for estimating. The chief engineer’s office developed a memo, Instructions to Districts on Engineer Estimates (chief engineer’s memo dated September 15, 2005), aimed at improving how the agency does estimates and emphasizing expectations. The instructions reviewed previous performance by district and established targets. In particular, the instructions emphasized the need to establish prudent QA/QC practices.

By first quarter of 2006, Caltrans had implemented the following improvement actions:

- Established performance objectives
- Established cost estimating engineer in the office of the HQ Chief Engineer
- Analysis by independent consultant on a sampling of projects
- District director certified estimates for projects over $5 million as a last gate or milestone constraint before “Ready to List”
- HQ office performed independent assurance estimate through a consultant with feedback to district directors
- Completed initial review of cost estimating guidance; identified actions for improvement of accountability, QA/QC process, and tools
- Outreach to districts via Project Delivery Management Boards, Project Delivery Advisory Council, district traffic managers, sending the message of the importance of accuracy in cost estimating and consistent updates in estimate management
- Established cost estimating warehouse on Design Division Web page, including policy, guidance, training, tools, best practices, and data
3.3 Developing an Organizational Vision

Some states seeking to develop broad and/or deep changes with regard to cost estimating and estimate management started out with an organizational vision—particularly a vision to deliver projects on time and in budget. When an organization develops a vision it conveys the agency’s objective for and commitment to process improvements. The vision helps to unite staff around common goals and motivate them to take action.

MoDOT set out to “delight” the agency’s customers and show outstanding ability to deliver the agency’s program on time and in budget. At the agency’s first “strategic advance” (opposite of retreat), department managers were challenged to list what customers expected from MoDOT; they decided on 18 tangible results, which subsequently became the continual improvement focus of everything from daily operations to long-term plans.

Mn/DOT also started with a vision, which stated: “Mn/DOT will manage and control costs through a department-wide priority on cost estimating and cost management, reliable and accurate estimates, statewide uniformity and consistency, improved communication and credibility with external stakeholders, and clear accountability.”

To be most effective, the vision needs to be supported by clear goals and objectives, and continued monitoring and adjustment of the performance of the organization to meet the goals. A number of successful DOTs have chosen to drive the vision with performance measures.

3.4 Driving the Vision with Performance Measures

Without being operationalized through monitoring performance to goals or objectives, visions lack strength. To support cost estimating and estimate management and other delivery-related process improvement initiatives, State DOTs have developed many performance measures, many of which are tied to milestones in the management process as a project proceeds from programming to delivery. All 50 state DOTs were contacted with an overview of measures collected in the course of research for NCHRP 8-36(72), to review and make any additions. Many commented on the usefulness of this resource. This resource is included in its entirety at the end of section 3.2, on performance measurement; however, some observations are as follows:

- **States often track program delivery and advertisement schedule against planned commitments or schedules.** Examples are the percentage of programmed projects let or advertised according to schedule, comparison of the proposed time frame with the actual time required, or percentage of estimated costs compared with actual costs.

- **Most states examine cost estimate management by comparing the original or engineer’s estimate to the awarded amount or low bid.** Some states, including Maryland, Missouri, and Utah, track the difference between programmed construction dollars and low bid for projects in the STIP.

- **Many DOTs focus a few performance measures on cost management during the construction phase.** For example, Missouri has a goal to ensure that change orders comprise less than 2 percent of the original project price, while Oregon measures the percentage of projects completed on or under projected preliminary engineering, right-of-way, and construction costs. Most of these performance measures indicate an overall goal to make budgets and schedules as accurate as possible before the construction phase to minimize cost increases.

- **Nebraska, Oregon, and South Carolina have additional goals tied specifically to construction completion.** Nebraska measures the percentage of construction projects completed in the days allowed plus those final in 60 days; Oregon analyzes the percentage of
projects in the construction phase completed in 90 days of the original contract completion date; South Carolina tracks the number of projects currently under construction and the percentage within the scheduled completion date.

- **Some state DOTs also have goals related to overall budget and financial management.** Kentucky and South Dakota measure the percentage of their federal funds used; Missouri measures the percentage of funding level target used by programmed projects by category in the current STIP year; Arizona and Missouri track the percentage of vendor invoices paid in 30 days and the average processing time of vendor invoices.

The following sections give state examples of performance measure tracking systems. One of the most comprehensive and successful performance management system, in terms of delivered performance and supporting incentive system, appears to be MoDOT’s Tracker. At the end of MoDOT’s 6-year effort, the chief engineer stated the agency delivered its FY 2002–2007 program within 0.013 percent of estimate.1

### 3.4.1 Missouri

After MoDOT executives developed expectations of where they wanted the agency to go, they instituted performance measures to encourage the changes. MoDOT made vigorous efforts to show the state legislature and the public tangible results, ultimately producing the impressive results reported above. The agency aggressively pursued cost-saving opportunities through practical design and value engineering; this work enabled the agency to award its FY 2007 projects at 7.4 percent ($89.8 million) under budget.28

In 2005, MoDOT transformed the agency’s earlier efforts at a performance measurement system into the agency’s on-line performance reporting system, the Tracker. All performance measures support 18 customer-defined tangible results—results that the agency identified as its essential services. The tangible results are assigned to senior managers who monitor and devise strategies to improve results related to the measures. This approach allows departmental goals to be linked to division and work unit actions. In conjunction with the quarterly Tracker publication, Tracker meetings are held with all senior managers and supporting staff to review the measures, strategies, and departmental progress toward improving performance.

MoDOT measures the following, in relation to cost estimating and cost management:

- **Percentage of estimated project cost compared with final project cost** to determine how close MoDOT’s total program completion costs are to estimated costs. Project costs include design, right-of-way purchases, utilities, construction, inspection, and other miscellaneous costs. Although the ideal status is a deviation of 0 percent, as of March 31, 2008, for FY 2008, a total of 397 projects were completed at a cost of $850 million, representing a deviation of −0.42 percent less than estimated costs.

- **Average number of years to go from the STIP programmed commitment to construction completion** to measure how long it takes to complete a project, including design and construction. As expected, the time to complete depends on the size of the project. Times to complete range from approximately 2 years for resurfacing and safety projects,
approximately 4 years for new or improved bridge projects, and 7 to 11 years for major bridge projects.

- **Percentage of projects completed in programmed amount.** Projects over and under $1 million are divided into two separate categories. Project costs include design, right-of-way purchases, utilities, construction payments, and other miscellaneous costs. MoDOT would like to see all projects completed in the programmed amount, allowing the greatest number of projects to be built with the available funding. So far in FY 2008, 53 percent of the projects in both categories have been completed within or below budget. MoDOT seeks to improve scoping estimates and using practical design and value engineering to reduce project costs.

- **Percentage of projects delivered on time** measures the percentage of projects completed by the established contract date. To date in FY 2008, completions by established contract date has increased 5 percent more than 2007. MoDOT emphasizes review of construction schedules and assessment of liquidated damages.

- **Percentage of change for finalized contracts** tracks the difference between contract award amounts and total construction costs. As a result of a strong emphasis on constructing projects within budget, the use of practical design, value engineering, and an employee incentive program, MoDOT’s performance for the first half of 2008 was 1.1 percent, well below the target of 2 percent.

- **Annual dollar amount saved by implementing value engineering.** In 2007, MoDOT’s reported design savings from value engineering studies was $49.5 million, a 25-percent increase from 2006. So far for 2008, design savings are $32.2 million. In 2007, construction savings from value engineering studies equaled $4.17 million; for the first two quarters of 2008, MoDOT construction savings equaled $2.6 million.

In MoDOT, districts and divisions have used the central Tracker performance measures to develop their own measures and performance incentive programs. The district and division trackers in turn help connect every employee to the tangible results. The tracking and linked incentive programs place a high level of leadership and responsibility on a broad range of individuals to generate unified results. This tracking provides a direct link between business units and overall department goals, and keeps communication lines open in units so all are aware of the direction and actions needed to enhance performance.

Members of Missouri’s legislative body, Missouri’s Governor’s Office, American Association of State Highway Transportation Officials American Association of State Highway Transportation Officials (AASHTO), Federal Highway Administration (FHWA), other state DOT staff, and news media are among the groups that regularly access these results through MoDOT’s Tracker. The system is available on MoDOT’s Web site at modot.mo.gov/about/general_info/Tracker.htm. The system has improved MoDOT’s ability to guide the agency’s destiny and relieved higher level concerns about cost and program delivery; the system has provided evidence that the agency is professionally governed and has the warning, feedback, analysis, and continuous improvement systems in place that the agency needs.

### 3.4.2 Virginia

In 2003, the Virginia Department of Transportation (VDOT) initiated a new, more focused, performance measurement program. Initially, the program focused on on-time and on-budget delivery of projects because these metrics were widely understood by the public and represented an area where improved performance by VDOT was critical to reestablish public and legislative credibility on cost estimating and estimate management and to effectively manage available resources. From 2001 to the estimated results for 2007, project on-time performance in
construction improved from 20 to 90 percent. Construction on-budget performance improved from 51 to 90 percent. VDOT attributes the improvement to the performance measurement and feedback systems in place. These systems focused agency attention on these top priority areas.

At the beginning of this effort, the focus on on-schedule delivery led to some issues with construction quality; however, after those issues were recognized, adjustments were made and additional measures related to construction quality, environmental compliance, and roadway safety were added. The focus on delivering contracts on-budget has led to the realization that a particular type of small- to medium-size bridge maintenance projects seemed to be very difficult to deliver in budget. This pointed out the need to better define contract scopes of work before contracting and illustrates the type of learning and improvement that resulted from the focus on performance management. Additional second-tier measures have been added to extend the VDOT performance measurement program to all of its functional areas. Starting in 2007, the Dashboard was expanded to include measures of congestion, safety, overall management, and customer satisfaction, as shown in Exhibit 4. The Virginia DOT DASHBOARD Online Tool below. A key principle in developing a holistic approach to performance management has been transparency. The Dashboard provides legislators, citizens, and the press with access to key performance indicators for VDOT, and the Department has been open to sharing performance results, both good and bad, on an ongoing basis. The openness to sharing all results and not trying to present all news as good news has helped VDOT reestablish its credibility. The Dashboard 3.0—Business Rules and User’s Information provides an explanation of the gauges and how to apply the measures and can be viewed at http://dashboard.virginiadot.org/Help/DB%20User%20Guide.PDF.

**Exhibit 4. The Virginia DOT DASHBOARD Online Tool**

![Dashboard Image](image-url)

3.4.3 Caltrans

Caltrans historically has reported key project delivery milestones internally and externally (i.e., California Transportation Commission and others). Caltrans’ director, Will Kempton, enters into contracts for delivery with each district director to ensure project delivery commitments are met. As a result, in each of the past 2 years, nearly 100 percent of contract project delivery commitments were met. The director also has entered into contracts for performance and
innovation with each of his deputy directors. These contracts include key performance objectives and measures that align with overall strategic goals.

Following are three Caltrans departmental goals for cost estimating:

- The final estimate should be within 20 percent of the estimate made when the project is first initiated.
- The final estimate should be within 10 percent at bid opening.
- The contract award amount should be the same as the actual cost to complete construction.

Caltrans cost estimating staff commented that, like the situation at many other DOTs, broad external market changes such as the availability of contractors and the cost of materials have complicated and challenged their ability to see results on their cost estimating and estimate management goals. Nevertheless, the agency is beginning to observe progress in closing the gap, assisted by use of the above goals, performance measures, monitoring, and feedback for improvement. “The districts are doing better because they are held more accountable with the performance measures in place.”

3.4.4 Maryland

Maryland’s Department of Transportation, State Highway Administration (MDSHA), has been engaged in performance management for 10 years. MDSHA’s initial efforts began with the passage of Maryland’s Managing for Results (MFR) statute. The statute requires that state agencies report performance data with their annual budget request. The focus is on organizational outcomes that are important to customers and external stakeholders.

MDSHA has cost estimating and cost management performance measures that are performance-based employee measures (pilot program) to individual offices and some that are agency-wide. Agency-wide measures are published in the 4-year SHA Business Plan and are measured for projects in the CTP (Consolidated Transportation Program—the 6-year Plan). MDSHA also has a measure related to project schedules. While not directly related to cost estimating, project timing and delays have significant impacts on budgets due to inflation. Currently, these measures are tracked through several systems in different offices, but MDSHA is working on a single system that will do most of the measuring and reporting for them.

MDSHA’s Business Plan for FY 2008 though 2011 contains the following performance measures on cost estimating and cost management:

- **Meet annual capital program budget targets.** Measured by the percentage of capital expenditure within 10 percent of the final CTP (6 year program) target.
- **Construction schedule.** Measured by the percentage of projects that meet the annual “Open to Traffic” date 90 percent of the time.
- **Design schedules.** Measured annually by the percentage of projects advertised within 30 days of the original estimated ad date at least 90 percent of the time.
- **Cost estimates.** Measured by the number of projects that did not exceed 110 percent of the programmed estimated cost.
- **Change Orders.** Annually, maintain construction change orders under 8 percent of the total construction cost estimate.
MDSHA’s leadership monitors agency-wide performance results quarterly. Feedback is provided to Key Performance Area leaders about performance that is outstanding, on track, or that needs improvement.

Managers’ performance appraisals are based on performance plans that link to office and district business plans as well as individual performance targets. Finally, agency-wide performance reported in MDSHA’s Annual Report is based on the business plan performance measures and strategy accomplishments. According to MDSHA’s business plan measures, which tend to focus on major projects, the agency is performing around 80 percent on the above measures related to project costs so far this year. Several initiatives are in place to improve various aspects of performance. It has not been possible for MDSHA to make immediate changes for those projects already in the pipeline.

3.4.5 Minnesota

Minnesota DOT (Mn/DOT) began developing performance management tools in the early 1990s, and it now has a system that spans most of its products and services and strategic priorities.

- **Program and project delivery**—monitoring of projects to track on-time and on-budget performance.
- **Process improvement and best practices**—reduced right-of-way and EIS processing time; regular face-to-face performance reports to executive management and districts, at least quarterly, provide accountability and are a forum for policy review and problem solving.
- **Construction Project Delivery**—from 2000 to 2005, construction of 94 percent of all major projects was completed on schedule. To manage the capital budget, department and district executives meet twice a year to review the actual and predicted results of their 4- and 10-year program against statewide performance targets for safety, smooth pavements, bridge preservation, and travel speeds. Each prepares a performance-based scenario that identifies total resource needs to meet performance targets, and a fiscally constrained scenario that sets forth projects to be built with available revenues. Institution of this performance-based approach helped achieve a major increase in preservation investment since 2003. Resource gaps between the two scenarios are reviewed with the state legislature. Having a consistent system for defining needs has enhanced legislative funding deliberations and public dialog.

Mn/DOT is in the process of considering performance measures related to cost estimating and estimate management. The agency is considering performance measures in each of the following areas:

- **Project Cost Estimation Potential Performance Measures**
  - Degree to which all project cost elements are included in the total project cost estimate
  - Consistency of project cost documentation between planning, scoping, design and letting phases
  - Degree to which projects are complete and in conformance with central estimating unit review
- **Uncertainty, Risk and Contingency Potential Performance Measures**
  - Degree to which set-aside funds are estimated and managed at the project level
  - Degree to which set-asides are more accurately predicted
  - Degree to which risks are identified in early estimates
  - Degree to which contingency resolution is tracked
Cost Estimate Communications Policy Potential Performance Measures
- Accuracy of media reports regarding project cost estimates
- Public confidence in the communications, based on market research

Project Cost Management Policy Potential Performance Measures
- Variation between project final engineer’s letting cost and baseline cost, by district
- Variation between project construction cost and letting cost, by district
- Variation between the letting construction cost estimate and the project construction cost estimate at the time the Scoping Report is approved
- Number and value of change orders and supplemental agreements: Median and average for all projects in each district’s program

Program Management Policy Potential Performance Measures
- Percentage of project scope and cost changes that are the result of changes in project purpose and need after project entered the STIP
- Percentage of all projects in the first (current) year of the STIP that are let for construction in their planned year
- Percentage of all projects in the fourth year of the STIP that are let for construction in 4 years, as scheduled
- Number and value of projects in the first (current) year of the STIP that are deferred or cancelled
- Variation between the fourth year STIP cost and the letting cost for each district
- Percentage of set-aside funds spent on set-aside activities

3.4.6 New Mexico

The New Mexico House Bill 2 performance measures, referred to as the Accountability in Government Act and the Governor’s Performance and Accountability Contract, are used to track and evaluate New Mexico DOT’s (NMDOT’s) overall performance. The results are reported to the executive and legislative offices as well as the public in the Good to Great document published quarterly by NMDOT. Good to Great is used as an accountability tool to update and track performance measures, goals, and accomplishments of the department, including its six districts.

The most recent report shows that New Mexico, like most states, is struggling to accurately estimate costs.31

- **Percentage of Final Cost Over Bid Amount.** This is a measurement of the department’s efficiency and compares the let cost of construction against the programmed cost. The target is less than or equal to 4 percent; actual for FY 2007 (most recent numbers available) was 20.5 percent. The difference is attributed to the difficulty of projecting the rising cost of construction materials.

- **Percentage of Projects Let to Bid in Target Period.** This measure has been showing a steady improvement since 2005, NMDOT expects to meet its target of 85 percent in 2008.

The Cabinet Secretary, who sits on the Quality Control Committee, is revisiting the agency’s strategic plan and has set a major focus area dedicated to on time and on budget. NMDOT is redoing its project development process and expects additional performance measures to improve
the estimating and scoping process; however, the tools for doing better estimating early in the planning and programming phases remain an issue.

3.4.7 New York

In 2004, NYDOT executive management embraced the continuous improvement performance measurement model depicted in Exhibit 5. New York DOT Continuous Improvement Performance Measurement Model and directed that it be implemented throughout the DOT. The Region One Design Quality Assurance unit implemented a performance measurement system for all projects let after April 1, 2007, using the following key performance indicators:

- **Percentage of original delivery dates met.** This indicator measures the customer benefit “Timely Delivery of Products, in Budget and in Scope.” Specifically, the Quality Assurance unit tracks:
  - The actual design approval date versus the date established at the scope meeting.
  - The actual date of last acquisition map completed versus the date agreed on between the project manager and the real estate group at the end of scoping.
  - The actual PS&E date versus the date established at the scope meeting. Adjustments are made for project schedule changes made by planning as a result of fiscal issues.
  - The number of environmental permits received before and after the advertisement date.

- **Percentage of variance between the estimated cost at scoping versus the actual cost at letting.** This indicator measures the customer benefit, “Timely Delivery of Products, in Budget and in Scope.” The Quality Assurance unit tracks the percentage of variance between the estimated cost at scoping versus the actual cost at letting for each project. Adjustments are made for additions of new work sites, inflation, and alternatives introduced after scoping.

- **Percentage of orders-on-contract as a percentage of project bid amount.** This indicator measures the customer benefit, “Changes during Construction Are Minimized.” The Quality Assurance unit will track the annual value of approved orders-on-contract as a percentage of the annual program size. Exclusions will be made for new work sites added to let projects, for emergency repairs, and standby contracts.

The Quality Assurance unit provides the results to the design staff at its annual meeting.
3.4.8 Utah

Utah DOT’s (UDOT’s) performance measures are more limited than MoDOT’s, as they relate to cost estimating. UDOT’s goal is to be 100-percent awardable on projects—an awardable project is one where the low bid is less than 110 percent of the estimate. The agency’s second goal is to have low bids +/-10 percent of the engineer’s estimate on at least 50 percent of projects, that is, a so-called “home run,” and that number goes into the so-called “batting average” as shown in the Exhibit 6. Utah DOT Batting Average below. UDOT has been tracking this information since 2005 and has seen continued improvement as the ability to award projects has progressed.

### Exhibit 6. Utah DOT Batting Average

<table>
<thead>
<tr>
<th>Region</th>
<th>Number of Projects</th>
<th>Number of Engineer’s Estimate Over 110%</th>
<th>Batting Average</th>
<th>Number of Homeruns</th>
<th>Homerun Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Region 1</td>
<td>10</td>
<td>0</td>
<td>1.000</td>
<td>5</td>
<td>550</td>
</tr>
<tr>
<td>In-House</td>
<td>1</td>
<td>0</td>
<td>1.000</td>
<td>0</td>
<td>000</td>
</tr>
<tr>
<td>Consultant</td>
<td>9</td>
<td>0</td>
<td>1.000</td>
<td>5</td>
<td>556</td>
</tr>
<tr>
<td>Region 2</td>
<td>16</td>
<td>0</td>
<td>1.000</td>
<td>0</td>
<td>000</td>
</tr>
<tr>
<td>In-House</td>
<td>4</td>
<td>0</td>
<td>1.000</td>
<td>0</td>
<td>000</td>
</tr>
<tr>
<td>Consultant</td>
<td>2</td>
<td>0</td>
<td>1.000</td>
<td>0</td>
<td>000</td>
</tr>
<tr>
<td>Region 3</td>
<td>11</td>
<td>2</td>
<td>0.818</td>
<td>2</td>
<td>182</td>
</tr>
<tr>
<td>In-House</td>
<td>6</td>
<td>0</td>
<td>1.000</td>
<td>1</td>
<td>183</td>
</tr>
<tr>
<td>Consultant</td>
<td>5</td>
<td>0</td>
<td>0.600</td>
<td>1</td>
<td>200</td>
</tr>
<tr>
<td>Region 4</td>
<td>18</td>
<td>1</td>
<td>0.944</td>
<td>11</td>
<td>611</td>
</tr>
<tr>
<td>In-House</td>
<td>12</td>
<td>1</td>
<td>0.917</td>
<td>7</td>
<td>583</td>
</tr>
<tr>
<td>Consultant</td>
<td>0</td>
<td>0</td>
<td>1.000</td>
<td>4</td>
<td>587</td>
</tr>
<tr>
<td>Statewide</td>
<td>55</td>
<td>3</td>
<td>0.945</td>
<td>18</td>
<td>327</td>
</tr>
</tbody>
</table>

**Cumulative Batting Average Trend**

**Cumulative Homerun Trend**

1. Represents the number of projects where the low bid is greater than 110% of the Engineer’s Estimate (from $096), meaning that (low bid / Engineer’s Estimate) > 110%.
2. The batting average is the number of hits over the number of projects. A hit is earned if the low bid on the project is less than 110% of the Engineer’s Estimate.
3. The homerun average is the number of homeruns over the number of projects. A homerun is earned if the low bid on the project is within 10% of the Engineer’s Estimate.


3.4.9 Other States and Summary Information on Performance Measures Relating to Cost Estimating and Estimate Management

Other states are working to integrate performance measures into their operations. For example, Pennsylvania (PennDOT) is developing performance measures, preparing to set a baseline cost early, and tracking how well the baseline cost is maintained. PennDOT believes this could be a turning point. South Dakota tries to obligate all federal funds and have few project delays, and
measures the agency’s ability to do so, though they have found it difficult to measure due to the volatility of materials costs. Montana DOT attempted to develop performance measures but hit too many roadblocks; the effort has been delayed.


#### Cost Estimate Management

<table>
<thead>
<tr>
<th>Performance Measure</th>
<th>States</th>
</tr>
</thead>
<tbody>
<tr>
<td>Degree to which all project cost elements are included in the total project cost estimate</td>
<td>MN</td>
</tr>
<tr>
<td>Award 90% of highway projects in programmed amounts</td>
<td>ID</td>
</tr>
<tr>
<td>Percentage of project phase in budget</td>
<td>KY</td>
</tr>
<tr>
<td>Percentage of final cost over bid amount</td>
<td>NM, CA</td>
</tr>
<tr>
<td>Percentage of dollars spent on completed projects delivered in budget</td>
<td>MO</td>
</tr>
<tr>
<td>STIP adopted vs. low bid—performance measure is set at 15% of the absolute difference between the work program (STIP)-adopted cost estimate and the low bid. CA measures whether the estimate at bid opening is in 20% of first estimate; Mn/DOT tracks percentage variation in major projects’ cost from estimates when projects first enter STIP to actual cost when let for construction</td>
<td>CA, FL, MN</td>
</tr>
<tr>
<td>Official or engineer’s estimate vs. low bid—performance measure is set at 10% of the absolute difference between the district-prepared official estimate and the low bid to determine the quality of the cost estimate. Utah defines success as achieving this on at least 50% of projects; Louisiana’s target is 55% of projects with an estimate of at least $500,000</td>
<td>CA, FL, UT, LA</td>
</tr>
<tr>
<td>Percentage of STIP projects awarded at or below 110% of the programmed construction dollars (low bid less than 110% of estimate/budget)</td>
<td>MD, MO, UT</td>
</tr>
<tr>
<td>Actual to planned expenses</td>
<td>VA</td>
</tr>
<tr>
<td>Uncertainty, risk, and contingency potential performance measures</td>
<td>MN</td>
</tr>
<tr>
<td>▪ Degree to which set-aside funds are estimated and managed at the project level</td>
<td></td>
</tr>
<tr>
<td>▪ Degree to which set-asides are more accurately predicted</td>
<td></td>
</tr>
<tr>
<td>▪ Degree to which risks are identified in early estimates</td>
<td></td>
</tr>
<tr>
<td>▪ Degree to which contingency resolution is tracked</td>
<td></td>
</tr>
<tr>
<td>Standard deviation between all registered bids</td>
<td>UT</td>
</tr>
<tr>
<td>Accuracy of project estimates contained in the 1-year program</td>
<td>NE</td>
</tr>
<tr>
<td>Initial cost estimate vs. Phase II. Goal is less than a 15% difference between the cost estimate used at project inception into the work program and the cost estimate at Phase II of plans development, to determine the quality of the estimate at mid-point of project development</td>
<td>FL-recommended</td>
</tr>
<tr>
<td>Initial cost estimate vs. adopted—set at 25% difference between the cost estimate used at project inception into the work program (escalated by the inflation factors in the work program) and the work program adopted cost estimate; performance measure objective is to determine the quality of the initial scope of work and cost estimate</td>
<td>FL-recommended</td>
</tr>
</tbody>
</table>

#### Construction Cost Management

<table>
<thead>
<tr>
<th>Performance Measure</th>
<th>States</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage of projects on budget for final project costs compared to award/contract budget</td>
<td>VA</td>
</tr>
<tr>
<td>Complete 90 percent of highway projects on time and in budget</td>
<td>WA</td>
</tr>
<tr>
<td>Complete 92 percent of projects with an initial bid of at least $500,000 for less than 110 percent of the initial bid (excluding urban and enhancement projects)</td>
<td>LA</td>
</tr>
<tr>
<td>Planned vs. actual results of scope, schedule, and budget</td>
<td>WA</td>
</tr>
<tr>
<td>Percentage of change for finalized contracts—CA performs tracking relating to the</td>
<td>CA, MO</td>
</tr>
</tbody>
</table>
agency’s decade-long effort to reduce change orders; MoDOT goal: change orders comprise less than 2% of the original project price

<table>
<thead>
<tr>
<th>Indicator</th>
<th>State</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage of construction projects in original budget</td>
<td>DE</td>
</tr>
<tr>
<td>Percentage of final cost over bid amount</td>
<td>NM, CA</td>
</tr>
<tr>
<td>Percentage of total dollars paid to the total awarded amount for all contracts</td>
<td>IA</td>
</tr>
<tr>
<td>Assurance that accumulative final contract amounts are in 104 percent of the detailed estimates</td>
<td>ID</td>
</tr>
<tr>
<td>Percentage of projects completed on or under projected preliminary engineering, right-of-way, and construction costs</td>
<td>OR</td>
</tr>
<tr>
<td>Variation between project final engineer’s letting cost and baseline cost, by district</td>
<td>MN</td>
</tr>
<tr>
<td>Variation between project construction cost and letting cost, by district</td>
<td>MN</td>
</tr>
<tr>
<td>Variation between the letting construction cost estimate and the project construction cost estimate at the time the Scoping Report is approved</td>
<td>MN</td>
</tr>
<tr>
<td>Number and value of change orders and supplemental agreements—median and average for all projects in each district’s program</td>
<td>MN</td>
</tr>
</tbody>
</table>

**Program management measures**

- Percentage of project scope and cost changes that are the result of changes in project purpose and need after project entered the STIP
- Percentage of all projects in the first (current) year of the STIP that are let for construction in their planned year
- Percentage of all projects in the fourth year of the STIP that are let for construction in 4 years, as scheduled
- Number and value of projects in the first (current) year of the STIP that are deferred or cancelled
- Variation between the fourth year STIP cost and the letting cost for each district
- Percentage of set-aside funds spent on set-aside activities

**Construction Completion/Project Delivery**

<table>
<thead>
<tr>
<th>Indicator</th>
<th>State</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage of construction projects completed in days allowed</td>
<td>NE</td>
</tr>
<tr>
<td>Percentage of construction projects final in 60 days</td>
<td>NE</td>
</tr>
<tr>
<td>Percentage of projects with the construction phase completed in 90 days of original contract completion date</td>
<td>OR</td>
</tr>
<tr>
<td>Number of projects currently under construction and percentage in scheduled completion date</td>
<td>SC</td>
</tr>
<tr>
<td>Number of projects that were in the original posting plus any account of projects added</td>
<td>SC</td>
</tr>
<tr>
<td>Complete 80 percent of construction projects with bid cost of at least $500,000 in the original time established in the contract (excluding urban and enhancement projects)</td>
<td>LA</td>
</tr>
<tr>
<td>Degree to which projects are complete and in conformance with central estimating unit review</td>
<td>MN</td>
</tr>
</tbody>
</table>

**Other Cost Management**

<table>
<thead>
<tr>
<th>Indicator</th>
<th>State</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design engineering (PE) as a percentage of total project costs</td>
<td>AK</td>
</tr>
<tr>
<td>Construction engineering (CE) as a percentage of total contractor</td>
<td>AK</td>
</tr>
</tbody>
</table>
Consistency of project cost documentation between planning, scoping, design, and letting phases

<table>
<thead>
<tr>
<th>Budget Utilization</th>
<th>MN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage of STIP funding level target used by programmed projects by category for the 2005–2009 STIP year</td>
<td>MO</td>
</tr>
<tr>
<td>Percentage of funding level target used by programmed projects by category for current STIP year</td>
<td>MO</td>
</tr>
<tr>
<td>100% of the total construction dollars planned to be awarded, are awarded</td>
<td>AZ, NE</td>
</tr>
<tr>
<td>Percentage of federal funds used</td>
<td>KY, SD</td>
</tr>
<tr>
<td>Percentage pay-as-you-go revenue</td>
<td>DE</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Scoping</th>
<th>AK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage of projects (with estimated construction bid amount over $1 million)</td>
<td></td>
</tr>
</tbody>
</table>
having
formal pre-
authorization
having
formal pre-
authorization
having
formal pre-
authorization
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formal pre-
authorization
having
formal pre-
authorization
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formal pre-
authorization
having
formal pre-
authorization

<table>
<thead>
<tr>
<th>Media and Outreach</th>
<th>MN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accuracy of media reports regarding project cost estimates</td>
<td>MN</td>
</tr>
<tr>
<td>Public confidence in the communications, based on market research</td>
<td>MN</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Contractor Relationships/DOT as Customer of Choice</th>
<th>AZ, MO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average processing time of vendor invoices</td>
<td>AZ, MO</td>
</tr>
<tr>
<td>Percentage of vendor invoices paid in 30 days</td>
<td>AZ, MO</td>
</tr>
</tbody>
</table>

### 3.5 Day-to-Day Leadership of the Change Effort, Supported by Performance Measures

While CEOs and chief engineers were leaders of the change effort at many state DOTs, design and estimating leadership often developed agency guidance, helped by review from preconstruction, planning, and contract personnel.

DOTs had different branches of the agency lead the change effort. Virginia DOT created the Project Management Office (PMO) and shifted the responsibility for delivery of the program to the districts, a structure similar to that of Florida DOT. In this structure, districts are responsible and accountable for their estimates. Both agencies continue to refine their performance measures. Maine DOT also decentralized its operations.

At Washington State DOT, the Design Office is leading the base cost estimating portion of the cost estimate validation process. The office is also involved in construction, environmental policies, and rights-of-way planning. Likewise, at MDT (Montana), the agency’s design lead drafted the cost estimating guidelines for the agency. MoDOT’s organizational results office serves as a resource for many change efforts, but individuals are responsible for reporting on the progress of performance measures in key action areas; mid-level managers are assigned as drivers for individual performance measures. Performance analysts provide support staff to each measure. One staff member in the MoDOT Organizational Results Office said that to produce results,
“the key was integrating performance measures into the management process. Each quarter, the director hosts a meeting of all senior managers and measurement drivers to review each performance measure. It’s a four-to-six-hour meeting with measurement drivers presenting MoDOT’s current performance and improvement strategies in place. To keep the meeting on track, the director uses an air horn if presenters go too long, get off topic, or worst of all, discuss future plans rather than immediate actions to improve. The large group meetings on performance measures allow our department to focus its time, talent and money on what’s most important to meet customer expectations.”

3.6 Establishing Needed Policies and Processes to Increase Consistency and Accuracy

After gaining recognition for the issues and an understanding of the general and particular agency problems with cost estimating and estimate management, DOTs often proceeded with new processes for districts and consultants to follow to improve consistency in how estimates are performed.

As Caltrans pursued new agency goals of no more than a 20-percent variation from initial estimates to letting, the estimate management process leaders felt like most of the changes were “from the policy end,” although some districts made organizational changes and took steps to address the process. Caltrans also established a policy for district directors to certify costs on every project over $5 million to increase accountability and accuracy.

While district directors “typically don’t get into the nuts and bolts of the project, they welcomed the change because it makes the directors get involved with their staff to make sure estimates are more accurate.” Also, whereas some district estimators previously tended to underestimate project costs to keep projects in the district budget, Caltrans’ policy of district director review prompted the staff be more realistic in their estimates. Other significant policy changes at Caltrans included a risk management process, a statewide initiative that became a model for Washington State DOT.

Maine, Utah, Virginia, and Missouri joined Caltrans and are among several state DOTs that now require higher level sign-offs for estimate and budget changes. Virginia DOT complements this approach with a high level of accountability in adhering to the final design estimate; performance measures are included in personnel profiles in an agency-wide system. Accountability goes up the chain of command to the chief executive. MoDOT’s performance Tracker and performance pay system for district accomplishments also provide a similar incentive.

Ohio DOT pushed consistency and documentation, offered training in these areas, and implemented monitoring and best practice sharing. ODOT has done this since 2003–2004, in conjunction with development of a comprehensive Web site for cost estimators and statewide cost estimating guidance. ODOT’s cost estimating guide provides procedures, best practices, a 10-step process, costs for numerous construction items, risk management templates, inflation rates, and a quality assessment review (QAR) list.

Minnesota DOT set out a number of strategies for achieving its vision of improved cost estimating and estimate management, as well as improving formal processes and tools. Mn/DOT developed six initial policy recommendations to help implement the agency’s new vision for cost estimating including policies on cost estimating; uncertainty, risk, and contingency; cost estimates communications; project cost management; and program cost management. Other policies are emerging for design-build projects and unplanned or advanced projects. These are included in Appendix C.

Mn/DOT decided to take the following actions on program management:
- Define requirements for projects to enter STIP/Highway Improvement Program: Scoping Report, Record of Decision, Base Estimate, and Project Contingency (in year-of-construction dollars).
- Define program-level contingency, if needed, and determine relationship to project-level contingency.
- Define acceptable levels of project cost variation (thresholds) for adjusting project cost in STIP.
- Establish formal review of project cost variations, including documentation, timing, and accountability.
- Establish an authorization process and chain of responsibility for approval of cost variations.
- Establish internal and external communications protocols.

To implement the cost estimate and estimate management policies and guidelines associated with each phase of project development, Mn/DOT identifies individuals responsible and accountable for cost estimation, cost estimate management and cost control in each project development phase and overall.

PennDOT is in the process of developing a manual to address cost estimates early in the planning and scoping process and revising project development procedures to get better definitions and incorporate planning into the overall NEPA process to meet SAFETEA-LU requirements. The guidance is more comprehensive than that of many DOTs, and early feedback internally and from external parties and states has been very positive. State links, listed in Appendix D - Online State Resources for Cost Estimation and Management, provide Internet access to their policy and guidance for cost estimating.

3.7 Centralization or Standardization Increases Consistency

Most state DOTs have decentralized design and project management work into districts or regions. This decisionmaking model results in varied levels of efficiencies. The perceived benefits of a centralized management system compared with decentralized management vary from one DOT to another. Benefits of a more centralized management structure include centrally located information, which can increase cost estimate consistency and transparency and make it easier to track the overall organization performance. Kansas DOT (KSDOT) is one of the few states that has a fully centralized design unit; KSDOT reports that centralization makes it easier to achieve consistency in estimates.

On the other hand, DOTs have pursued decentralization for several reasons. For one, when the construction manager is not engaged throughout the process, constructability issues can arise that escalate project costs well beyond the estimates. A more decentralized structure with district and regional autonomy may offer more flexibility to adapt to project-specific needs and encourages creativity by those most involved in the day-to-day work. Good communication is always important, but in a DOT where project management and cost estimating is decentralized, good communication throughout project development and across organizational boundaries is critical to minimize cost escalation late in the process. Such communication may occur more easily when smaller groups are formed to work on multiple aspects of projects in the same geographical area (region and district).

Most DOTs have decentralized management, although many state DOTs acknowledge that this form of management can cause problems in estimating. Decentralized management also can make it harder to track changes and performance because it depends on whether the individual districts and regions make estimating a priority and adhere to common practices.
DOTs often reported that achieving uniformity and exactness with methods for estimating items of a project has been difficult, especially in the decentralized environment so common to DOTs. WSDOT is still developing consensus for how to develop the ultimate estimate structure. The agency has developed guidance on estimating, but it is not specific enough to be helpful for some particular projects. Staff members have different ways of building their projects, putting projects together, and describing the items associated with the projects. For example, when estimating a quantity of asphalt, staff could develop an estimate based on the cost of the asphalt itself, or include the cost of transporting the item. The agency’s guidance does not extend to this level of specificity or direction.

In California and Ohio, the responsibility for estimates varies from one district to the next, but the procedures for doing cost estimates are the same across the agency. In both states, the districts maintain autonomy and are responsible for their budgets; headquarters maintains a corporate role and provides assistance as needed, but does not perform the budget estimates. Florida DOT is decentralized across seven districts, and procedures vary from district to district. Each district provides its own management and quality control function. FDOT recently conducted a statewide review of estimating procedures and work program integration. Like Caltrans, FDOT is pursuing statewide implementation of identified best practices in the district, as well as increasing consistency in estimating process overall.

Many states have divided cost estimating responsibilities between the districts and regions and headquarters, with a tilt toward responsibility going to the districts regions. In this arrangement, the districts may make the initial estimates through design, but a centralized unit is responsible for providing guidance and for quality assurance/quality control of the final estimate before letting the project. In most cases, the construction manager takes over budget management, including management of contingencies and change orders, until the project is complete.

3.7.1 Centralized Goals, with Maximal District Ownership and Responsibility

A number of DOT headquarters staff described a customer service approach to helping the regions and districts be successful in an estimating and estimate management process that gives regions and districts had increasing ownership. Caltrans headquarters staff described a process of setting policies and standards, which the districts then decide how to implement. MoDOT’s process provides incentives to regions or district staff to work together to produce results according to agency priorities. Accountability processes that required project managers to explain scope changes ultimately evolved to a more unified approach to supporting project managers and finding funds at Maine DOT.

When region opposition emerged to a newer centralized structure, Utah DOT staff helped win over regions through diligent, helpful service and special efforts to be polite, respectful and professional in interactions, and emphasizing their support role. Maine DOT also came to strongly emphasize the support/service role of higher level reviewers; such staff came to see their role as finding ways to accomplish commitments made by Project Managers, more than questioning the budget increases Maine DOT Project Managers were obliged to report. Utah DOT ultimately decentralized again to some extent; UDOT developed a red flag check list and statewide estimating review process that received buy-in from management and put the responsibility for estimates back in the regions.

Mn/DOT process leaders described “trying to get at (cost estimating and estimate management) from both top down and bottom up approaches.” On the top, they were “selling it to management, district engineers, and leadership. No one can argue with trying to be on-time, on-budget.” Then staff “started also going out to various groups, the trenches of the project managers and functional
areas—materials and design engineers.” Mn/DOT assigned two staff members to continue contact and communication with the field staff.

According to a Virginia DOT representative, leaders built support by “circuit riding it in nine districts, selling them on the concept (be better stewards to citizens), and meeting with everyone involved. They had the data on how far the estimates were off and that gave them some ammunition. People said they’d never be able to make the commissioner’s goal, but if you don’t have a target, you aren’t moving and any road can take you there.”36 Staff admitted, “it was a tug-of-war every day.”

3.8 Turning the Locomotive: Cultural Changes in Cost Estimating and Estimate Management

At an organizational level, implementing major changes can be very difficult; whether the changes are in policy, process, tools, or the structure of the organization. Implementing any kind of major change is frequently met with a natural resistance. As one DOT representative stated regarding a new policy, the agency “is a big locomotive full of folks. It takes a huge effort to turn it around. It was a new procedure and they had to drag some kicking and screaming, but those were a minority.” Several DOTs recognized that resistance to a change in power or control over the process was best resolved by setting clear expectations and allowing some flexibility while making clear the roles and chain of authority for decisionmaking. A VDOT representative said, “Innovation, flexibility, risk-taking, questioning, and problem-solving line the path to success at VDOT.” On the other hand, Montana experienced less resistance; a few holdouts held the notion “but this is the way we have always done it” and continued to do things as before. For the most part, people embraced the improved process because it affirms what people are already doing and gives them better tools. As noted above, management support and garnering staff attention were key.

Cost estimating and estimate management efforts have entailed significant culture change in some cases. MoDOT interviewees felt that their agency’s performance measurement program was key to producing the substantial culture change MoDOT has experienced, with a much greater orientation to action and results, accountability, and finding new efficiencies. In that changed culture, cost control and performance to the desired measures are extremely important. New Mexico DOT cited creation of its Office of Performance Management as an important cultural change, affecting the agency’s cost estimating and estimate management process improvement efforts.

Maryland SHA also cited the importance of cultural change in the agency as staff seek to have more accurate information available faster than ever before. The agency, according to a staff member, is still working on “getting people to see that the first estimate is the most important one, the one you will be held to, and that it will impact the project early on. Until certain information is included in the estimate, the SHA can’t go to milestone reviews.”

Cultural change is evidenced by alterations in a number of core process areas, such as scoping and implementing new cooperation, attention, and strategies across districts and functional areas. MoDOT’s estimate and cost management efforts spun off a Practical Design initiative to get technical design engineers to design differently. MoDOT is also moving toward performance-based specifications. According to one MoDOT representative, “The leadership has demanded these results and staff have found and supported innovative practices.”37 MoDOT and other DOTs have described a cultural issue at the core of the change management challenge for DOTs: the tradition of “Build the best project possible at all costs. Build it the right way and the safest way at all costs.” DOTs are now seeing a shift. The more recent message is
“We are not changing the standards, but we realize there is a cost.” MoDOT’s “Practical Design” initiative is a major shift toward this approach. As the introduction to that manual states, Practical Design challenges traditional standards to develop efficient solutions to solve today’s project needs. MoDOT’s goal of Practical Design is to build ‘good’ projects, not ‘great’ projects, to achieve a great system. Innovation and creativity are necessary…To accomplish Practical Design, we must properly define the scope by focusing on achieving the project purpose and need while considering the surroundings of each project. We must be sensitive to where the project is located…The surrounding context helps determine the design criteria. Our goal is to get the best value for the least cost. Life cycle costs must be considered. It is not our goal to shift the burden to maintenance.

The next step in implementing Practical Design is adopting new policies in areas most affecting our improvement costs. These areas are known as “cost drivers.” Reducing costs in these key areas, while still serving motorists’ needs, will enable us to construct more projects, thus better serving the taxpayer…. We must build the most efficient solution to the transportation need we have identified so we can spread our money to more projects across the state.

MoDOT senior managers developed these new policies in October 2005, following a review of best practices intended to encourage the staff to think outside the box. They encouraged staff to design future improvement projects to provide the best value for the taxpayers. The policy represented a significant change in MoDOT direction and superseded the direction on these topics contained in MoDOT’s Project Development Manual. To implement Practical Design, MoDOT is now implementing an electronic one-stop shop for design, right-of-way, bridge, construction, traffic, and maintenance activities. Utah DOT noted that important cultural changes started in 2005 with economic concerns when the department changed back to more centralized management and control. As a UDOT process leader explained, the agency “made it policy to have a central estimate review before advertisement, which was not popular. Regions felt like we were saying they don’t know what they’re doing. We were mostly protecting them from political pressures they didn’t know they were experiencing.” Likewise, “consultants didn’t know how important it was to produce a good, awardable estimate. Their understanding of that did help the department.” The representative said the agency underwent “a distinct change in (the previous) philosophy of wanting to shop bids…(they) used to just plunk down estimates to see if they could get low bids. There was political pressure to make estimates fit in the budget, but now staff don’t artificially lower estimates to get them under the approved amounts—they address problems before bid letting.”

### 3.9 Key Turning Points in the States’ Implementation Processes

After a DOT identified the need for change in the cost estimating process, the agency chose a method for implementing the desired change. As discussed to this point, DOTs face a number of common challenges and barriers to achieving organizational change, including organizational inertia, gaining attention and motivation to deal with the issue, and DOT engineers’ culture of building the best project possible.

Implementation processes often had turning points when notable change occurred. Some of the most common ones are discussed below.

- **High level leadership, endorsement, and political pressure.** Several DOTs identified the leadership’s endorsement of change as the primary turning point, as well as political pressure...
from the state’s legislature or governor. Caltrans’ upper management strongly supported the revision to the cost estimating process because Caltrans had trouble making its cost estimates consistent with low bids. Virginia’s commissioner took every opportunity to promote the Project Cost Estimating System (PCES) and was instrumental in making its use standard procedure. Mn/DOT received a similar endorsement for change from its leadership. Utah DOT experienced political pressure to make estimates fit in the budget, which led the department to address problems before the bid, to avoid artificially lower estimates to get them below the approved funding. The Washington State legislature put pressure on WSDOT to update its processes after an audit revealed that the agency lacked a uniform cost estimating process across staff and project planning.

- **Regulatory changes and legislatively mandated requirements** forced turning points on some DOTs. Mn/DOT became subject to new regulatory requirements after the state legislature passed a bill that imposed new performance reporting requirements focused on program delivery and on-budget performance. Missouri’s legislature also pressed MoDOT toward improved performance reporting and better estimating, to deliver the entire scheduled transportation program.

- **Agency changes in philosophy** were cited by some DOTs as key turning points. Utah DOT found that consultants began to understand the importance of producing a good, awardable estimate after the department changed its philosophy from so-called “shopping bids” or putting down estimates to try to solicit low bids; focusing on producing good estimates improved the process. Montana (MDT) also saw a turning point when staff began to embrace the new process and understand the importance of good estimates. Caltrans’ philosophy changed after the realization dawned that the agency could not rely exclusively on historical data and began to work with industry to better forecast bid prices on certain items. Maryland (MDSHA) experienced a turning point in its program after a series of meetings with districts and consultants that emphasized consistent use of process and procedures and improved documentation methods. MoDOT implemented a new level of agency-wide accountability where cost management and accurate estimates became everyone’s job; the agency decided to, as one representative put it, “build Fords instead of Cadillacs,” and publicized the progress quarterly.

- **Reengineering and initiating internal process improvement efforts**. Several state DOT improvement efforts were internally driven and turning points were integral to those efforts. MoDOT initiated internal reengineering to improve the scoping process. Likewise, Mn/DOT undertook improvements to its scoping process, and, in reviewing the agency’s cost estimating process, identified several key gaps that the agency then addressed with the strategies previously discussed.

- **Performing scoping much earlier in the process and performing estimates at scoping.** Florida DOT found implementation of its Efficient Transportation Decision Making (ETDM) system, with environmental screens of projects in the 20-year plan and before development of the 5-year work program (STIP) to be a major turning point. PennDOT’s major turning point occurred when the agency started doing cost estimates much earlier during scoping.

- **Cash flow and project funding challenges.** For some DOTs, overcoming cash flow and project funding challenges was a major turning point in the implementation process. Maine DOT determined that cash flow challenges hindered the agency’s ability to identify how much money was actually available to be spent on projects, making it difficult to identify the number of projects to advertise. The agency realized it needed more accurate numbers to predict schedule and cash flow. Maine DOT also determined that an overall lack of priority to maintain and update data resulted in poor quality data for estimating. WSDOT looked closer
at how it implement projects after the state legislature decided in 2003 to fund projects by line item and require a completion date. The agency had an incentive to look more closely at estimating procedures to make the process more effective and efficient.

- **Decision to increase internal financial expertise.** A final turning point identified by several DOTs occurred when the decision to increase internal financial expertise. Maine DOT assigned each program in project development a financial specialist to help project managers identify available funds in portfolios. The agency determined that project managers needed an ongoing support team to provide greater assistance with cost estimating and scheduling. South Dakota increased the number of Project Identification Coordinators (PICs). Before the change, one person did all of the scoping; after the change six people work in the scoping process. The additional staff support allows the agency to monitor contingencies in preliminary engineering and construction engineering.

One state reported bringing a consultant on board as a notable turning point. Some states said the turning point was a gradual process of people embracing the process and understanding the importance of making a good estimate.
4 Program Level

4.1 Staffing

As one DOT representative stated, “You can’t get a good estimate without devoting substantial resources.” Chief among the resources, and often most difficult to assemble, are staff resources. Insight is needed to estimate required staff and talent in cross-cutting areas. A representative at Caltrans said, “Cost estimators don’t all reside within design, some are in construction, but all report to a chief engineer in Sacramento for project delivery. All are within the broader umbrella for delivery, which helps improve practice exchange.

Once staff resources are assembled, it is important to leverage their abilities and the estimating work accomplished in each phase, to greater levels of efficiency and effectiveness. Historically, planners, project managers, designers, and cost estimators were all doing estimates and tended to start over each time instead of sharing each other’s work. Better understanding is needed about the special needs of each phase, why work in other phases tends to be insufficient for their purposes, and how communication and cooperation could be improved to develop a good baseline estimate. That baseline estimate must then be managed as it evolves across phases.

4.1.1 Assessing Staffing Needs

Some DOTs have dedicated estimating staff and a central estimating office. For example, Florida DOT (FDOT) has a central estimating office, but the agency outsources most of its design work. Design consultants are responsible for developing the project cost estimate. The central Estimates Office maintains and updates costs in the long-range estimating system, with input from the districts.

The estimating process at almost all DOTs requires communication through a wide range of environmental, right-of-way, utility, and traffic staff members during development. The intention in almost all states is for estimates to be informed by multidisciplinary teams. For example, at Ohio DOT, an estimating team with a well-trained and experienced estimating team leader makes budget estimates for all projects. The number of members on the team varies, but members are chosen for their experience, communications ability, thorough knowledge of the scope and site, and ability to evaluate critical issues, such as risk. The team seeks input from other experts for items not exclusive to bridges, roadways, and earthwork. Members of the team may change as the project reaches various phases; however, the team leader sees the project through completion. Team members are listed in the documentation. If the estimate is done by a single individual, then contacts with experts for advice and costs are listed in the documentation.

While dedicated estimating staff is the ideal, flat or declining staff levels significantly affect DOTs with large and multiple estimating tasks. While larger, more complex DOTs have dedicated staff to estimate costs, many others still lack separate estimating sections or dedicated estimators. Without separate estimating sections and dedicated estimators, DOT staff are
stretched to perform adequate scoping and estimating. DOTs have difficulty hiring additional staff and often consider alternative means to absorb additional work. Some DOTs convert existing vacancies, some redefine responsibilities of current staff, and others use consultants to fill the gaps.

Estimators have special skills, for which a national group, Transportation Cost Estimators Association at http://tea.cloverleaf.net provides support as does AASHTO’s Task Force. As a Washington State DOT (WSDOT) design engineer noted, “Each project is unique. To accurately develop an estimate of the construction costs for a project, an estimator must be capable of mentally constructing the project and then accounting for all the activities necessary to complete it. Many of the best cost estimators are knowledgeable in both transportation design and construction.”

For DOTs without estimating support, there is a risk that increasing workloads may lower the attention given to cost estimate management and reduce the task to a secondary component of designers’ jobs.

DOTs across the board indicate they are doing more with less (see box). Some states indicated they had added one or two staff members to support cost estimating and estimate management. Responsibilities varied with the organizational structure, locus of leadership, and the initiatives underway; however, the following list summarizes how some states cover estimating tasks:

- Maryland SHA plans to hire two people who will keep the cost estimating guidelines updated, track costs from planning to final design, and train other staff. The two additional staff will comprise a registered cost-estimating engineer and a cost estimator with experience in road design or construction and a good background in cost estimating.

- Maine DOT bolstered the role of its Contracts Section with additional staff to support tasks such as cost estimating.

- Montana DOT (MDT) reorganized to identify two existing full time equivalent (FTE) positions that were not already filled to avoid seeking additional positions from the state legislature. The new staff will keep the guidelines updated, track costs from planning to final design, and train other employees. They will be technical experts in estimating, with experience in road design or construction, and be resources department-wide.

DOTs Doing Much More with Much Less

DOTs have been making vast strides in internal resource management over the past decade. Ohio DOT’s trajectory is not uncommon; DOTs are doing much more with much less. Prior to 1995, ODOT’s operating costs were rising at an average rate of 5.7 percent – a rate of growth that threatened to obliterate capital budgets within a matter of a few years. Through a re-engineering effort which began in 1995, ODOT became a considerably leaner organization, downsizing from 7,800 to 6,031 employees. Many other DOTs have made similar reductions. ODOT kept its average annual payroll increases to 0.78 annually over a period of ten years ending in 2004. In ODOT’s case, re-engineering also decentralized budget authority to district offices, allowing them to keep operational savings (e.g., equipment budgets) and plow savings back into district pavements and bridges. Some DOTs have begun to track and compete with each other on administrative costs, as seen in MoDOT’s claim to now have the third lowest administrative costs, nationally. As public servants well know, the private sector is not necessarily more efficient either; a number of DOTs as well as an AASHTO committee are tracking costs of performing services internally vs. externally. External design and engineering management can cost three times more.
Virginia DOT has two dedicated staff plus IT support to maintain the agency’s Project Cost Estimating System (PCES). At VDOT, the project manager has no dedicated resources. Districts have two people to update and maintain PCES, and an eight-person staff at headquarters to make final estimates and help districts use the tools. VDOT completes about 300 to 350 estimates per year.

Mn/DOT has one staff person devoted full time and another nearly full time. Working teams and a project team absorbed additional duties.

Some states, even with very small staffs relative to other DOTs, are making major investments in improving cost estimating and estimate management processes. For example, South Dakota developed special estimating sections or so-called “swat teams.” Previously, at SDDOT, one person did all the scoping; STIP estimates were not revisited and could be off by more than 50 percent. SDDOT initiated two Project Identification Coordinators (PIC) who updated the estimate annually and did the final estimate, connecting the beginning to the end of the process from scope to bid. Those staffers have three duties: scoping, estimating for STIP and final bid (not construction), and monitoring the project throughout to raise red flags on scope creep. They are responsible for controlling the scope and cost, and they update estimates annually and do the final engineer’s estimate. SDDOT now has six PICs with the capability to develop and monitor contingencies in preliminary and construction engineering. SDDOT reports that “now scope creep is under control from scoping to letting. PICs are in control of what is put into the estimate on the first day and what goes into the final estimate.”

Amid cash flow challenges, Maine DOT designed positions to better pinpoint available funding for projects. A financial specialist is assigned to each program in project development to help project managers identify available funds. The support team provides cost estimate and scheduling assistance. To build this team, the agency modified existing positions and tapped staff who demonstrated an aptitude for financial and schedule management. Now these individuals accompany project managers to meetings with upper management, provide financial support to make managers more effective in delivering projects on time and within budget.

Missouri has a robust auditing program for estimates while maintaining the third lowest administrative costs of any DOT. Districts are responsible for developing and maintaining cost estimates, but a central final cost estimating group with four full-time staff and occasionally engineers from the bridge division is available on call to districts.

Some states indicated they would like to hire more estimators. For example, Ohio DOT said they have seven estimators, most near retirement or already retired but on call. Two of these estimators do 98 percent of the estimating work. Ideally, Ohio DOT would like to hire an estimator in each district to track project costs for district programs though they do not foresee funding to do so, at least until the next emergency. Although districts would not themselves do estimates, they would have a firm understanding of the progress of estimates and the components in the costs. Funding is limited, but additional staff would be beneficial. Caltrans does have such positions and values them highly.

### 4.1.2 Adding Responsibility to Existing Staff

Estimating process improvement affects many staff members. Some DOTs have attempted to undertake the whole improvement effort without devoting new staff or by re-allocating FTEs. The following discussions summarize how some states have changed by adding responsibilities to existing staff.
- Utah DOT assigns two to four staffers to perform red flag analyses and inflation rate adjustments, in addition to other responsibilities. Project lead engineers are responsible for ensuring cost estimates meet deadlines and contain all necessary information.

- WSDOT incorporated estimation processes into the existing duties of relevant staff focusing on how to improve current procedures, without adding resources or establishing a separate estimating department. WSDOT has central office support and designated district contacts, but otherwise relies on consultants from On-Call Cost Estimate and Validation Process/Cost Risk Assessment (CEVP®/CRA) using the Risk Analysis Services On-Call List and Subject Matter Expert On-Call List. The agency considers its efforts to be in the beginning stages but successful. In fact, the agency is finding that staff welcome the uniformity of estimation approaches and tools for different complexity levels.

- PennDOT has no plans to hire new staff to help with increased workloads. The agency has individual estimators who develop project estimates. At project milestones, the QA process is a team effort, similar to project management teams. Rather than adding to estimating staff, PennDOT is putting more emphasis on the front end of the process to identify risks and ensure excellent communication. For example, utility coordination is recognized in cost estimates, and PennDOT has agreements with utilities well before final design. Interviews with 17 DOTs for the SHRP2 R15 project on DOT-Utility Coordination found this type of communication is an increasingly common practice; many DOTs are coordinating with utilities at the 30-percent design level. PennDOT has no central cost estimating unit, but most districts have a staffer responsible for cost estimating. Contract management is also decentralized. The project manager or a consultant does early estimating in preliminary engineering. The central office performs some limited reviews and policy oversight. For federal oversight projects, PennDOT’s Engineering and Construction Management System (ECMS) system stores all contract information, casting the central office in a QA/QC role.

### 4.1.3 Staffing Changes in the Works

DOTs in other states, such as Caltrans and Mn/DOT, are considering staff changes.

At Caltrans, project engineers usually do the cost estimating, but each district has a cost certifier who recommends estimates to the director. Estimates are sent to all personnel involved on the project and everyone must sign a routing slip, though the project engineers are ultimately responsible. More recently, some districts have reorganized to create cost units, and other districts are beginning to develop cost estimating expertise in the office engineer unit. A Caltrans representative said, “Each district is developing expertise in the district instead of each project engineer trying to figure it out on their own. Project engineers are not cost estimate engineers.” Districts are primarily taking current staff and redefining their roles; changes in staff roles are based on experience with estimating costs.

Mn/DOT is considering potential organizational changes to provide additional staff support including a dedicated planning-to-letting estimator in each district and a Central Estimating Office. The Central Estimating Office would provide planning-to-let direction, support, and guidance to districts and review major projects and sign off at specific milestones. Currently Mn/DOT has an estimating unit that applies only to the last phase before bidding. Future improvements might involve a sign off at different points and assigning responsibility to district estimators with local knowledge for all initial cost estimates, including quantities, before the estimate is coordinated with the Central Estimating Office.
4.1.4 Capacity Building in the Face of Declining Staff

DOTs are losing staff to retirements and, in some cases, by design. Many DOTs continue to shave staff in pursuit of administrative staff reductions. To address a shortage of qualified, experienced estimating staff and agency vulnerability to loss of institutional knowledge in this area, DOTs are providing training programs, opportunities to move within the organization, succession planning, and leadership development. New processes will help capture information that might otherwise be lost for new personnel.

WSDOT is considering improving exit interviews and pairing newer staff with staff who may retire soon. South Dakota DOT is taking steps to improve skills through mentoring. Caltrans and Utah DOT senior estimators mentor junior estimators. Virginia DOT invests in capturing and incorporating as much information as possible in knowledge management systems. MoDOT is studying compensation and job duties to identify staff responsibilities and document needed judgment and skills to prepare for knowledge transfer.

Maryland has one of the most comprehensive approaches to addressing staff turnover. MDSHA has developed guidance for handing off information to new employees. As one staff member stated, “Guidance does not replace 30 years of experience, but it is good for 70 to 80 percent of the projects. People retain a lot more than they can write down and document.” MDSHA has produced a model cost estimating and estimate management guide. New engineers do mandatory 1-year rotations in two to four offices and in construction to become familiar with all phases of the process. MDSHA offers extensive education opportunities for honing technical skills and obtaining advanced degrees. MDSHA staff also teach courses and provide background materials at the University of Maryland for civil engineering students, who are not usually exposed to highway-related aspects such as geometrics design, hydraulics, design speed, and super elevation.

4.2 Communication: Breaking Down Silos

Division-centric management, or “silos,” results in isolated operations with a lack of communication. Because of the need for better, more accurate, reliable, and timely information, many DOTs seek explicitly to reduce the effect of cost estimating silos. The following sections describe how some states are approaching communication to break down silos.

A Maryland SHA representative said that when “everyone was working in their own silos (bridges, traffic), (they) didn’t know how much everything would cost until final design.” A representative from another DOT said that increased demand for information at DOT divisions and bureaus “forced them to work
together more often to break down information barriers and to ease the flow of project information exchange between the departments...to better promote cross-collaboration among departments to share project funding decisionmaking.” Many representatives mentioned during the interviews the need for communication and increasing cooperation—in particular breaking down the silos that have grown up by transportation phase and functional area.

For some states with smaller staffs, such as South Dakota and Montana, breaking down silos was merely a matter of everyone trying to work together in a more unified manner. SDDOT reported that the previous culture was to work in silos, but now a more seamless process includes planning and bid letting combined in one office. The agency is working closer and earlier with utilities to avoid impacts and minimize delays. A Montana (MDT) representative said that “internal communications are a strength; it helps that the same people work together as a team.” MDT uses good communication, milestone meetings, teleconference meetings, and phone and e-mail communication to bridge its combination of centralized and decentralized management.

Other states took more involved steps to increase cooperation and reduce silos. PennDOT built a quality assurance process at project milestones, similar to project management teams, to maintain communication and update estimates as the project evolves. Maine DOT made the Planning and Project Development department leads co-chairs in the estimate management process improvement effort. Maine DOT also strengthened its contracting section, and Project Development and Contracting began to hold monthly meetings and exchange information on department-wide meetings. The contracts section is now involved in the collaborative check-and-balance system of project implementation, which ensures that adequate funding is available before a project is advertised to contractors. To further break down silos between design and construction, Maine DOT dismantled its Design Office; now Maine DOT organizes its projects by infrastructure and mode, and teams are regionally based. Teams consult with one another before changes are made to projects, supporting informed decisionmaking. As parts of the organization work more closely together, Maine DOT reported transparency has also increased.

Districts or regions may remain a sacred cow silo, which can lead to duplication of efforts such as data tracking, guidance, and tool development. Still, DOTs may benefit from smaller geographic areas that offer smaller cross-functional teams and improved accountability through standard agency-wide guidance, processes, and measures. California, Utah, Virginia, and Missouri have discovered that measures and standards effectively surmount many of the issues created by silos and decentralization.

VDOT started its Project Management Office (PMO) and shifted responsibility for program delivery to the districts and instituted performance measures. Now districts are responsible and accountable for estimates. A new statewide process integrated into the engineers’ Project Cost Estimating System helped ensure no omissions of important budget elements.

Following is a list of some strategies DOTs have developed to reduce internal silos:

- Mn/DOT is using a mass e-mail campaign to the project team, although sometimes messages are overlooked or go unread. Cost Estimating and Estimate Management teams are talking with various functional groups and seeking to expand the e-mail audience.
- In multiple states, peer review has brought different levels of expertise and from different functional areas together.
- Decentralization in districts and regions allows smaller groups of design squads, utility coordinators, and traffic support, to facilitate coordination. The project manager is responsible for the macroscopic view to prevent miscommunication across silos.
- Project management systems help DOT project managers schedule the support they need from regional offices or headquarters.

- Utah DOT has weekly video conferences between the regions and headquarters for cost estimating. The meetings come under an open door policy, but the meetings are not always well attended by the regions.

- Maine, Minnesota, and Virginia use multidisciplinary, cross-silo teams to improve various agency processes.

- Louisiana Department of Transportation Development (LADOTD) planning and design units hold scope transition meetings to remediate previous lack of communication between divisions. New York State DOT (NYSDOT) also decided on a team approach so “planning and budgeting can be on the same side as designers, construction, and maintenance. The whole organization needs to understand the implications of their decisions on the final project costs.” One notable improvement is that they are now looking at ways to include the planning group.

- Colorado DOT and Utah DOT use cradle-to-grave project management. By combining management of design projects and construction, the project manager oversees the scope, budget, and schedule and works with designers to identify red flags. In several other states, only mega projects are managed cradle-to-grave, when the whole team reports to the project manager. The project manager is responsible for delivery of the project on schedule and within budget, but depends on others outside his or her chain of command, making it critical to keep the lines of communication open.

- MoDOT uses project status or milestones and tracking meetings, similar to a risk management process. MoDOT’s engineering policy guide describes the audit process and central office design liaisons, which audit files throughout the estimate process. WSDOT has a similar process.

- NMDOT is developing a strategy for assigning co-leads at key points of the project development process to improve communication and consistency. For example, early in planning a district planner and an environmental manager share responsibility to identify potential scope creep issues early in the project.

- Many states, from New York to New Mexico, said estimators need closer links with planning and a more formalized policy to ingrain the process into the organization’s culture. In particular, collaboration between right-of-way and design units needs to improve. Better information and decision support systems help; however, lead estimating staff at VDOT noted uncertainty if VDOT’s Right-of-Way Information System, one of the better ones, interfaces with the agency’s Project Cost Estimating System (PCES). Staffers said they “asked ROW to be more specific in their estimating and have more detail in it than ever before,” which ROW found very difficult to accommodate, despite the excellent systems supporting both ROW and estimators.

- In Maine, the agency’s dashboard system has promoted collaboration and transparency in funding decisions; however, upper management’s (e.g., Commissioner and Deputy) increased involvement in project maintenance has, at times, made it challenging for project managers, who traditionally had more control over project funding management. For example, project managers are accustomed to cutting parts of their projects when funding runs low, but project managers now have less decisionmaking authority. Instead, project managers must consult senior management and present the reasons for project changes, potentially resulting in project delay or criticisms over project management. The focus of greater collaboration has,
for the most part, provided support to project managers, helping them find funding sources if money cannot be identified through the project manager’s portfolio of projects.

### 4.3 Training

DOTs report a general lack of training materials and opportunities related to cost estimating, although the workshops organized by TRB, the University of Minnesota Center for Transportation Studies, Mn/DOT, and AASHTO have provided tremendous support and received rave reviews. In most states, mentoring is still the primary mode of training.

A few DOTs have developed training courses as part of their cost estimating and estimate management improvement efforts:

- **Mn/DOT** is developing staff training as the final phase of the cost estimating and estimate management process improvement effort. The training will draw on the *Technical Reference Manual* (under development) to document the agency’s new process. The manual will include a set of tools ranging from peer reviews of estimates, to checklists, to analysis of historical data.


- **Virginia DOT** provides training on how to use the in-house Project Cost Estimating System (PCES), an estimating tool that covers the scoping phase through the right-of-way authorization phase of project development. PCES comprises three elements: a cost estimation tool, an improved scoping process, and a project development Web site. Training participants learn how to use the Web site and Excel-based workbook. This course is required for all employees who need access to PCES to upload project cost estimates for review and approval by VDOT project managers. Additional information is available at [www.virginiadot.org/business/default.asp](http://www.virginiadot.org/business/default.asp) and [www.virginiadot.org/business/resources/PCESTraining_forLocalities.pdf](http://www.virginiadot.org/business/resources/PCESTraining_forLocalities.pdf).

- **Washington DOT** offers workshops and guidance for project teams, risk leads, cost leads, and subject matter experts in cost risk assessment (CRA). Workshops stress the need for consistency in the practice of risk-based estimating while ensuring that CRAs allow for flexibility and scalability necessary in dealing with a wide variety of projects that vary in size, location, and complexity. Guidance and information on WSDOT’s CRA workshops is available at [www.wsdot.wa.gov/Projects/ProjectMgmt/RiskAssessment/](http://www.wsdot.wa.gov/Projects/ProjectMgmt/RiskAssessment/).

- **UDOT** offers a Web site resource, *Estimator’s Corner*, designed to assist project managers and designers prepare engineering estimates and show status on bid opening day. Downloads include a newsletter (update of inflation information, market prices, and trends); a weekly updated graph of how many year-to-date projects have been bid within 110 percent of the engineer’s estimate; weekly lessons learned with helpful information about projects bid; and the statewide Engineer’s Estimate Review Process. Additional information is available at [www.sr.ex.state.ut.us/main/f?p=100:pg:2300975413934027::::T,V:1624](http://www.sr.ex.state.ut.us/main/f?p=100:pg:2300975413934027::::T,V:1624)

- **The National Highway Institute** (NHI at [www.nhi.fhwa.dot.gov](http://www.nhi.fhwa.dot.gov)) offers a 2-day course, “Addressing Uncertainty in Cost Estimating,” that provides an overview of current cost estimating practices for highway projects, including consideration of risk and uncertainty in
project cost estimates, and the importance of cost estimating. After discussion of various
estimation methods, participants identify methods most appropriate to use during the various
phases of project development. The course specifically addresses cost estimating for large
and complex projects, but the concepts presented are applicable to developing estimates for
all types of transportation projects. Participants also learn how to report cost and schedule
estimates accurately and analyze and evaluate the process of creating a cost estimate to
determine if it is consistent with the FHWA’s Major Project Guidance. Two pilot courses
were held in partnership with VDOT in Richmond, VA, in July 2007, and Caltrans in Los
Angeles, CA, in October 2007. During the pilot courses, participants gained hands-on
experience through various exercises to understand how to use historical cost data and
account for risk and uncertainty in an estimate. After learning the fundamental concepts of
cost estimating, participants used case studies to apply learned theories to real-life
transportation projects.

4.4 Developing and Sharing Tools and Resources for Cost Estimating
and Estimate Management

During our interviews, representatives from state DOTs consistently expressed the need for
existing tools and templates to adapt to their own agency’s needs: they need better, user friendly
tools to develop good estimates in planning, for parametric estimating, to capture historic data,
and for some escalation forecasting. Commercially available tools meet some of the criteria, but
improvements are needed to make the tools comprehensive, easy to use, more reliable and
flexible enough so that each agency can adapt the tools to their specific needs.

DOTs would like the resources to be available in an easily accessible location; consequently, we
will provide these resources to SCOP for potential posting on the Web site,
statewideplanning.org. Appendices to this report include the compiled resources on the following
topics:

- Appendix D:
  - Construction Cost Estimating Guide (NJDOT)
  - Cost Estimating Forms (Caltrans)
  - Construction Cost Indexes (Caltrans)
  - Utility Owner Issues and Estimate Worksheet (NJDOT)
  - Contingencies and Escalation Form (NJDOT)
  - Non-standard Item Number Request (NJDOT)
  - Utility Cost Estimation Summary Sheet (NJDOT)
  - Utility Owner Conflict Identification Worksheet (NJDOT)

- Appendix E: Communities of practice in cost estimating, especially for transportation

- Appendix F: FHWA Cost Estimate Guidance

- Appendix G: DOT Vision for an Improved Cost Estimating and Estimate Management
  Process

- Appendix H: Planning Cost Estimating Tool (FDOT)

- Appendix I: Efficient Transportation Decision Making Process (FDOT)

- Appendix J: Uncertainty, Risk and Contingency Policy for Estimating (Mn/DOT)
Representatives reported that states draw on some of the numerous tools provided in Appendix D of the NCHRP Report 574 for planning, programming, and preconstruction, although few states undertook extended best practice review. States also conducted scans of internal best practices, tools developed in-house, and commercial off-the-shelf (COTS) systems. DOTs report using both custom and COTS tools to estimate construction costs. Custom approaches may be as simple as Excel spreadsheets shared, used, and updated by estimators and designers or they can include sophisticated software. Exhibit 8. State DOT Cost Estimating Tools below identifies different costing methods used by various states.

The most commonly used COTS is Trns*Port, a software system developed by AASHTO for estimating costs from planning through project development, letting, contract award, and construction operations. Trns*Port consists of 14 components designed to meet most highway and transportation agency needs during a project life cycle from planning through archival of final contract information. Most modules are licensed separately so that the licensee can choose only the modules needed. The following text box briefly describes each module.

states suggested that AASHTO more actively promote Trns*Port. In addition to Trns*Port, many states have developed their own software and other tools adapted to meet their specific needs. The following paragraphs give some examples of tools DOTs use.

Virginia DOT Cost Estimate Improvement Study and Development of a Project Cost Estimating System

As recently as 2002, VDOT lacked a consistent, uniform method to scope projects. That year, VDOT developed a task force to locate an existing, proven method for estimating costs or develop one. VDOT identified the following criteria for selection of cost estimation tools:

- Effectiveness for the job needed
- Conducive to statewide implementation
- Greatest potential to be deployed in VDOT without a long delay

To identify what tool or tools would be most useful and appropriate, VDOT undertook the following tasks:

Review of COTS Tool Alternatives. VDOT examined one main proprietary tool, TRACERTM (Transportation Cost Estimator). Earth Tech, Inc., developed a software prototype named TRACER to estimate the cost of transportation construction. The package is an adaptation of a successful software application that Earth Tech created to estimate the costs of other kinds of construction. The prototype available for testing and the literature that accompanied it gave a good idea of the capabilities: (1) ease of use for an engineer or technician armed with the available information about the project; (2) the ability to create and update a cost estimate throughout the design process; and (3) consistent estimates based on consistent standards and costs, no matter who makes the estimate and no matter where the estimate is made. The software bases the cost estimate on quantities or units of work: tons of structural steel, cubic yards of
**Exhibit 8. State DOT Cost Estimating Tools**

<table>
<thead>
<tr>
<th><strong>Cost Estimation System (CES)</strong></th>
<th>is the primary Trns•port module for construction cost estimation and it has a full range of cost estimating capabilities from project concept to the final engineer's estimate. CES also provides a parametric cost estimation functionality.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Proposal and Estimates System/Letting and Award System (PES/LAS)</strong></td>
<td>allows the user to enter project data and prepare the PS&amp;E estimate. Standard reports include the detail estimate, the proposal estimate and the proposal.</td>
</tr>
<tr>
<td><strong>Construction and Administration System (CAS)</strong></td>
<td>tracks contractor payments, funding allocation and change orders. Outputs that can be produced in CAS include partial payment vouchers, construction reports, contract status reports, and item-level funding.</td>
</tr>
<tr>
<td><strong>Decision Support System (BAMS/DSS)</strong></td>
<td>is used for the analysis of construction project data to provide decision support in the areas of bid monitoring and evaluation, vendor (contractor, subcontractor, and DBE) and market analysis, item price estimation, and the planning and budgeting process.</td>
</tr>
<tr>
<td><strong>Expedite</strong></td>
<td>allows bidders to receive proposal information including item schedules, DBE requirements, and affidavits; enter all information required for a valid proposal; and submit item bids in a secure machine-readable form.</td>
</tr>
<tr>
<td><strong>Estimator</strong></td>
<td>is a cost estimation system that supports generation of cost estimates using cost-based and bid-based techniques. Estimator can import and transfer data between the other modules for further refinement of estimates and for integration of project estimates into program estimates.</td>
</tr>
<tr>
<td><strong>FieldManager</strong></td>
<td>is a comprehensive electronic construction management system for managing and tracking construction projects, documenting construction progress, initiating contractor payments, and communicating with a central office contract administration system.</td>
</tr>
<tr>
<td><strong>FieldNet</strong></td>
<td>enables the electronic transfer of contract, estimate, contract modification, and reference information among offices. FieldNet can also be used to obtain supervisor approvals for estimates and contract modifications and to transfer the information to other users.</td>
</tr>
<tr>
<td><strong>Intranet</strong></td>
<td>opens selected portions of Trns•port to any authorized user with a web browser, such as Netscape or Microsoft Internet Explorer.</td>
</tr>
<tr>
<td><strong>SiteManager</strong></td>
<td>provides for data entry, tracking, reporting, and analysis of contract data from contract award through finalization.</td>
</tr>
<tr>
<td><strong>SitePad</strong></td>
<td>is used in the field with a handheld data collection device, in conjunction with SiteManager. Through the creation of Daily Work Reports (DWRs), field personnel can track item and material progress, record weather and temperature data, track contractors' personnel and equipment, and document site conditions.</td>
</tr>
<tr>
<td><strong>SiteXchange</strong></td>
<td>enables contractors to enter subcontractor information once a contract is awarded. The contractor program may contain a miscellaneous data screen with form elements, and it provides a printed report. The completed form is then sent back to the transportation agency to be loaded into SiteManager.</td>
</tr>
<tr>
<td><strong>Transportation Cost Estimator (TRACER)</strong></td>
<td>is a parametric cost engineering tool designed for (1) ease of use (for an engineer or technician armed with the available information about the project); (2) the ability to create and update a cost estimate throughout the design process; and (3) consistent estimates based on consistent standards and costs, no matter who makes the estimate and no matter where the estimate is made. The software bases the cost estimate on quantities or units of work: tons of structural steel, cubic yards of excavation, etc. For an early stage project, TRACER supplies default values for most quantities as a function of a few very basic specifications. As the project matures and more information becomes available, the software user can override and replace the default values to create a progressively more accurate estimate of the true quantities.</td>
</tr>
</tbody>
</table>
excavation. For an early stage project, TRACER supplies default values for most quantities as a function of a few very basic specifications. As the project matures and more information becomes available, the software user can override and replace the default values to create a progressively more accurate estimate of the true quantities. The software appeared to have the ability to generate consistent estimates among its users and be relatively easy to use; however, VDOT decided that because it is a proprietary software package, it would have been difficult for VDOT to modify or substitute Virginia-specific data during the timeframe of the study. The state decided to pursue other alternatives.

- Of the 14 Trns*Port components, the most frequently used are CES, PES, Estimator, and TRACER; however, the DOT representatives also stated that many of the modules are too cumbersome. Many states have developed their own tools or are in the process of doing so. Some

- **Tool Development and Testing.** After selecting the Excel-based cost estimating tool used in VDOT’s Fredericksburg District, VDOT assessed its accuracy by doing before and after comparisons of cost outputs and final costs for 132 completed projects, which identified areas for further study and improvement. VDOT incorporated other best practices into the existing model and continued testing for accuracy.

- **Further Involvement and Ownership Building in the Process of Cost Estimation System Modification.** The Fredericksburg template selected by the task group with the full knowledge that many adjustments and augmentations would have to be made to encompass all road projects (e.g., there was no way to estimate interstate projects) and to account for cost variations across the state. In addition, the template did not include components for building estimates of right-of-way and utilities costs. VDOT district and central office staff had several opportunities to provide comments and feedback regarding successive versions of the tool.

Subsequently, the Excel spreadsheet with roadway and bridge estimates was expanded to include construction engineering, to be applicable for interstates, and to generate estimates for right-of-way and utilities costs. Data on completed projects were collected from all VDOT districts to help calibrate the model further to account for cost variations across the state. Initially, VDOT sought to develop a system that would serve the average project; however, as the project progressed, the project task force decided that the cost estimation tool developed could be used, at least in the early stages of project life, for almost all highway construction projects.

Testing of the cost estimation tool was completed in the summer of 2003. Analysis of a sample of completed VDOT construction projects throughout the state showed that the tool yielded results that, on average, differed from actual final project costs by 22 percent. After further modifications, the Project Cost Estimation System (PCES), as it was named, became a fully operational system in 2003, maintained and updated by VDOT’s Scheduling & Contract Development Division. PCES is composed of three elements: a cost estimation tool, an improved scoping process, and a project development Web site. Local governments and VDOT all use this Web-based tool now.

PCES does a basic cost-per-mile estimate, and features for design standards, quantities, year of advertisement can be added in. It establishes an early conservative budget for the project including an estimate of inflation. PCES is used from scoping through the public hearing and contains the most recent 24 months of bid data. After the public hearing VDOT switches to the PES module of Trns*Port.
Washington State DOT

WSDOT has two tools for use during the Project Definition and Project Initiation and Alignment phases to estimate funds needed in the long range plan and prioritize projects. Typically, little to no design detail is included. WSDOT developed an MS Access database to estimate costs on various projects such as widening existing roadways and bridges, building new roads or bridges, and modifying existing interchanges or building new ones. It uses a unit price approach that accounts for regional differences and various land use types and development density. The tool comes with default quantities per lane-mile and unit costs obtained from historical data from WSDOT’s past projects. The tool also estimates right-of-way costs based in the amount of ROW needed and regional-specific unit prices. The user friendly program can store, perform calculations, and produce reports for numerous projects.

The second tool, the Mobility Project Prioritization Process (MP3), is an Excel workbook used to estimate cost-efficiency on a specific project using a benefit-cost ratio for the project life cycle (usually 20 years). Costs include ROW, engineering, construction, and operations and maintenance. Using MP3, each biennium highway mobility project is prioritized to provide maximum value and justify program tradeoffs under budget constraints.

A scoping level estimate is used to set the baseline cost for the project and program the project. The legislature uses the baseline estimate to set the budget and future estimates are compared against it. WSDOT uses historical bid pricing, cost-based estimates (the contractor’s costs to complete the work) plus and/or risk-based techniques for estimating. All changes are documented, including assumptions and data origins, in an estimate notebook. Estimates prepared at various design levels are updated as scope definition improves and all changes are clearly documented. The PS&E Engineer’s Estimate is prepared for advertisement, to obligate construction funds, and to evaluate contractor’s bids. The tool also uses historical bid-based, cost-based, plus and/or risk-based techniques. Design engineers and estimators can specify all work items that will be required for the project. The matrix in Exhibit 9, WSDOT Cost Estimating Guidance Manual for All Project Phases shows the WSDOT estimating process for each phase of project development.
In the context of cost estimating, the cost impact of project risks (favorable or unfavorable) must be included to derive a total project cost. In 2001, faced with escalating project costs, WSDOT determined it needed a better way to estimate and plan for risk associated with proposed projects. WSDOT developed a Cost Estimate Validation Process (CEVP®) that entailed bringing together 15 experts for 2 to 3 days to review the current base cost estimate of a given project. The technique identified and assessed risks and opportunities early in project development and avoided cost overruns and delays that had eroded the agency’s credibility with the public.

Experts could also conduct a Cost Risk Assessment (CRA) by assigning a project cost to explore the potential risk of each item, as well as assign a probable dollar risk to each item. (CRA is a workshop process similar to, but less intense than, a CEVP®.) Based on these assignments, a Monte Carlo simulation was completed to generate a probability distribution for cost and schedule. The agency implemented CEVP® for nine of its largest projects, and then announced the results to highlight knowledge gaps. A key difference between conventional estimating and CEVP/CRA is the project cost and schedule is a range rather than a single number.

In its analysis, WSDOT considered the following risk elements:

- Time (inflation, materials, shortages)
- Funding (funding not usually available at once)


<table>
<thead>
<tr>
<th>Project Development Level</th>
<th>Project Maturity (% of design completed)</th>
<th>Purpose of Estimate</th>
<th>Methodology</th>
<th>Estimate Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planning</td>
<td>0% to 2%</td>
<td>Screening or Feasibility</td>
<td>Risk-based or Judgment</td>
<td>65% to 200%</td>
</tr>
<tr>
<td>Washington Transportation Plan</td>
<td></td>
<td>WTIP/HSP (20 Year Plan)</td>
<td>Historical % Similar Projects</td>
<td>Parametric MP3 PLCE</td>
</tr>
<tr>
<td>Highway System Plan</td>
<td></td>
<td>WTP – Washington Transportation Plan</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>HSP – Highway Systems Plan</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Concept Study or Feasibility Implementation Plan</td>
<td>Parametric MP3, PLCE</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1% to 15%</td>
<td>(10 Yr Plan)</td>
<td>Analogous Projects</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Risk-based CEVP CRA</td>
<td>Risk-based</td>
<td></td>
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<td></td>
<td></td>
<td>Self-Modeling</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scoping</td>
<td>10% to 30%</td>
<td>Budget Authorization or Control Capital Improvement &amp; Preservation Plan (CIPP)</td>
<td>Parametric MP3, PLCE</td>
<td></td>
</tr>
<tr>
<td>Project Summary (PD, DDS, ERS)</td>
<td></td>
<td></td>
<td>Analogous Projects</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Historical bid-based (UBA, BidTabs Pro)</td>
<td>Risk-based</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>CEVP CRA</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Self-Modeling</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Design</td>
<td>30% to 60%</td>
<td>Design Estimates (Project Control of Scope Schedule Budget)</td>
<td>Historical bid-based (UBA, BidTabs Pro, EBASE)</td>
<td>-30% to -50%</td>
</tr>
<tr>
<td>Design Documentation I/S Plans for Approval Design Approval</td>
<td></td>
<td>Cost-based</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Risk-based CEVP</td>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td>CRA</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Self-Modeling</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PS&amp;E</td>
<td>90% to 100%</td>
<td>Engineer’s Estimate (prior to bid)</td>
<td>Historical bid-based (UBA, BidTabs Pro, EBASE)</td>
<td>-10% to 10%</td>
</tr>
<tr>
<td>Plans, Specs, Estimate (R/W Plans approved)</td>
<td></td>
<td>Cost-based</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Risk-based</td>
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<td>Self-Modeling</td>
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</tbody>
</table>

Source: WSDOT Cost Estimating Guidance
Demand on labor from outside influences

WSDOT liked the results so much that in a few years, the agency applied this cost estimation process to all of its major projects. It is now a requirement to apply a CRA or a CEVP® to all projects. Depending on the magnitude of risk, the agency can apply an analysis early in the planning stages or as late as right before bid. CEVP®/CRA results are helpful for project communication, developing risk management strategies, analysis of project alternatives, and project management. WSDOT’s Detailed Risk Plan Spreadsheet used to track and monitor risk management efforts is available at www.wsdot.wa.gov/NR/rdonlyres/936C097C-C3B9-492A-BC5D-909A81C312DE/0/RMPdetailrev2006Feb08.xls. This link takes you to all the steps and tools in WSDOT’s process (more than shown below) and available tools.

For each project at Washington DOT, the cost components included in WSDOT estimates are:

- Environmental component of construction cost (taken either from contractor’s bid document or engineer’s estimate)
- Share of total right-of-way acquisition cost (based on discussion with project team)
- Allocated share of contractor’s mobilization (based on discussion with project team, usually assumed to be 10 percent of overall construction amount)
- Allocated share of WSDOT’s cost for construction engineering and administration (based on discussion with project team)
- Allocated share of WSDOT’s cost for planning, NEPA and design (based on discussion with project team, usually assumed to be 5 to 15 percent of overall project costs).

Data for each of these elements is tracked in WSDOT’s electronic Program Delivery System, which provides a comprehensive accounting system for the department.

**Caltrans**

Caltrans stresses the importance of reliable cost estimates at every stage of the project development process for responsible fiscal management and the agency utilizes a variety of forms and tools.

Caltrans’ goal is to avoid project cost overruns by identifying unforeseen items of work before a project has been programmed to minimize the difference between preliminary project planning cost estimates and project design cost estimates. To ensure quality estimates, Caltrans uses a consistent and comprehensive methodology combined with research and comparison of current costs as well as professional judgment.

Cost estimates fall into two categories:

- Project planning cost estimates are used for project justification, analysis of alternatives, approval, and programming. Realistic assumptions for the final concept, scope, and cost are established as early in the life of the project as possible.
- Project design cost estimates are used to summarize the cost of a project’s contract items of work and become part of the construction contract.

The project engineer monitors and updates all estimates throughout the life of the project including milestones such as the start of the programming cycle, on approval of the project development report, or when there are significant changes to project costs such as when environmental issues or geotechnical problems are identified. At a minimum, estimates are updated at least once a year. The most recent cost estimate is maintained in the Project Management and Control System (PMCS) database and used in monthly project status meetings.
Project cost estimates are developed with the input of all other appropriate functional units and agencies inside and outside Caltrans including Structures, Right of Way, Traffic Operations, Materials, Maintenance, Construction, Environmental, Landscape Architecture, and local entities. Collaboration and communication among the various partners is necessary to ensure reliable project cost estimates.

Initial cost estimates prepared before programming helps management determine whether to proceed with project initiation. For new roadways or new alignments, the most likely method for cost estimates is a cost-per-mile basis. For maintenance or improvement of existing roads, adequate field investigation and scoping are essential to identify high cost items such as utility relocations, retaining walls, and traffic management. Cost estimates are updated and become more detailed as more information becomes available and constructability reviews evaluate and validate the project estimate and assumptions made.

Two methods are commonly used for estimating prices. One method is to use previous bid prices as a basis for establishing prices on the proposed project. Caltrans also uses supplier contacts in the industry, an online service “Global Insights” that provides information, and catalogs for non-standard items. The other method is to analyze production rates, labor costs, and material costs. After a project is approved and until completion of the PS&E process, the project design cost estimates focus on construction costs of the project and are input into the Basic Engineering Estimating System (BEES). The district provides highway costs to create the preliminary engineers’ cost estimate and the Office of Structure Design provides bridge costs. BEES stores the data until the project reaches the end of the PS&E development phase and contract documents are finalized. The final engineer’s cost estimate includes all contract items and is combined with the final structures cost estimate when the project is ready to list. The final estimate, which is locked in the BEES by the headquarters office engineer, cannot be altered without management approval. This estimate is used for comparison with the contractor bids and is the basis for award of the contract. Weblinks to Caltrans tools are included in Appendix D.

**Utah DOT**

UDOT uses a Project Development Business System (PDBS) database populated with historical bid estimates and actual costs as a project is developed. PDBS is used for all new projects from preconstruction through construction and includes project quantities and types.

UDOT provides additional support for estimators at the “Estimator’s Corner,” a Web site ([www.sr.ex.state.ut.us/main/?p=100:pg:2300975413934027:::T,V:1624](http://www.sr.ex.state.ut.us/main/?p=100:pg:2300975413934027:::T,V:1624)) that makes available an array of practical information designed to assist project managers and designers prepare engineering estimates and track performance. UDOT also uses the following tools:

- Newsletters to provide a monthly updates on contemporary issues such as inflation rates, estimating tips, guidance on process, conversations with contractors, and lessons learned. Archived newsletters are available.
- Batting average, a weekly updated graph of how many year-to-date projects have been bid in 110 percent of the engineer’s estimate and provides a transparent status of performance.
- Lessons Learned, a weekly updated spreadsheet that lists all projects bid and provides a brief statement of lessons learned, as applicable.
- Red Flag Analysis Help Manual, the most current guide to help account for the many factors that affect a project’s costs and suggest methods for raising or lowering an estimate to address the current bidding environment.
- Review Process, i.e., the statewide Engineer’s Estimate Review Process.
Ohio DOT

ODOT’s Office of Estimating provides a comprehensive Web site with the tools and resources estimators use including bid data, trends and forecasts, guidelines, cost indices, estimator templates, and many other tools and information to support estimators. All of ODOT’s tools and manuals are available at www.dot.state.oh.us/CONTRACT/estimating/. Following is a brief summary of some of ODOT’s tools:

- The Files and Information sheet provides English and metric versions of Item Master Files in Adobe PDF, text, and Excel versions that can be imported into project documents. Official tabulation of bids from 1993 to 2008 and historical bid item data beginning in 1998 are also accessible from this sheet. Historical bid files contain a project item level breakdown of the data contained in the Summary of Contracts Awarded (also available on the Web site), a useful tool for analyzing items project by project rather than on the annual totals.

- The Estimating Support sheet includes ODOT’s procedures for budget estimating. The document is an Excel spreadsheet format that provides comprehensive, easy-to-use guidance to estimate the critical path for a project, best practices, the 10-step process and procedures, cost categories that include traffic control, environmental mitigation costs, and many others in addition to major cost drivers.

  ODOT made the decision to use the Estimator software licensed by AASHTO, and now requires consultants to use it. A users guide and Estimator™ templates are available on ODOT’s Estimating Support sheet for Estimator™ version 2.2a.

- The Item/Bid Data Search provides a link to ODOT’s Construction Management System (CMS) software. Projects are loaded from AASHTO’s Trns*port into CMS, and then the daily construction activities are recorded online. The system generates estimates on the request and passes that information onto Accounting. CMS has two major subsystems: Construction Administration Subsystem (CAS) and Testing Administration Subsystem (TAS). CMS manages projects from award to finalization, tracking contract information and contractor payments. TAS manages the testing of materials that go into a highway improvement project and allows suppliers to enter their own information.

- Customer Support provides a contact list of people in the department that can provide cost estimation support and answer plan submittal issues.

- Construction cost summaries and construction cost trends are updated monthly on the Trends and Forecasts link. An annual business plan inflation calculator helps forecast costs based on the project start date, midpoint construction date, and costs in today’s dollars.

- District Information is an ODOT intranet site that provides forms and miscellaneous information for ODOT employees.

ODOT is also in the second phase of evaluating AASHTO’s parametric cost engineering tool, Tracer, and the agency is getting some positive results for conceptual estimating. In addition to the estimate, it is useful for tracking assumptions and it can produce quantities and items of work.

Florida DOT

FDOT uses a combination of Trans*Port modules (PES, CES, LAS, and SiteManager) and internally developed applications. Projects are initiated in the FDOT Financial System. District estimators transfer the information into PES through the Designer Interface, an FDOT Web application. The Designer Interface is also used to upload and update items and quantities from CADD’s Quantities Manager. Webgate is another FDOT-developed tool that works with FDOT’s estimating systems including Designer Interface, Trns*Port reports, Long Range...
Estimating, and others to assist estimators with pay item needs, reports, and other applications. The reports menu allows users to select and produce reports based on current information as well as historical projects and future (proposed) projects. The Long Range Estimates System (LRE) is a specific estimating software tool that supports cost estimating in the early phases of project development before plans and quantities are available. LREs are developed based on typical sections and length of the project, historical prices, and the type of project. The estimate continues to be updated as the scope of the project is refined. Access is controlled for all the applications and users must be trained and specifically granted access by the district estimates coordinator.

The Basis of Estimates (BOE) is an online reference document that is updated semiannually. It contains general estimating information and pay item information such as units, related or recommended items, forms, references, and the pay item structure. FDOT’s Transportation Costs Report provides periodically updated historical data on highway cost per centerline mile (for rural and urban roads of two through eight lanes), new bridge construction and bridge preservation cost per square foot, costs of traffic signals, right-of-way costs, engineering costs, and unit costs for bicycle and pedestrian facilities.

South Carolina
In 1987, the South Carolina DOT (SCDOT) implemented a Preconstruction Project Management System (PPMS), a set of procedures designed to help improve the effectiveness of the preconstruction process in dealing with complex interrelationship of projects, work activities, people, and funding. In December 2002, SCDOT issued a Primavera-based scheduling system, a more flexible and robust system that interfaces with their in-house resources and current scheduling software programs for scheduling SCDOT project preconstruction activities on a district and/or statewide basis.

The DOT handles project management and design, with support from consultants and with all working cooperatively via Primavera software. The Project Controls Unit has all the projects in the DOT’s five-year Statewide Transportation Improvement Plan loaded into Primavera. The project managers update their schedules using the dashboard in Primavera, and those schedules are submitted to Program Controls where are downloaded into Primavera. All consultants and contractors are able to access the dashboard and SCDOT houses all data in one database. Anything over $5 million is required to be done in Primavera. Contractors’ schedules must indicate pay items and line items, they must be resource loaded, and they have to produce a payout curve. SCDOT also relies on Primavera for documenting a history of where each project started, where it is currently, and where it will finish. What used to be a best guess has now become measurable data that allows the agency to forecast real numbers.

Primavera tracks each contract from the initial cost estimate through countless negotiations and final approval comments; cost proposals are tracked and managed using this system as the client and team members are always notified of all potential changes on a specific project. Upon the input of a new proposal, project managers can instantly review, evaluate, and assess impacts on their budgets by printing system generated cost analysis reports. Change orders are generated in the system.

Consistent, Easily Available Project Information, Archived History
Accurately estimating and matching projects with available funds is a core DOT challenge. According to our interviews, agency staff typically understand the need, importance, and ramifications of inadequate performance in this area, and DOT staff generally have embraced performance reporting. Virginia and Maine DOTs have implemented dramatic improvements to
their systems in this area. Several other states, including California, Washington, and Florida, are making major improvements.

- **Maine DOT.** When faced with budget pressures and the need for more accurate estimating, Maine DOT implemented a dashboard system aimed at improving the consistency and quality of project information and performance. The system allows users to drill-down by portfolio and project. Maine’s interactive tool allows project managers to quickly and easily keep track of a project’s status to ensure that projects are completed on time and within budget, fostering accountability. Maine DOT simultaneously implemented a Workplan Management System.

- **Virginia DOT** also identified better project information as essential for greater accountability and ease of project management. VDOT set out to develop an easily accessible repository of information for every project. Members of the cost estimation task force, along with staff from VDOT’s IT Applications Division, helped develop a new project Web site as an intranet-based repository to contain all information for every VDOT project. Staff can view estimates, plans, maps, documents, video, project cross sections, the names of project contacts (and how to reach them)—anything that is pertinent to the project—on the site. The site is searchable by project number and district and displays detailed information about individual projects, such as location, description, scope of work, project status, and project manager. An e-mail feature enables staff accessing the site to contact the project manager. VDOT designed all these features to enable staff to access critical information on any given project in a one-stop shopping format. Perhaps most crucial, the approach enables VDOT to maintain, save, and eventually archive the history of every project from cost estimates to environmental documents in one location.

- **Ohio DOT** also focused resources on improving project management and project development, although with less of a technological focus. The DOT developed a new Project Development Process (preliminary engineering, environmental clearance, design, right-of-way acquisition, and construction). Historically—in ODOT and other state DOTs—project delivery was plagued by inconsistency and delay. When first measured in 1998, Ohio DOT found that only 72 percent of projects were delivered on time. Today, ODOT delivers 90 percent of its projects on time, even though milestones are set years in advance, on planning level information. Consistent project delivery is a core business function and is a vital precursor to most other department goals.
5 Project Level

Cost management and estimate management at the project level involve many factors. Extensive literature from the last two decades support many findings relating to project management throughout the process:\textsuperscript{53}

- **Schedule Management**: Project Schedule Changes, particularly extensions, caused by budget constraints or design challenges can cause unanticipated cost escalation even when the rate of inflation has been accurately predicted. Two components of the issue are: 1) the inflation rate; and 2) the timing of the expenditures. Many DOTs have a fixed annual or biannual budget and project schedules must often be adjusted to ensure that project funding is available for all projects as needed. Estimators frequently do not know what expenditure timing adjustments will be made.

- **Scope Management** can lead to underestimation of project costs. Such changes may include modifications in project construction limits, alterations in design and/or dimensions of key project items such as roadways, bridges, or tunnels, adjustments in type, size, or location of intersections, as well as other increases in project elements. **Agency and Local Concerns and Requirements** typically include mitigation of project effects and negotiated scope changes or additions. Actions by the DOT are often required to alleviate perceived negative impacts of construction on the local societal environment as well as the natural environment, introducing changes to project design, alignment, and the conduct of construction operations. The steps that will be needed to accommodate and increase project acceptability to necessary levels among local residents, business owners, and environmental groups are often unknown during the early stages of project development and can be substantial in terms of cost and project scope. Projects can require very large mitigation investments.

- **Risk and Cost Management** relate to the above, as well as additional project management elements.

  - **Engineering and Construction Complexities** caused by the project’s location or purpose can make early design work very challenging and lead to errors and omissions in internal coordination among the often large number of disciplines frequently involved in the planning and design of a project. Constructability problems may also be encountered as the project develops. If these issues are not addressed in a timely fashion, cost increases are likely to occur.

  - **Market Conditions** or changes in the macro environment can affect the costs of a project, particularly large projects. Often only large contractors or groups of contractors can work or even obtain bonding for a large project. The size of the project affects competition for a project and the number of bids that a DOT receives for the work. Typically, the risks associated with large projects are much greater, both for the owner and contractor, which affects project costs. Inaccurate assessment of the market conditions can impact project cost estimating.

  - **Effects of Inflation/Escalation** is a key factor in the underestimation of costs for many projects. The time value of money can adversely affect projects when 1) project estimates are not communicated in year-of-construction costs, 2) the project completion is delayed and therefore the cost is subject to inflation over a longer duration than anticipated and/or 3) the rate of inflation is greater than anticipated in the estimate. The industry has varying views regarding how inflation should be accounted for in the project estimates and in budgets by funding sources. In the case of projects with short development and
construction schedules, the effect of inflation is usually minor, however, projects having long development and construction durations can encounter unanticipated inflationary effects. For example, the original project estimate, which was developed in 1982 and based on the FHWA guidelines in the Interstate Cost Estimate (ICE) manual, did not include inflationary factors relating to the final construction schedule for the project.

- **Inconsistent Application of Contingencies** causes confusion as to exactly what is included in the line items of an estimate and what is covered by contingency amounts. Contingency funds are typically meant to cover a variety of possible events and problems that are not specifically identified or to account for a lack of project definition during the preparation of early planning estimates. Misuse and failure to define what costs contingency amounts cover can lead to estimate problems. In many cases it is assumed that contingency amounts can be used to cover added scope and planners seem to forget that the purpose of the contingency amount in the estimate was lack of design definition. DOTs run into problems when the contingency amounts are applied inappropriately.

Attention to project management elements—risk management, cost management, schedule management, and scope management—can make project and estimate management jobs much easier. WSDOT noted the complexity involved in increasing the accuracy of cost estimates from planning through project delivery. The improvement progress requires educating many staff personnel on approaches to their work, well beyond merely following simple steps in a process. **Exhibit 10. Improved Cost Estimating and Estimate Management Interconnect with the Project Management Processes** illustrates the interconnections between improvements to cost estimating and estimate management in relation to the overall project management processes.

**Exhibit 10. Improved Cost Estimating and Estimate Management Interconnect with the Project Management Processes**

This project identified notable DOT practices in each of these project management areas, which are summarized in this section and in some cases, in the report appendices.
Notably, a number of DOTs have been making substantial investments to improve their internal project management systems. WSDOT’s effort has risen to $15 million in cost, including a team of expert project management consultants and a system that will primarily rely on Commercial-Off-the-Shelf (COTS) products. Virginia DOT has developed most of the agency’s information systems in house. Virginia DOT’s iPM system is an award-winning software application, developed in-house, that allows many users to log in to the program and work at the same time on various projects. It allows the project manager to track a project schedule instead of micromanaging the staff. Among the various aspects of project management, the system maintains each project’s schedule and controls access through a built-in security component. The system was created to be simple to use. Initial training was conducted using a video conference. On the small scale end of the spectrum, a South Dakota DOT representative said the agency has no project management office, but it does have a good central office project manager system. Assigned managers monitor more than 200 tasks and activities that comprise project development.

5.1 Risk Management

Risk management is more effective near the beginning of any process, but with cost estimating, the early project phase can be the most challenging because of the lack of project details. Risks are defined as uncertain events that have a positive or negative effect on at least one of the project objectives (scope, schedule, budget, quality). Risk management is the practice of dealing with project risk; the practice includes planning for risk, assessing risk, developing risk response strategies, and monitoring risk throughout the project life cycle.

In their research on cost overruns, both Pickrell\textsuperscript{54} and Flyvbjerg\textsuperscript{55} acknowledge that not all details and unexpected problems can be anticipated, but it is possible to forecast the likelihood that issues will be encountered based on experiences from other projects. They recommend increasing transparency of cost estimates and methods, use of performance specifications, and accountability.

According to the Federal Highway Administration (FHWA), “Risk management processes, tools, documentation, and communication are less standardized than any other dimension of transportation project management.”\textsuperscript{56} This was confirmed by many participants in the April 2008 Cost Estimation and Cost Management Process Workshop and in the interviews conducted for this study. Only a few state DOTs, including Caltrans and Washington State DOT, have established explicit risk management processes to incorporate risk management in their planning to increase the probability and impact of positive events (opportunities) and decrease the probability and impact of adverse events (threats) to project objectives. Other states are working on developing such resources.

Risk tolerance may diminish if a more certain outcome is preferred and more money is at stake. High impact/high probability risks may be tackled through avoidance, mitigation, or transference:

- **Avoidance**—Changing a project objective to eliminate the threat posed by an adverse risk event. For example, natural and cultural resources are avoided or unnecessary interchanges and associated impacts are occasionally dropped from plans, as on US 285 in Colorado. In planning for expansion of California’s I-710, from the Ports of Los Angeles and Long Beach, the diesel emissions effect on an Environmental Justice community were reduced by
changing the goals, purpose and need, and scope of alternatives to be considered and mandating the inclusion of rail.

- **Mitigation**—Reducing the probability or impact of a risk to an acceptable threshold. For example, in its S-curve reconstruction in downtown Grand Rapids, Michigan DOT opted to close off the major downtown access route. To mitigate the economic, social, and public relations risks, MDOT assigned an internal communications specialist to maintain consistent, full-time community relations, news appearances, and other outreach activities for the project. MDOT also used support from a public relations firm.

- **Transference**—Shifting the negative impact of a threat, along with the ownership of the response, to a third party. For example, in the MDOT S-curve renovation, the agency turned to the local transit authority to move citizens instead of managing access through the construction site; the local transit authority planned extensively for the bridge closure, with cooperation and partial funding from MDOT, and introduced new services to accommodate the increased need for transit during construction. Transit authority staff visited businesses to explain the detour planning. The closure ran smoothly and the project was a success, from collaborative design through completion. In a Eugene, Oregon DOT project on the Beltline interchange, ODOT and FHWA used an innovative intergovernmental agreement to shift project design responsibilities to the City of Springfield to reconcile local preferences with federal standards. More often, DOTs transfer risk to the future. For example, in the US 285 case in Colorado, the issue of induced growth and potential future transit need was explicitly left to be addressed in 20 years. In another example, with the state- and agency-funded Ecosystem Enhancement Program, NCDOT has transformed some of its land management risk into opportunity for partner agencies and conservation organizations that sought such environmental investments and had the organizational infrastructure and experience to manage lands in perpetuity.

In the project interviews, several state DOT representatives indicated in the interviews a desire to, as a PennDOT representative said, “get a better handle on understanding risk management on projects.” A Maryland SHA staff person thought “using a risk-based approach to cost estimating will be the easiest to try to implement (improvements to the cost estimating and estimate management process), and also provide a way to get the most improvement without changing around the whole process.” Like many, an Ohio DOT representative indicated interest in risk assessment and risk management, but said the agency was constrained by resources to devote to the task.

With some projects, DOTs take exceptional steps to plan for risk avoidance and minimization. Some agencies incorporate stakeholder interviews to minimize risk and understand project issues.

**In-depth Scope Exploration.** For example, in New Jersey on the Route 31 project, the project team conducted one-on-one interviews with stakeholders such as property owners, developers, interest groups, and local governments (both elected officials and technical staff). These interviews provided valuable insights into site-specific development issues and the interests of local jurisdictions on the proposed bypass project. The NJ Route 31 project team also created an advisory group that included representatives from NJDOT, FHWA, local governments, and local business associations. To facilitate both the stakeholder interviews and advisory group meetings, the project team held multiple-day design workshops. These workshops, which included stakeholder interviews, site visits, and working sessions, created a studio environment that helped the project team test design ideas and continue to learn about local priorities and issues, minimizing the DOT’s risk later in the process of being off base with community preferences. Such extensive efforts can sometimes increase costs, but such approaches also increase predictability with regard to final project budgets and can, as in this case, eliminate the need for more expensive solutions such as the bypass originally envisioned.
Commitment tracking through Design and Construction help avoid costly surprises. On its massive Woodrow Wilson Bridge and Inter County Connector projects, Maryland State Highway Administration’s construction commitment tracking systems functioned as registers for risk monitoring and control through the design and construction phase of the project. On the Woodrow Wilson Bridge project, an onsite coordinator tracked 1,400 project commitments that affected all resources, until a risk was retired or no longer a threat. Such commitment tracking or risk reporting was a standing agenda item at project team meetings.

Proactive mitigation planning. On the Woodrow Wilson Bridge project, MDSHA and project partner VDOT were also proactive in planning offsite mitigation of environmental impacts, effectively avoiding threats and risks of prolonged delay from lack of interagency agreement, environmental non-compliance, and possible project work stoppages or lawsuits. When environmental violations were alleged in one case, the allegations were dropped when MDSHA’s responsiveness to the issues in question were amply demonstrated through the agency’s commitment tracking and risk management system. More manageable, low probability risks can be dealt with by active acceptance through a contingency reserve to handle the risk, or by working through low impact or low probability issues as they arise. Oregon’s Collaborative Environmental and Transportation Agreement for Streamlining (CETAS) project and Colorado’s Shortgrass Prairie Initiative are other well-known examples of proactive mitigation planning which increased predictability of project costs and saved time.

Better estimates and costs control will rely on process changes and controls as much as on gaining estimating and estimate tracking tools and skills. The following list cites some better practices that are already helping DOTs diminish uncertainty:

- Describe the scope of solutions for all issues early in project development.
- Evaluate the quality and completeness of early cost estimates.
- Identify major areas of variability and uncertainty in project scope and costs.
- Track cost impacts of design development at steps between major cost estimates.

A DOT’s ability to manage and address issues in a timely fashion increases as the staff can draw on and update information about environmental costs at points throughout the transportation planning, project development and design, and construction processes.

5.1.1 Developing and Managing Contingency Costs

An important factor in risk management is the identification of the amount of contingency and the circumstances for applying contingency funds; however, most DOTs admit they need a better process for developing and documenting contingencies early in planning and, just as important, managing the contingencies through construction.

The definition of “contingency” and the use of contingencies vary widely across the country. Some agencies limit the use of contingency costs for unpredictable, unforeseeable problems during construction or to cover the cost of inflation in the price of materials on large projects that take years to complete. Others include a high contingency in the PS&E package to account for a change in scope, missed line items, or unresolved right-of-way, environmental, utility, and traffic issues. In addition, stakeholders outside the agency, for example contractors, local governments or special interest groups, may view contingency funds as a slush fund to provide project enhancements that go beyond the purpose and need for the project. Problems with contingency funds can be mitigated through consistent application of contingencies, documentation of assumptions, and cost tracking at project milestones.
A more common practice is to begin with a high contingency at the conceptual planning phase and, as more design detail becomes known, the contingency is eventually reduced to zero percent by project advertisement. Exhibit 11. Ohio DOT Project Development Process Design Completion Risk Graph to Cost Estimate Major Projects shows Ohio DOT’s Project Development Process (PDP) Design Risk Graph to illustrate contingency as it changes throughout design stages, ranging from 25 to 35 percent at earliest conceptual planning to zero contingency at PS&E.

Now that the South Dakota DOT has additional staff, the agency monitors contingency factors in preliminary engineering and construction engineering, and contingency adjustments are used only for unknown issues. As detail is developed, the estimate improves in precision and contingencies decrease to zero at the final estimate.

The New Jersey DOT uses its Cost Estimating Guidelines with a contingency and escalation form that steps an estimator through determining contingency costs based on whether the project is new construction or reconstruction; the type of project, such as resurfacing, widening, or bridge repair; the length of the project; and the duration to mid-point of construction. Virginia DOT uses contingency funds for unforeseen field conditions such as unidentified utilities or increases in fuel or steel costs.

To account for unknowns throughout the design process, the Maryland DOT applies the following contingencies or contingency ranges to construction cost estimates:\(^5^8\)

- Planning and Concept Development Phase—30 to 40 percent
- Public Involvement Phase—25 percent
- Semifinal Phase—15 percent
- Final Review—5 to 10 percent
- PS&E—0 percent

WSDOT offers guidance on the development and management of contingency costs, although some procedures are still being discussed. For example, the agency is still considering if contingency costs are based on project-specific risks. For now, at least on large projects, contingency cost evaluation is based on project-specific risks.

Montana DOT defines contingency as “...an unintended or unlikely event that may occur for which project funds should be allocated.”\(^5^9\) Contingency is assigned to the identified issues that likely will occur with unknown costs. When developing the detailed cost estimate, a 15-percent contingency is assumed for the initial estimate. This percentage is reduced to 5 percent for the final estimate; funds are not used to account for inflation. This process has helped the agency better estimate contingencies.
The New Mexico DOT assigns a 3 to 4 percent contingency to a project at the completion of the final estimate to account for change orders in the field. The agency is rethinking the process to better manage scope creep.

The Utah DOT requires contingencies to be in place at different points in the project development process, but the agency recognizes the need to better define where contingencies are used and the amount that needs to be included (up to 20 percent in urban areas). At concept planning, the agency uses bulk contingencies because project details are unknown. At the final estimate, the contingency is 10 percent on new projects and reconstruction projects and 5 percent for preventive maintenance. The agency notes that defining the contingencies continues to be a challenge.

5.1.2 Cost Indices

DOTs have battled enormous construction cost increases for several years. High energy prices, overseas demand, and disaster recovery efforts such as hurricane Katrina have exacerbated already high demand for steel, Portland cement, and petroleum based products. DOTs have responded by trying to minimize the risks in estimating and construction cost control by developing construction cost indices, including the following:

- American Road and Transportation Builders monthly and annual construction material price reports. (www.artba.org/economics_research/recent_statistics/prod_price_index)
- Caltrans Construction Cost Indices (www.dot.ca.gov/hq/oppd/costest/EngCostEstForecastTool.xls)
- Colorado Construction Cost Index and Quarterly Cost Data for Construction and Maintenance, CDOT Market Analysis Branch (www.dot.state.co.us/App_eema_cdb/)

WSDOT’s Construction Cost Index is updated quarterly based on bid data tracked since 1990 on seven materials categories including, crushed surface materials, concrete pavement, structural concrete, hot-mix asphalt, steel reinforcing bar, structural steel, and roadway excavation. WSDOT tracks its CCI against that of the FHWA and of California, Colorado, Oregon, South Dakota, and Utah. It also checks its CCI against the quarterly updated CCI in Engineering News-Record: http://enr.construction.com/features/confEco/subs/default.asp. (On its Asset Management pages, FHWA recommends the use of ENR’s construction cost index; see http://www.fhwa.dot.gov/infrastructure/asstmgmt/primer03.htm.)

5.1.3 DOT Risk Management Approaches

In recent years, several state DOTs have demonstrated notable success at cost-effectively meeting these performance objectives, despite stagnant revenues, increasing costs (especially asphalt, concrete, and steel), and heightened public expectations. The following select examples summarize some notable approaches.
Washington State

WSDOT decided it needed a better way to estimate and plan for risk associated with proposed projects. WSDOT did this by developing a Cost Estimate Validation Process (CEVP®). WSDOT’s CEVP entailed bringing together about 15 experts—primarily internal to the agency and usually with little knowledge of the given project—for 2 to 3 days to review the base cost estimate for a current project. Experts could also conduct a cost risk assessment (CRA), which is less intense than a CEVP, by assigning a project cost and a probable dollar risk to each item. Based on these assignments, the team of experts completed a Monte Carlo simulation to generate a probability distribution for cost and schedule. The agency implemented a CEVP for nine of its largest projects, and then publicly communicated the results to highlight knowledge gaps.

WSDOT’s approach considered the following risk elements:

- Time (inflation, materials shortages)
- Funding (not usually available all at one time)
- Demand on labor (from outside influences)

WSDOT successfully and quickly reviewed available information about projects, and estimated how potential risks might affect the actual cost after a project was implemented. According to NCHRP 8-36-(72) interviews, WSDOT liked the results so much that, within a few years, the agency applied this cost estimation process to all of its major projects. WSDOT now requires that all projects undergo a CRA or a CEVP. Depending on the magnitude of risk, the agency conducts the analysis in early planning stages or as late as right before bid. CEVP and CRA results help project communication, development of risk management strategies, analysis of project alternatives, and project management. Additional detail of WSDOT’s risk assessment process and available tools and templates are available at www.wsdot.wa.gov/Projects/ProjectMgmt/RiskAssessment/ and included in Appendix O.

MoDOT reported it uses a process similar to WSDOT’s assessments, but it uses different terminology.

WSDOT tries to eliminate risk elements in contracts by subjecting bids to unit price adjustments from time-of-bid base bid costs. In its toolbox for management of materials-related inflation in construction are:

- Time bids to hit cost windows
- Grant flexibility to contractors to encourage seeking of economic value
- Offer early payment provisions to lock in material prices close to bid time
- Cost reduction incentives
- Adjust project scope to limit materials needs
- Cancel projects that materials inflation has made too expensive

Caltrans

DOT project delivery performance is judged on quality, adherence to schedule, and being within budget. Caltrans’ Risk Management Handbook outlines a process project managers can use to manage risk and meet project delivery goals.60

At Caltrans, the project management team completes a Risk Management Plan when the project is initiated. The plan is monitored and updated throughout the life of the project. Caltrans requires project managers to maintain scope, cost, and schedule estimates in a permanent project history file, which is updated annually, at project milestones, or when significant changes occur between
milestones. This documentation must accompany any program change requests sent to the Headquarters Division of Project Management.

Caltrans’ risk management process includes six steps:

- **Risk management planning** is the development of a Risk Management Plan for potential risk identification and development of a strategy to manage the risks. Caltrans uses a standard template that includes methodology, roles and responsibilities, budgeting, timing, risk categories, definitions of risk probability and impact, probability and impact matrix, reporting formats, and tracking to be used with the handbook. The template is available at [www.dot.ca.gov/hq/projmgmt/guidance.htm](http://www.dot.ca.gov/hq/projmgmt/guidance.htm).

- **Risk identification** is the documentation of risks that might affect a project. The process, which uses input from internal and external stakeholders, is iterative; it evolves as the project progresses. Caltrans provides tools to help identify risks, such as a sample risk breakdown structure by project components—environmental, design, right-of-way, construction, external, organization and project management—and a list of risks by component.

- **Qualitative risk analysis** prioritizes risks for further action. After the risks are identified, the team assesses the probability and impact of the risks and categorizes them into high, moderate, and low risk based on the potential effect on schedule, cost, scope, or quality. The risks are then ranked by degrees of probability and impact.

- **Quantitative risk analysis** uses statistical techniques to estimate the probability that a project will meet its cost and time objectives. The analysis shows how likely the plan is to come in on schedule or on budget; how much contingency of time or money is needed; and which activities or line-item cost elements contribute the most to the possibility of overrunning the schedule or cost estimates.

- **Risk response planning** develops options to reduce or avoid risks and assigns responsibility for implementing the risk management strategy and monitoring the risk over time.

- **Risk monitoring and control** keeps track of identified risks, residual risks, and new risks over the life of the project. It also monitors the execution of planned strategies and evaluates their effectiveness.

Caltrans is committed to using a project management system, including risk management, to ensure that individual projects are delivered on time and within budget. The director delegated responsibility for project delivery to the district directors, and the deputy director of finance has responsibility for approving changes in project scope, cost, and schedule. Only the state Transportation Commission can change the programmed cost and programmed fiscal year for projects in most programming documents.

Additional recommendations that Caltrans developed after a recent study of consultant and internal cost estimates also minimize risks:

- More frequent updates to estimates (implemented by Department memo).

- Base Caltrans Construction Cost Data on the average of the unit prices from the 3 low bids received, excluding obvious “flyers,” as Structures OE does for their data for bridge items. This provides more stable estimates of unit costs, removing business decisions and bidding techniques of the contractors outside the purview of an estimate. Long term, if this provides unit costs higher than those being submitted as low bids, adjustment factors will be more clearly identifiable.
In the Caltrans Construction Costs Data, provide additional average unit prices for Roadway Excavation, Aggregate Base, Asphalt Concrete, and Portland Cement Concrete Pavement, based on relative quantity groupings.

For multi-year projects, project unit price estimates to the middle of construction of the contract item, considering staging and construction sequence.

**Florida**

Florida DOT uses the Caltrans’ risk analysis method, but FDOT also developed a risk-based graded approach—a quick process to identify the overall risk value of a project, and the Project Risk Register—a formal risk analysis using input from internal and external stakeholders for complex and risk-prone FDOT projects. Similar to the WSDOT assessment, the first step in the FDOT method is development of a Risk Management Plan to identify and document potential project risks. The types of risk shown in **Exhibit 12. Risk Types Covered in a FDOT Risk-Based Graded Approach Analysis** are used as a starting point, but the assessment is adapted to reflect individual project conditions.
Exhibit 12. Risk Types Covered in a FDOT Risk-Based Graded Approach Analysis

<table>
<thead>
<tr>
<th>TECHNICAL RISKS</th>
<th>ORGANIZATIONAL RISKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preceding phase project deliverables are incomplete</td>
<td>Inexperienced staff assigned</td>
</tr>
<tr>
<td>Preceding phase reports/plans are in error</td>
<td>Lack of staff assigned to the project</td>
</tr>
<tr>
<td>Right of way studies are not accurate</td>
<td>Loss of critical staff at critical point in project</td>
</tr>
<tr>
<td>Environmental analysis is incomplete or in error</td>
<td>Insufficient time to plan project</td>
</tr>
<tr>
<td>Unexpected geological issues</td>
<td>Unanticipated Project Manager workload</td>
</tr>
<tr>
<td>Inaccurate design assumptions in PD&amp;E Report</td>
<td>Delays getting approvals and decisions</td>
</tr>
<tr>
<td>Surveys are late or are in error</td>
<td>Support units unavailable or overloaded</td>
</tr>
<tr>
<td>Geotechnical reports in error</td>
<td>Changed priorities</td>
</tr>
<tr>
<td>Hazardous waste analysis incomplete or in error</td>
<td>Project under-funded</td>
</tr>
<tr>
<td>Need for design variations or exceptions</td>
<td>Inconsistent project goals (objectives, schedule, budget and quality)</td>
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<tr>
<td>Context sensitive solutions create design delays</td>
<td></td>
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</tbody>
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<table>
<thead>
<tr>
<th>EXTERNAL RISKS</th>
<th>PROJECT MANAGEMENT RISKS</th>
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</thead>
<tbody>
<tr>
<td>Right of way delays as a result of court actions</td>
<td>Project need and purpose poorly defined</td>
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<tr>
<td>Changed priorities</td>
<td>Project scope is poorly defined or incomplete</td>
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<tr>
<td>Local communities or groups pose objections</td>
<td>Selection of a poor consultant or subconsultants</td>
</tr>
<tr>
<td>Funding changes</td>
<td>Selection of a poor contractor</td>
</tr>
<tr>
<td>Political factors change</td>
<td>Project Manager does not have control over staff priorities</td>
</tr>
<tr>
<td>Stakeholders request late changes</td>
<td>Too many projects</td>
</tr>
<tr>
<td>New stakeholders emerge with new demands</td>
<td>Estimating and/or scheduling errors</td>
</tr>
<tr>
<td>Influential interests raise objections</td>
<td>Poor communication within the team</td>
</tr>
<tr>
<td>Lawsuits to halt or change the project</td>
<td>Unrealistic schedule</td>
</tr>
<tr>
<td>Pressure to choose time over costs or quality</td>
<td>Changed schedule</td>
</tr>
<tr>
<td>Delays in agreements with local agencies, railroads, etc.</td>
<td>Lack of coordination among support units</td>
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<tr>
<td>Utility relocation delays</td>
<td>Lack of management support</td>
</tr>
<tr>
<td>Permitting issues</td>
<td>Changes in key staff members</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>ENVIRONMENTAL RISKS</th>
<th>PROJECT MANAGEMENT RISKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delays in permit approval</td>
<td>Many of the above issues will apply to the consultant as well, however consultant Project Managers must also address risk as it applies to profitability. Some unique risks for a consultant Project Manager may include:</td>
</tr>
<tr>
<td>Changed requirements for permits</td>
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<tr>
<td>Changes in environmental regulations</td>
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</tr>
<tr>
<td>Reviewing agencies require higher-level review than expected</td>
<td></td>
</tr>
<tr>
<td>Lack of specialized staff to perform environmental analysis</td>
<td></td>
</tr>
<tr>
<td>Unidentified special-interest sites discovered (historical, endangered species, etc.)</td>
<td></td>
</tr>
<tr>
<td>Environmental class of action changes</td>
<td></td>
</tr>
<tr>
<td>Public controversy arises over environmental issues</td>
<td></td>
</tr>
<tr>
<td>Change in alignment requires new environmental analysis</td>
<td></td>
</tr>
<tr>
<td>Section 4(f) lands become involved</td>
<td></td>
</tr>
<tr>
<td>Pressure to compress the schedule for environmental analysis</td>
<td></td>
</tr>
</tbody>
</table>

A risk-based graded approach analysis quantifies project risks early in project development and helps determine planning and control requirements; however, the assessment is not used as a
FDOT’s risk-based graded approach analysis helps:

- Determine where to assign limited PM resources
- Define the project scope
- Evaluate risk elements (risk versus cost)
- Get agreement from all members of the project team

FDOT identified 15 critical risk elements (other risks can be added or some eliminated) to assess the overall level of risk, per element, per project priority (i.e., scope, schedule, cost, and quality). The project team assigns each element a value between 1 and 5. The risks are then prioritized, based on the scores, and assigned a value of 1, 3, or 5. The total risk score is calculated by multiplying the risk scores by the priority scores for each of the 15 elements. The risk element scores are totaled to determine the overall project risk score. Exhibit 13. FDOT Risk-Based Graded Approach Worksheet illustrates a sample worksheet.

Exhibit 13. FDOT Risk-Based Graded Approach Worksheet

<table>
<thead>
<tr>
<th>ITEM</th>
<th>RISK ELEMENT</th>
<th>RISK ASSESSMENT</th>
<th>PRIORITY</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Utility Involvement</td>
<td>1</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>Project Schedule</td>
<td>5</td>
<td>5</td>
<td>25</td>
</tr>
<tr>
<td>3</td>
<td>Interfaces</td>
<td>3</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>Experience/Capability</td>
<td>3</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>5</td>
<td>Right-of-Way Involvement</td>
<td>5</td>
<td>5</td>
<td>25</td>
</tr>
<tr>
<td>6</td>
<td>Environmental Impacts/Contamination</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>Regulatory Involvement</td>
<td>3</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>8</td>
<td>Contractor Issues</td>
<td>5</td>
<td>3</td>
<td>15</td>
</tr>
<tr>
<td>9</td>
<td>Resource and Material Availability</td>
<td>3</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>10</td>
<td>Project Funding</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>11</td>
<td>Political Visibility</td>
<td>3</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>12</td>
<td>Public Involvement</td>
<td>3</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>13</td>
<td>Safety</td>
<td>3</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>14</td>
<td>Construction Complexity</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>15</td>
<td>Weather Sensitivity</td>
<td>3</td>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>

Risk Score: 137

Source: FDOT Project Management Handbook

After the project management team prioritizes potential risks using the qualitative risk analysis described above, the effect of those risks can be quantified. The qualitative risk analysis prioritizes the risks and assigns a cost in dollars if the risk occurs. Techniques for quantifying risks include interviewing stakeholders to determine probabilities and impacts, sensitivity analysis, decision tree analysis, and simulation (i.e., Monte Carlo technique).
Finally, a risk response plan assigns one of the following strategies for each risk, considering the risk priority:

- Change the project plan to eliminate or avoid the risk.
- Change the scope of a proposed or existing contract to transfer the risk to a consultant, contractor, or insurance company.
- Mitigate the risk to reduce the probability and impact of a risk to an acceptable level.
- Accept the risk.
- Select a strategy that has the best cost-benefit.

Exhibit 14. FDOT Risk-Based Graded Approach Worksheet illustrates a sample FDOT risk response plan.

### Exhibit 14. FDOT Risk-Based Graded Approach Worksheet

<table>
<thead>
<tr>
<th>Risk</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>High Priority Risks</strong></td>
<td></td>
</tr>
<tr>
<td>Local communities will pose objections</td>
<td>Include a well prepared community action plan in the consultant scope and ensure consultant devotes adequate staff in negotiations.</td>
</tr>
<tr>
<td>Delay in railroad agreement</td>
<td>Begin negotiations with railroad early in the project and ensure adequate consultant support is available.</td>
</tr>
<tr>
<td>Unanticipated project manager workload</td>
<td>Request that an assistant P.M. be assigned to the project. Work closely with Professional Services to ensure the consultant selection process results in a consultant that can be expected to produce with minimum oversight by the FDOT project manager.</td>
</tr>
<tr>
<td><strong>Intermediate Priority Risks</strong></td>
<td></td>
</tr>
<tr>
<td>Selection of an inexperienced consultant</td>
<td>Follow recommendation in response for unanticipated project manager workload.</td>
</tr>
<tr>
<td>Aggressive schedule</td>
<td>Review schedule before finalizing consultant scope and revise if necessary.</td>
</tr>
</tbody>
</table>

### Utah

In Utah, project managers have always been responsible for the project scope, schedule, and budget. The responsibility is not regimented, and managers are not told how to assume risk or value risk. Rather, they have discrete tools for the estimating process, project management guidelines, and internally developed software (Electronic Program Management) to show them what is expected. UDOT’s Red Flag Analysis is a type of risk management and is used to account for the many factors that affect a project’s cost and help the engineer develop the estimate. The Red Flag Analysis tailors the estimate to specific project characteristics to assist in achieving an awardable estimate. The analysis suggests raising or lowering the engineer’s estimate to address the current bidding environment.
Based on historical data, certain characteristics, if present, are identified as a red flag to increase the estimate 2.5 percent or a negative red flag to reduce the estimate by 2.5 percent. Following are some of the characteristics:

- Pavement preservation projects are simple and straightforward, and are assessed a negative flag.
- Bike or pedestrian projects are assessed a red flag because bids are historically higher than estimated.
- Local government projects can be more complex due to size and increased number of project stakeholders and are red flagged.
- Projects in remote locations increase the cost of hauling and materials and are assessed a red flag.
- Strict schedules that prevent contractor flexibility increases project costs and are red flagged.
- If minimal contractor interest is expected, costs increase and the project is red flagged.
- Projects advertised in the winter months receive more awardable bids per project because contractors look for work in the upcoming season. Projects advertised in the winter months receive a negative red flag.

Cost sensitive materials, specialty items, and non-bid items are also assessed a 2.5 percent increase in the estimate. The Red Flag Analysis software sums the red flags, and the sum of the red flags represents the suggested total adjustment; the decision remains up to the engineer to use judgment in the final analysis.

Wisconsin

Wisconsin DOT publishes summary output from its cost estimating validation process on its public Web site. Additional information about the status of each major construction project also appears on the Web site. The Web site shows a project description and benefits, any assumptions made to adjust estimates, cost probability ranges, and major risk factors. In addition, some unknown factors that could increase the cost of the project are also shown. A team of public and private sector experts reviews the costs periodically and adjusts them as project information emerges.

FHWA

The FHWA training course, “Addressing Uncertainty in Cost Estimating,” provides an overview of current cost estimating practices for highway projects, including consideration of risk and uncertainty in project cost estimates, and a segment on the importance of cost estimating. The course specifically addresses cost estimating for large and complex projects, but the concepts presented are applicable to developing estimates for all types of transportation projects. Among other things, the course teaches participants how to conduct preconstruction or early cost estimating to quantify the likelihood of risk events and determine how the results could trigger a cost increase or delay in a project.

5.1.4 Auditing

Some DOTs are conducting internal audits of cost estimates to understand where improvements or refinements to the process are needed. Missouri and Ohio DOTs are two examples of agencies that have implemented rigorous auditing processes for estimates. The Missouri DOT audit process and central office design liaisons, which audit files throughout the estimate process.
Missouri DOT has identified its auditing process as similar to that described by Washington for risk management, but using different terminology.

Ohio DOT has conducted one round of quality assurance reviews (QARs) with districts. The reviews involved consultants; districts are ultimately responsible for the cost estimate, even if a consultant performs the work. Consultants are required to use the same software as the DOT uses. When consultants complete their estimates, they send them to the districts for review. The first round of audits in Ohio surveyed major projects or jobs in progress to ensure districts follow the new cost estimating procedures. In the next round, which is half completed, the survey is identifying four to six projects per district to review for project estimates. The objectives are to pick projects in various design phases and give the districts minimal lead time to prepare in order to get an honest sampling. The process has produced an extra benefit because districts and consultants understand the high-level scrutiny and focus on estimating; they more often contact headquarters for expertise and support on unique scenarios rather than attempting the estimate independently.

Caltrans began to develop improved practices for review of consultant’s estimates in 2005, when the California Transportation Commission (CTC) became concerned with what they observed as a significant increase in the number of requests made for Supplemental Funds. They were concerned that, beyond the recent dramatic increases in the costs of cement and steel, the Department’s estimates were not adequately projecting construction costs. In response, the Department agreed to review its estimating practices, including comparing its practices and results with those of its consultants. In a study of variation, Caltrans found that the most common contract items that varied were: Time Related Overhead, Traffic Control, Earthwork, Aggregate Base, pavement, Concrete, Concrete barrier, and Mobilization.

### 5.2 Schedule Management

Schedules are developed for all projects with varying levels of detail. State DOTs are devoting increased attention to actively managing project schedules. Schedule delays affect not only the agency’s credibility with the public, but they also usually experience increased costs. It can be extremely difficult for an estimator to predict the effect schedule uncertainties have on the final estimate. A commonly expressed concern is that overly aggressive and unrealistic schedules often result in errors and delays later in the process. Taking the time up front to develop the details can result in a better cost estimate, a more realistic schedule, and increase success in delivering a project on time. **Exhibit 15. Project Schedule Tracking and Benchmarking Methods** identifies schedule tracking and benchmarking methods used by different state DOTs.

Florida DOT’s *Project Management Handbook* devotes an entire chapter to schedule management. The Handbook provides guidance on how to develop a schedule, monitor the schedule, and make corrections as needed. It also emphasizes the importance of developing and executing a project schedule with sufficient detail to identify clearly the critical path items to anticipate problems. If issues arise, the Handbook suggests developing a strategy for corrective action to mitigate and eliminate potential problems before they affect the schedule. The handbook notes that schedule management, “helps to manage the dollar commitment for each stage of the project.” A detailed schedule also helps the project manager allocate adequate funds for each phase of the project. The manual is available at [www.dot.state.fl.us/projectmanagementoffice/PMhandbook/pmhandbookindex.htm](http://www.dot.state.fl.us/projectmanagementoffice/PMhandbook/pmhandbookindex.htm)
5.3 Scope Management

Project scoping process improvements were important in a number of states that showed impressive results in cost estimating and estimate management. Defining the scope of a project early in planning is a challenging endeavor in any organization because the decisions made during the scoping process—the design of the project, the project budget, and the project schedule—are initial estimates that are prepared with only minimal information. In the opinion of at least one respondent, such scoping should involve full participation from all professional disciplines and outside input from local political officials.

Scoping is defined as a process to develop a project’s purpose and need, cost estimate, budget, schedule, and extent. Project tasks are identified using the project tasks and scheduling guidelines and a project schedule template. The schedule is built in the Integrated Project Manager (iPM) system or MS Project using input from team members. The project manager and project team review and update the schedule at a minimum of every 90 days, at each project milestone, or more frequently as needed. The review includes documentation of variances and related adjustments.

Virginia DOT’s project management procedures include development of a project schedule. The project manager is responsible for the development and maintenance of the project schedule with collaboration and support from the project team. Project tasks are identified using the project tasks and scheduling guidelines and a project schedule template. The schedule is built in the Integrated Project Manager (iPM) system or MS Project using input from team members. The project manager and project team review and update the schedule at a minimum of every 90 days, at each project milestone, or more frequently as needed. The review includes documentation of variances and related adjustments.

Exhibit 15. Project Schedule Tracking and Benchmarking Methods

<table>
<thead>
<tr>
<th>Program Delivery/Advertising on Schedule</th>
<th>DE, IA, ID, KY, MD, NE, MO, NE, PA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number or percent of programmed projects let or advertised according to schedule (same fiscal year). Subdivisions in this category include:</td>
<td></td>
</tr>
<tr>
<td>5-year program (NE)</td>
<td></td>
</tr>
<tr>
<td>1-year program (DE, IA, ID, KY, MN, MO, NM, NE, PA)</td>
<td></td>
</tr>
<tr>
<td>Percentage of projects going to construction phase in 90 days/quarter of target date or original posting (NM, OR, SC)</td>
<td></td>
</tr>
<tr>
<td>90 percent of projects advertised in 30 days of original date or avoid delaying bid opening more than 30 days (MD)</td>
<td></td>
</tr>
<tr>
<td>Percentage of dollars delivered as programmed (OH, MO)</td>
<td></td>
</tr>
<tr>
<td>Percentage of projects awarded (NE)</td>
<td></td>
</tr>
<tr>
<td>Other additions:</td>
<td></td>
</tr>
<tr>
<td>Percentage of projects awarded (NE, UT)</td>
<td></td>
</tr>
<tr>
<td>Percentage of projects with a cost estimate at least $500,000 bid on or before scheduled bid opening date (LA)</td>
<td></td>
</tr>
<tr>
<td>Percentage of non-state–owned road, bridge, and transportation enhancement projects meeting targeted letting year</td>
<td></td>
</tr>
<tr>
<td>Number of Hometown Streets projects committed vs. delivered</td>
<td></td>
</tr>
<tr>
<td>Number of Safe Routes to School projects committed vs. delivered</td>
<td></td>
</tr>
<tr>
<td>Percentage of projects delivered or completed on time</td>
<td>DE, MO, TN, VA</td>
</tr>
<tr>
<td>Percentage of contracts completed (i.e., Letter of Final Acceptance issued) by the end of the fiscal year following the project completion date</td>
<td>AK</td>
</tr>
</tbody>
</table>
Methods for producing preliminary cost estimates vary widely across state DOTs, especially in consideration of environmental costs. For example, Indiana’s Cost Estimation Guidance says about environmental costs only that “expected environmental problems” such as hazardous materials or wetland mitigation should be taken into account.\(^6^9\) WSDOT, Caltrans, Florida, Minnesota, and Maine DOTs have more detailed processes, as described in this section (1.1.3).

The process before scoping formally begins has received attention in the form of an emphasis on initial scoping activities, such as learning what type of opposition may arise for a particular project, establishing expectations with interested parties before the scoping meeting, and ensuring a clear project purpose has been stated (e.g., to decrease run-off-the-road accidents on a two-lane facility by improving horizontal alignment and shoulder width as funding allows).\(^7^0\)

NCHRP project 8-49 report 574 states that many DOTs use scoping documents early in the project development process to identify and specify critical design elements. These documents create a baseline scope for the project and any changes in the scope are measured against this baseline-scoping document. The following sections provide examples from seven states with scoping guidelines and tools that other states can adapt to meet their particular program.

### 5.3.1 Importance of Scoping

The importance of taking the time up front to identify accurately the scope of a potential project cannot be understated. A robust scoping effort will lay a solid foundation to keep internal and external stakeholders focused on solving the transportation problem and minimize scope and schedule creep. As important as this first step is, many DOTs reported that they do not do scoping until the NEPA process begins; frequently the DOT and other agencies lack the resources to devote the time up front, although it can save a lot of time and money in the long term.

One VDOT district respondent expressed the need for intense and complete scoping of each project as “the only way to obtain a truly accurate (or at least the best possible) estimate.” Good project scoping will improve the agency’s credibility with the public when actual construction costs are more consistent with programmed cost estimates. Most states use the results of the scoping process in project programming to prioritize projects for funding in the next budget request to the legislature.\(^7^1\)

Some of the benefits of a sound scoping process are:

- Better cost estimates
- Alignment with performance goals
- Less rework
- Predictable delivery schedule
- Greater public trust
- Improved coordination with partners
- Everybody on the team working toward the same goal

Better data collection and compilation of lessons learned are helping DOTs address some major cost estimation challenges, especially those related to environmental matters:

- Describe scope solutions for all issues early in project development.
- Evaluate the quality and completeness of early cost estimates.
- Identify major areas of variability and uncertainty in project scope and costs.
- Track cost impacts of design development that occur between major cost estimates.

5.3.2 Planning — The Beginning of the Scoping Process

The Scoping Process reaches back into Planning, where cost estimates are used for project justification, analysis of alternatives, approval, and for programming. The initial programmed cost appears the first time a project is listed in the STIP. The project scoping process goal is to have a well-defined project with a reliable cost estimate and delivery schedule before it appears in the STIP. This requires that each project be scoped comprehensively. As one DOT noted, “scope management = cost management.”

At the national workshops on cost estimating and estimate management in November 2007 and April 2008, DOTs pointed to planning level estimating and scoping as two of their greatest challenges. Earlier studies support this perception. For example, when the Virginia Commonwealth’s Auditor of Public Accounts (APA) completed a review of VDOT’s internal processes affecting estimating, the Auditor concluded: “Transportation should develop and employ a more rigorous cost estimation process, and allocate more resources (front loading) to the development of cost estimates during the planning process.” A connection and continuity needs to be built between long range planning estimates, work plan estimates, and design estimates. Some DOTs are doing more detailed design work earlier and earlier in the process and initial estimates take into account big-ticket items earlier, including such things as:

- Utility identification and design
- Environmental mitigation
- Stormwater management
- Right-of-way
- Traffic control

Identifying cost estimating functions in planning is a particularly challenging area for some DOTs, including such issues as:

- **Determining estimate basis**—Define the project type and review planning documents, drawings, project complexity, unique characteristics, project parameters, and point A to B needs.
- **Preparing the base estimate**—Know the project elements, project definition, project conditions, and the available and appropriate estimating tools or techniques.
- **Determining risk and set contingency**—Identify levels of uncertainty and risk related to planning scenario and quantify, based on what is known about the project.
- **Reviews and approvals**—Determine review level dependant on project type, verifying estimate completeness, and intended project purpose or fiscal constraints.
- **Communication**—Estimate basis, uncertainty, and risk mechanism.

Florida DOT is notable for the progress the agency has made in moving estimation into planning and creative and comprehensive risk assessment in difficult areas. FDOT has invested in risk analysis, particularly in planning; there are many different areas related to cost and cost estimating. FDOT is committed to data for better decisionmaking, not “gut decisions” by
designers. The agency is investing in developing consistent processes that can be evaluated and improved.

Georgia is developing a DOT and MPO standard methodology for developing planning level cost estimates. GDOT is also updating the costs of inactive projects and projects that have not received an initial work authorization for preliminary engineering. They have a pilot set of 600 out of 4200 projects, the purpose of which will be generating accurate project cost estimates, for project programming purposes.

The benefit of a Planning Level Cost Estimation Handbook will be a department-wide, standardized process that will include:

- Documentation of process including inputs, steps, and outputs
- Policies and constraints
- People, tools, and responsibilities
- Integration with historical databases, cost estimating tool, and other processes

In Phase I of their process improvement effort, GDOT is developing a cost estimation process to include documentation of their existing process via interviews with the preconstruction office and District offices. For example, GDOT has found that:

- Currently preliminary engineering is 10 percent of the construction estimate.
- Planning lacks information on ROW impacts
- An excel spreadsheet has per mile cost but that has varied by office and there is no keeper of the spreadsheet. Per mile cost may not be updated annually.
- Utility relocation may or may not be estimated. If it is, it has been added to the construction estimate.
- At the planning level, project scopes are not well defined, the tools are not consistent or updated, cost estimates are reviewed and then added to the program if recommended but then placed in a holding pattern. There is little or no documentation of assumptions or thought process other than “X miles at Y cost.” The cost estimate is not updated until a PE is authorized several years later or a project becomes active in the construction work program.
- Typically, the following has not been included in the planning level estimate:
  - Contingency, inflation, change in unit quantities and cost
  - Environmental factors, unknown environmental impacts and mitigation cost, uncertainty from changes in environmental regulations
  - Preconstruction costs, lump sum items like traffic control, signals, and landscaping, staging and other big ticket items.

GDOT is developing a handbook on how to develop project cost estimates that will describe a standard and consistent process. The handbook, to be completed by late 2008, will indicate other tools (GIS) and how to use those. GDOT is also developing a user-friendly, interactive Web-based tool for planners and engineers to use when developing cost estimates. This will be shared with all offices, local governments, MPOs, so they can all use the same starting point. It provides the opportunity for multiple offices to enter information. Once a project enters preconstruction, cost will be regularly tracked. GDOT is also developing a Planning Level Cost Estimation Tool will integrate and complete the following databases to accurately consider and incorporate Preliminary Engineering, ROW, Utility Relocation, and Construction—BAMS/DSS The tool will
document the process and allow tracking and updates of project cost beginning at the planning level up to construction letting.

### 5.3.3 Programming—Transition from Planning to Design

In programming, approval of the project by management allows the project to transition from the project planning phase to the project design phase. All of the project features should be known and many contract items of work can be identified. In addition, the items of work identified and estimated during the project planning phase should now be better defined as work that is being completed by the design staff and the other functional units is completed. **Exhibit 16. The Mn/DOT Project Planning Process** illustrates the Mn/DOT project planning process.73

**Exhibit 16. The Mn/DOT Project Planning Process**

A comprehensive scoping process should include representatives for all potential internal and external stakeholders including the agency’s utility, right-of-way, traffic, environmental, and maintenance units. Inclusion of constructability experts can prevent delays late in the process with the early identification of potential problems. Outside representatives may include resource agencies, citizens, and local governments; however, VDOT and others noted that outside agencies often lack the staff to participate fully in the scoping process. The DOT may need to use alternative means to engage external representatives such as written documents explaining the purpose and need, project description, known issues and other pertinent information. Another possibility is to schedule a one-on-one meeting at another participant’s office.

When appropriate for budget development, each region or district may also hold a project scoping meeting where draft project summaries are discussed with federal and state resource agencies,
Tribes, and local municipalities. Based on their feedback, final estimates and document details may be developed in a more informed manner.

Some outside agencies cannot provide detailed input until the DOT can fully define the project—which is achieved only after scoping is completed. Nevertheless, understanding the potential problems up front provides the DOT with an opportunity to plan and design the project to avoid the problem and potentially costly mitigation. Organizing and holding an all-inclusive scoping meeting requires additional time and effort up front, but it can go a long way to prevent surprises and costly delays at the end of the process.

5.3.5 Barriers

Despite the acknowledged importance of scoping, a number of DOTs noted that staff shortages and accelerated project schedules do not allow the necessary time up front to fully develop the project scope. The resulting risk is scope creep through project development and construction. At least one DOT noted that some years the agency has as little as a week to scope dozens of projects just before they are programmed.

Many representatives cited a lack of resources dedicated for planning estimates, scope development, and tracking scope changes throughout project development. Limited staff is also a problem for outside agencies, making it difficult to get their input early in the project. Some commented that attending scoping meetings is a waste of their limited time because project scopes frequently change over the course of project development, requiring redo of much work. The decentralized project management strategy used in most states makes it difficult to get people involved in rigorous scoping, and then sign off on the estimate and scoping report unless the district buys into the importance of scoping. Further, in some states, planning and project development are separate units with no handoff or continuity from one phase to the next.

Many interviewees said they understand the need for improved scoping, but agencies need a standardized policy, guidance and improved tools, in addition to management support to provide time to conduct adequate and thorough project scoping. One state representative said development of a standardized form with scoping and tracking capabilities would be helpful.

It can be difficult early in project planning to identify the many factors that can drive up the cost estimate. Typically, the planning estimate and final design and construction costs span several years. Often, contingencies are used to cover major risk factors, but the volatile cost of materials, right-of-way, environmental mitigation, traffic management, utility relocations, and unknown geotechnical complications are difficult to forecast. The most commonly stated problem that influences cost estimates is changes in project scope or scope creep. Many DOT representatives said that external political pressure from local agencies results in a change of scope or add-ons that were not considered in the initial estimate. A gap exists between lane/mile estimates, scoping time, and before line-item estimates. Many DOTs are trying to obtain better historical data and archive it for use earlier in the process. More information is needed on how to classify a project and determine project parameters to help with conceptual estimating. It currently is very labor intensive to use cost history.

In sum, state DOT representatives interviewed for this study agreed three primary barriers to improving cost estimates at scoping: (1) lack of dedicated resources, (2) lack of policy and guidance and (3) limited project details. District engineers do the best they can to supply judgment, experience, and knowledge of the local area.
5.3.6 State Examples

**Caltrans**

Because detailed data may not be available in early stages, the Caltrans initial Project Feasibility Cost Estimate assumes the worst probable case scenario, particularly on reconstruction projects. A systematic field survey is used to prepare a strip map with proposed project features and a typical section. Attention is given to high cost items such as mitigating hazardous waste and other environmental impacts, utility relocation, noise barriers, major storm drains, and traffic handling. This information is not used for programming projects, nevertheless, it must be factual because Caltrans’ management use this early cost estimate to decide whether to proceed with project initiation.

The Project Study Report (PSR) is a project initiation document used to program projects for the STIP. Among other things, the PSR Cost Estimate expands on the Project Feasibility Estimate and is used as the programmed cost for the STIP, State Highway Operation and Protection Program (SHOPP), or other programming documents. Additional information to be obtained includes exiting and forecasted traffic, geotechnical design information, materials and pavement structural section design information, advanced planning estimates for new structures and modifying existing structures, potential environmental issues and mitigation, right-of-way and utilities data, and transportation management plans. A Caltrans representative said, “The importance of a reliable estimate at this stage cannot be overemphasized. It is the initial base against which following estimates are measured and has extremely high visibility.”


The Preliminary Environmental Analysis Report (PEAR) provides an initial environmental evaluation of a project and all feasible alternatives before it is programmed in the STIP or SHOPP. The PEAR also estimates the scope, schedule, and costs associated with completing environmental compliance. Because the environmental process can have a substantial impact on the project alternatives, design, costs, schedule, and delivery, the PEAR must clearly present and discuss the results of preliminary environmental studies to identify environmental constraints that may affect design. The information contained in the PEAR serves as the foundation for the environmental team to begin studies in the Project Report phase, facilitating early consultation with Federal and State resource agencies.

**Florida**

Florida DOT’s Efficient Transportation Decision Making (ETDM) process includes a planning screen and a programming screen to engage agencies and the affected community earlier than they were in the traditional planning process. Information and recommendations from the agencies and the public as a result of these screening events are summarized and help identify the technical studies and preliminary engineering that may need to occur during project development, and, thus, estimate environmental costs.

A planning screen occurs in conjunction with the development of long-range transportation plans. This initial screening of planned projects allows participants to review project purpose and need statements and comment on the potential impact of projects to environmental and community...
resources very early in the planning process. Direct and indirect effects of proposed projects are evaluated and documented in the Environmental Screening Tool (EST). This opportunity enables planners to adjust project concepts to avoid or minimize adverse effects, consider mitigation alternatives, and improve project cost estimates through early consideration of environmental matters.

The programming screen occurs before projects are funded in the FDOT 5-Year Work Program. Input about the potential effects to environmental and community resources are the basis for agency scoping to facilitate compliance with federal and state environmental laws. Lead agencies decide on a Class of Action Determination for each priority project summarized along with potential project effects, preliminary project concepts, reasonable project alternatives, and scoping recommendations. The details of Florida’s ETDM process are available at FDOT’s Web site at www.dot.state.fl.us/emo/pubs/etdm/etdmman.htm.

**Minnesota**

At Mn/DOT, the end of scoping is the end of discovery for a project. The estimator will not have the complete design, but, even in planning, many features of the project are known, such as the life expectancy of the infrastructure, the number of turn lanes, potential environmental issues, and others. Mn/DOT’s new scoping process implemented in 2006 includes early identification of issues and concerns, helps identify knowns and anticipate unknowns and is used to document and communicate the risks and contingencies.

Characteristic of the process, scoping occurs early, before a project appears in the Statewide Transportation Improvement Program. It is also comprehensive; the scoping process includes a planning process to narrow the number of projects to be scoped to just a few more than will likely be programmed. Each project on this short list is assigned a project manager who guides the project through scoping and project development. Functional groups are informed of the project and expected to provide written recommendations for what should or should not be included in the project scope. A timeframe is specified so enough time is allowed for scoping, but the scoping period has a definite deadline. To use staff time effectively, Mn/DOT bases the number of projects selected for detailed scoping on the size of the program and fiscal constraints of the district budget.

Mn/DOT has developed a number of comprehensive tools to aid in the scoping process. The following documents are available on the Mn/DOT Web site at http://www.dot.state.mn.us/tecsup/xyz/plu/hpdp/scoping/scoping-hpdp.pdf:

- Master Project Document List—a list of documents used in the Mn/DOT scoping process with space for adding links and completion dates to keep track of documents
- Planning Lists/Spreadsheets—a list to track needs, candidates, and projects through the project planning process
- Project Planning Report—a short summary of information gathered and decisions made in the project planning process
- Early Notification Memo—a memo and project summary to inform various offices of the project and solicit input (HPDP Forms: Early Notification Memorandum)
- Scoping Worksheets—worksheets for each functional group providing a list of the basic things to consider when scoping a project and documenting the functional group’s recommendations
- Project Scoping Report—summarizes the scope (both included and omitted)
- Scope Amendments—a form to document the effects and approval of scope changes
- Project Modification Program Evaluation Document—a form to document a program change and determine the effects

**Missouri**

Due to budget pressure and increased public scrutiny, MoDOT evaluated its scoping process and made significant improvements. Their key to scope management was to develop a detailed scope of the project early in planning and limit changes to only those necessary to deliver the project.

In 2001, MoDOT created a Scope Management Team to develop a better process for scoping projects, and in 2003 the agency published its recommendations for revisions to the project development manual and improved procedures. MoDOT defined a project’s scope as:

> “the set of design parameters that precisely satisfy the purpose and need of the project. A poorly identified scope that is broader than the purpose and need will result in an unnecessarily high project budget and schedule, while a scope which falls short will yield a project that accomplishes little of significance.”

The Team asserted that only when the elements and limits of a project are well defined can accurate costs and project delivery schedules be forecast. Like many DOTs, the agency’s scoping process was characterized by the following:

- Adequate project scoping did not occur at the beginning of the project resulting in chaos at the end.
- The scoping process was not addressing the fundamental question, “What is the solution to the need?”
- Inadequate scoping at the beginning of the process compromised the agency’s ability to deliver a quality product due to the chaos at the end of the process.

In their research, the Team found that between 1999 and 2001, 43 percent of the projects deviated from the original budget estimate due to scope changes. Additionally, scope changes were the leading reason for projects not meeting the original commitment date made in the STIP. Their recommendations to improve MoDOT’s planning and programming process included:

- Identified and prioritized needs are given to project managers instead of assumed solutions at the beginning of the scoping process, to allow the project team to identify the correct solution to meet the project need, establish an accurate budget and a reasonable project delivery schedule.
- Only preliminary engineering (excluding right-of-way and construction dollars) is included in the STIP to identify a project until the project scoping process is complete. This allows the project team to complete the scoping prior to making STIP commitments for the scope, cost or delivery schedule.
- Additions or deletions to a project’s scope after the STIP commitment has been made must have the approval of MoDOT management. This ensures that management is aware of the implications of the changes and limits scope modifications to only those that MoDOT management feels are critical.
- Management and Planning must review and concur with the project concept, budget and schedule early in the process to ensure that resources are not wasted developing solutions that don’t solve the identified problem.
- Design of the solution must progress to at least the Preliminary Plan state prior to programming any right-of-way or construction funds, or prior to making any project-specific STIP commitments.
In their review of the existing process, the Scoping Team identified the need for improved involvement and input from the entire project team. To help address this issue, the team developed a standardized checklist of the most probable issues to be considered in scoping. The checklists are not all-inclusive and MoDOT expects that the lists will be modified to meet specific project needs. The checklist identifies the critical issues a project manager must have addressed for common types of projects. MoDOT developed check lists for project scoping, planning, project development, design, right-of-way, traffic, environmental, maintenance, construction and materials, public outreach, utilities and FHWA. As in Virginia, these lists facilitate items not being left out, with adverse impacts to estimate accuracy.

**Virginia**

In the past 10 years, VDOT has attempted to improve the scoping process. The agency completed an internal review of its scoping process with the explicit goal of reducing scope creep. Attention focused on the pre-scoping process with emphasis on initial activities. VDOT developed several guidance documents and corresponding checklists to help with the scoping process. The agency leveraged its estimating and scoping process improvement efforts through a good linkage between its Cost Estimation Improvement Task Force and Project Scoping Committee. One member of the project cost estimation task force, VDOT’s Fredericksburg District Location & Design Engineer, joined the VDOT Project Scoping Committee as its co-chair. This person kept the cost estimation improvement task force continuously updated on the progress of the committee.

To identify possible improvements to project scoping, VDOT’s task force interviewed 27 staff personnel representing five VDOT districts, one planning district commission, and FHWA. Interview questions addressed the role of scoping in project development, the involvement of outside agencies, the use of documentation for tracking scoping-related decisions, and steps VDOT districts have since taken to improve scoping.

DOT representatives in the interviews noted problems grouped into three topics: (1) the link between scoping and other processes, (2) the involvement of outside agencies in scoping, and (3) scoping itself. Other problems included technological obstacles such as the need for a single database for all project information. Scoping may be more difficult in decentralized states because information and assistance must be obtained from diverse functional units. As noted by one group of interviewees, the project manager has the responsibility for—but not control over—all project activities.

A review of VDOT’s scoping process identified a number of procedural problems:

- Insufficient number of personnel or insufficient experience of existing personnel
- Lack of clarity regarding what the scoping process should deliver
- Need for better, higher level cost estimates especially for some types of projects
- Need to better document follow-up commitments and changes in scope that occur after project scoping day
- Need for a single user-friendly source for obtaining all project information
- Alignment of planning cost estimates and scoping estimates
- Lack of a clear purpose and need statement from the planning process
- Some projects are scoped for which full construction funding is inadequate
In its final report on its scoping process improvement effort, VDOT’s Project Scoping Committee recommended raising the profile and importance of scoping at VDOT. The recommendations included best practices for the following tasks:

- Structure of the scoping team
- Preparation for the scoping meeting
- Communication among staff
- Documentation of the process
- Definition and control of scope creep
- Re-scoping of projects when they change significantly

The internal review recommended four changes to the scoping process: (1) provide a purpose and needs statement, (2) establish an electronic system for recording a project’s approved scope and subsequent scope changes, (3) schedule multiple project scoping meetings on the same day, and (4) perform scoping before the project is introduced into VDOT’s STIP. Generally, the first three recommendations have been implemented: projects may include a purpose and need, districts schedule multiple scoping meetings on the same day, and the Integrated Project Manager (iPM) was established to archive some scoping-related material.

VDOT’s *Project Management Practices & Procedures Manual* identifies the roles of various entities in the project scoping process, such as the project sponsor, the project manager, and specific VDOT work units. The agency developed several checklists to help staff avoid overlooking important factors that influence cost estimates including key stakeholders to include in the scoping meeting, maintenance features, and environmental issues. Following is a brief summary of the checklists available:

- The emphasis on having relevant parties involved with scoping is emphasized in the VDOT Project Management Office’s checklist for the scoping team meeting, which notes up to 22 work units, including outside parties where applicable, such as FHWA, the Virginia Department of Rail & Public Transportation (VDRPT), utility owners, and local government.
- VDOT’s Structure & Bridge Division’s Scoping Checklist (for maintenance projects) asks 20 questions pertaining to project management and construction feasibility, such as utility concerns, coordination with other VDOT divisions, consistency with features of other long-range plans (e.g., lighting, sidewalks), and drainage.
- VDOT’s Environmental Division uses a checklist that identifies key questions, such as whether a noise analysis is needed, whether water quality permits are required, and whether a Section 4(f) evaluation (which considers the impacts of takings from parks, recreational areas, historic sites, and wildlife refuges) is required.

The most authoritative source regarding the expectations of the scoping process is VDOT’s Informational and Instructional Memorandum LD-210.4. This memorandum notes that results of the scoping phase are formally recorded in two forms: the LD-430 (which contains results of the initial field review, project schedule, project cost, and six responsibilities) and the LD-404 (which certifies that the final project, just before right-of-way acquisition or construction, either has not deviated from the scope outlined in the LD-430, or has adequate justification for doing so.

VDOT identified eight process and product solutions that involve, to varying degrees, both central office and district staff. The decision regarding whether or not to implement them as a matter of policy rests with VDOT’s Chief Engineer. More solutions focused on the process rather than technology.
- Establish (or continue) a monthly project day statewide.
- Use the initial scoping meeting to ask questions (thereby making the scoping meeting a “day of decision” regarding the project budget and scope rather than a day of seeking additional information).
- Consider initiatives suggested by individual districts such as the use of staff for conceptual plans, a risk assessment page, and a facilitator at the scoping meeting.
- Allow electronic submission of the scoping form.
- Provide an accounting mechanism that allows some scoping to be performed prior to the programming stage (thereby using those results to influence which projects are placed in the program).
- Strengthen the link between scoping and planning (through involving planners in scoping and/or having a clearer purpose and need from the planning process).

VDOT’s product solutions were to:

- Develop a single primer that explains how scoping affects a project’s outcome.
- Enhance VDOT databases such as making scoping data accessible to outside agencies.

**Maine**

The Maine DOT Enhanced Project Scoping Process is used to document a project’s purpose and need and provide a well-defined scope of work, costs, and schedule. The goal is to reduce the likelihood of conflict with communities and the public regarding project expectations and provide a basis for managing the project scope and cost throughout the development process. Scoping is applied to a prioritized pool of projects in the 6-Year Plan or to any other viable project being considered for advancement. The Planning and Project Development’s multidisciplinary project teams collect information on the project purpose and existing physical and environmental conditions. The teams also collect information derived through contacts with municipal officials and, if necessary, the general public. Minimum elements addressed in the scoping process include project purpose and need, environmental conditions, statewide and regional considerations, municipal input, and information on physical conditions, property, and utilities.

Documentation of the scoping process for each project is critical to avoid confusion, save time rehashing decisions, minimize tort liability, and pass information on to those working on the project. Documentation of the basis for the estimate including scope, definition of the project, and assumptions also helps explain changes to costs later on.

**South Dakota DOT**

Many DOT representatives stated that scope creep is often the result of political pressure on local government projects. A primary improvement South Dakota DOT made to their scoping process was to address this issue by having one staff person coordinate with and meet with local agencies to make clear up front that any add-ons must be justified. SDDOT is also beginning to take a more aggressive approach to reach agreement with local governments to lock-in estimates.

**Washington State**

At WSDOT, scoping includes identification of the project purpose and need, proposed solution, estimated cost, (including the cost of design and construction as well as environmental review, permitting, and mitigation) and a benefit-cost ratio for the project, which includes the projected change in system performance. The forms WSDOT uses to document the results of the scoping process including the schedule, expected performance outcome, and budget of and for a project
5.4 Cost Management—Managing Internal and External Factors

Cost management has become a key area of focus in its own right, and in its relation to cost estimating and estimate management. DOTs have developed a number of strategies to deal with areas previously considered outside of their control, even going so far as to cancel a project when material costs are inflated and have become unaffordable. Proactive DOT cost management strategies are discussed in this section.

Like DOTs across the country, MoDOT faced stagnant revenue, increasing costs, and heightened customer expectations. Long-range planning showed an $18 billion gap between expected revenues and the cost of needed transportation improvements over the next 20 years. The MoDOT response was to focus cultural changes that radically control costs through innovation and maximum competition. In less than 3 years, MoDOT significantly improved its ability to stretch its resources, deliver its STIP commitments, improve the condition of its major roads, and improve public perception.

Florida DOT, for example, has invoked a number of strategies to manage estimates and control costs including refining its awards criteria, fine-tuning its estimating process, using alternate bids and bid maximum specifications, optimizing use of night work, and adjusting the scope and length of contracts. To address labor shortages, FDOT is conducting a work force study and cooperating with community colleges to recruit workers. FDOT is dealing with conflicts in mobility and freight and looking into using risk management for material availability, specifically aggregates. Florida is trending away from using federal-aid standards because federal-aid funding makes up only 25 percent of the FDOT program budget.

FDOT has reviewed how it accounts for inflation and identified a number of areas in its process that could be improved to help determine exact dollar amounts set aside for inflation. FDOT strategies focused in the following major areas:

- **Ability to identify the dollar amount set aside for inflation.** FDOT checked for consistency among districts.

- **Project unknowns and inflation are separate cost components.** Project unknowns occur on highway projects, and it is not possible to anticipate all of them. For example, unforeseen ground conditions could require a change in bridge footing design. Project unknowns and inflation are different components of cost, and FDOT could benefit from accounting for them separately.

- **Estimate unit prices must represent present-day costs.** The goal of estimators at FDOT is to develop present-day cost estimates for projects, in other words, the cost of a project let today. A major component of a project estimate is the combination of a set of estimated material quantities multiplied by unit prices. FDOT’s estimating systems provide estimators with access to current average unit prices, though districts have admitted to increasing unit prices to account for inflation.

- **Consider the impact of project start date and duration.** More than 40 percent of FDOT projects last 2 years or more. FDOT is shifting to use of the anticipated mid-point of construction to determine which combination of annual inflation factors apply to a particular project.
5.4.1 Reducing Cost Through Increasing Competition and Communication

In cooperation with their partners, DOTs have identified the following strategies to deal with construction cost escalation by increasing communication and competition. Caltrans and FDOT were among the DOTs noted that the most severe cost escalation came when competition from a housing boom, combined with bunched DOT lettings, reduced bidders to just one or a few.

As a strategy, DOTs have increased communication by calling bidders when necessary, timing bid advertisements to promote competitiveness and contractor ability to respond, and communicating current and future contract opportunities and projects. Using these strategies, MoDOT saved an estimated $22 million on 52 projects in FY 2006, and by the spring of 2007, another $4.3 million on 13 projects.82

5.4.2 Contract Structure

Some DOTs are willing to modify contract structures to manage costs by breaking up or bundling projects to attract bidders. DOTs also have experimented with giving flexibility to contractors for “performance or end product specifications.” MoDOT has shifted its contracting to this structure for the most part. Flexible start dates also allow construction contractors to structure efficiencies into their operations and reduce costs.

5.4.3 Contractor’s Choice

DOTs from coastal boom states to Midwest and Western states such as Missouri, Arizona, and Utah have made substantial efforts to improve responsiveness and become the “owner of choice” for contractors. Following are some actions DOTs have undertaken:

- Provide early payment provisions (materials on hand).
- Listen to contractor community concerns and the concerns and issues of individual contractors on the job.
- Try cost reduction incentive proposals.
- Practice fair and efficient contract administration, such as tracking DOT 30-day payment of contractor invoices.
- Allocate risk fairly and efficiently in contracting relationships.
- Be consistent in specifications and establish a fair process for response and clarification.

Becoming a preferred owner/client of contractors has helped DOTs boost the number of bids they receive and reduce costs.

5.4.4 Employee Incentives

MoDOT implemented an employee incentive program, Performance Plus, several years ago to offer incentives to project construction offices for final STIP construction costs that come in at 1 percent or less over the contract award amount. The incentive mark is 1 percent even though contingency is at 2 percent. MoDOT also offers an incentive for design teams to save money, and similar incentives are added for employees who accurately estimate project costs so that project award amounts are within 1 percent over or 5 percent under the STIP construction budget.83
5.4.5 Reduce Cost through Reduced Scope and Practical Design

Reducing cost through reduced scope is a controversial area for DOTs, especially in context sensitive solutions and DOT attempts to be highly responsive to the communities where they work. South Dakota DOT is a few years into a scoping and cost estimate improvement process. Feedback on accuracy and letting price is beginning to come in, but the agency continues to encounter resistance from the field and local agencies in restraining the scope to purpose and need. SDDOT has discussed how to deal with a so-called “shopping cart” mentality when a project comes up—in other words, “get all you can while you can.” Avoiding scope creep has been elevated as a priority in Ohio, where staff said money is particularly tight on local projects. If a local community wants an increased scope, the community must pay for increased costs.

MoDOT and Idaho DOT implemented what MoDOT has called “Practical Design,” which espouses “building Fords, not Cadillacs.” MoDOT considers the effort a centerpiece to all of the agency’s other cost and estimate management efforts. Practical Design is rooted in the principle that building a series of good, not great, projects will result in a great system. This is accomplished not by cutting corners, but instead ensuring that the project meets its purpose and need so that funds are saved instead of being spent on over-designed items. Practical Design savings of $400 million were made in projects included in the 2005–2009 STIP and the savings were invested in additional transportation projects. Since then, Practical Design has been incorporated into all projects from the conceptual stage. The department realized savings between 30 to 60 percent on specific types of work such as minor system bridge replacements and resurfacing work in fiscal year 2006. MoDOT estimates it has saved $17 million on pavement design alone. Following are two examples of MoDOT projects that netted significant cost savings:

- I-64 and I-170 Interchange. The three-level structure originally conceived was reduced to two levels. The design was simplified, and speeds and shoulder widths were reduced. Fewer ramps and bridges and a design more in line with driver expectancy saved $37 million.
- DeKalb County, Route N. MoDOT replaced a deteriorating bridge with a triple-cell box culvert rather than the three-span bridge originally considered, saving $95,000.

5.4.6 Value Engineering

Value engineering during project design and construction phases in FY 2006 saved MoDOT more than $39 million in design phase and over $3 million in the construction phase. In FY 2007, MoDOT expected savings of between $10 and $15 million for contractors and MoDOT with construction-phase value engineering.

Value engineering doesn’t necessarily mean downgrading community amenities or environmental mitigation. Washington State Department of Transportation received an award for “Most Value Added Proposal in Pre-Construction Engineering for a $25 - $75 Million project” for its evaluation of the best ways to control and treat stormwater runoff from the highway connecting Washington’s largest cities, I-405. Much of the original design relied on the use of traditional stormwater treatment structures – massive vaults and treatment systems. The VE team explored more environmentally sustainable solutions to eliminate hard structures. The VE team’s most value added proposal involved the replacement of these vaults with a number of alternative treatment options, offering additional accepted cost advantages exceeding $62 million in maintenance savings over the life cycle of the project.

In 2003, WSDOT received the National award for Outstanding Innovative Value Engineering Achievements for the SR 509/I-5 Corridor Completion Project. The VE study reviewed the
stormwater and staging aspects of the project and included neighborhood representatives, local government, transit and community colleges, in addition to WSDOT design and environmental staff. The project involved 16 drainage basins and fish habitat, at an initially projected cost of $102 million. Value Engineering saved the project 38 percent of that cost, resulting in fewer stormwater facilities to maintain and an 11 month reduction in the schedule. Importantly to CSS objectives, the VE analysis increased the value that could be achieved in a number of ways:

1. Use of State Department of Ecology guidelines for compensatory stormwater treatment as an alternative to full mitigation when the existing pavement to remain is substantial (a watershed approach to direct mitigation where it will be most effective and produce the greatest environmental good). Stormwater control and treatment are based on additional impervious surfaces only.

2. Participate in the coordination and funding of the regional detention facility recommended by the Basin Plan. This facility will permit King County Level I flow control for proposed corridor improvements within the Des Moines Creek watershed.

3. Complete construction in five stages rather than six. The I-5 portion is the critical path for the project. Therefore, I-5 construction activities determine the 52-month project duration. The preliminary plan was 63 months.

4. Encourage bid competition, which will ultimately lead to a lower construction cost. Seven contracts were recommended, with three being design-build.

In the process of identifying opportunities, the VE team used some traditional CSS methods; design visualization was utilized, along with a scale model of the project, including contours. An interdisciplinary, interagency Design Advisory Group (DAG) was formed, with representation from local neighborhoods and stakeholders. The group provided input from stakeholders and various sources of expertise over an extended period during the development of the conceptual design alternatives and increased overall public acceptance of the project. Other project design changes were suggested, resulting in improved level of service and safety, utilization of existing interchange ramp structures, and increased pedestrian safety.

5.4.7 DOT Cost Control Efforts and Partnerships with Contractors to Control Costs

Several DOTs, including Caltrans, FDOT, and TxDOT have discussed with the contracting community strategies to reduce costs. For example, TxDOT’s Chief Engineer, Amadeo Saenz, established a Cost Control Task Force that identified 50 recommendations and garnered useful feedback from the contracting community, including recommendations such as the following:

- Standardize bridge design elements.
- Design for a whole corridor.
- Standardize forms and form liners. Contractors can reduce costs if they know they can reuse forms and form liners and bid more projects in an area. Contractors stated the concrete bid price can double if the forms are not reused.
- Reduce complexity and unique designs to save money. Repetitive elements decrease costs and improve schedule.
- Allow contractors to flex the schedule so they can bid more projects.
- Give a timely response to contractor’s questions.
MoDOT also partners with industry leaders, government officials, and interested citizens to find ways to build transportation projects faster, better, and cheaper with limited resources. MoDOT has involved at least 132 participants and generated more than 177 concepts to get projects finished quicker using innovative methods for project delivery and contracting. MoDOT dedicates $30 million annually for an economic development cost-share program. Cities, counties, and private industry recommend projects, and approved projects generally receive 50 percent of the project costs from MoDOT (under certain conditions, they could receive up to 100 percent funding). This allows MoDOT to accelerate economically beneficial projects and collaborate with other groups to stretch available funds.

5.4.8 Project Delivery Improvement Efforts

A number of DOTs have undertaken efforts to improve project delivery, partially in an effort to better control costs and estimates. Caltrans initiated a change order control process over a decade ago. Two recent notable project delivery efforts geared to produce gains in estimate and cost management are discussed below.

**PennDOT District 12**

PennDOT District 12 implemented an ISO 9001 process in project delivery, an effort that produced $16 million in cost savings over two years and notably expedited project delivery. Relative to scoping and cost estimating, the effort improved the quality of design plans, enhanced internal communications between units to achieve a project that is properly scoped. The effort virtually eliminated redesign due to changes in the project scope of work, while also improving constructability and maintainability, thereby reducing project cost. They dramatically reduced change orders and rework in the construction phase, controlling project cost and improving consistency in all phases of Project Delivery. Construction oversight cost was reduced as well. Ultimately, the District identified those key aspects of Design, Construction, and Maintenance that define a successful Project Delivery System and incorporated fifty key processes into ISO 9001 registration. An overview of ISO 9001 inspired questions that DOTs can ask of themselves in their quest to improve their estimating and estimate management systems is included in the appendix to the attached guidance.
Florida DOT

FDOT has invoked a number of strategies to manage estimates and control costs including refining its awards criteria, revisiting inflation rates factors, fine-tuning its estimating process, using alternate bids and bid maximum specifications, optimization of the use of night work and adjustments to the scope and length of contracts. Regarding labor shortages, FDOT is conducting a work force study and is now working with community colleges to recruit workers. Conflicts in mobility and freight are being dealt with, and risk management for material availability, specifically aggregates, is being looked at closely. Florida is trending away from using federal-aid standards, since federal-aid funding only makes up 25 percent of the FDOT program budget.

- **Investigating Material Supply and Consumption Statistics**—In addition to the aggregate study, FDOT is attempting to develop a better understanding of the supply and demand issues related to materials commonly used in highway construction, including asphalt, cement and ready-mixed concrete, and steel products (in progress);

- **Maintaining a Statewide Construction Database**—In an effort to better understand the relative magnitude and timing of construction projects of other major purchasers in Florida, FDOT has implemented a Web-based system that allows other organizations to enter and maintain their plans for construction activity. FDOT already has and will regularly solicit input from several hundred purchasers of construction services.

- **Tracking Outstanding Contract Values and Existing Backlog of FDOT Contractors**—FDOT has begun to track relative workloads and backlogs of its contractors in order that it might better gauge overall capacity and utilization trends.

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ISO 9000 is a family of standards for quality management systems. ISO 9000 is maintained by ISO, the International Organization for Standardization and is administered by accreditation and certification bodies. Some of the requirements in ISO 9001 (which is one of the standards in the ISO 9000 family) include a set of procedures that cover all key processes in the business;

- monitoring processes to ensure they are effective;
- keeping adequate records;
- checking output for defects, with appropriate and corrective action where necessary;
- regularly reviewing individual processes and the quality system itself for effectiveness; and
- facilitating continual improvement

A company or organization that has been independently audited and certified to be in conformance with ISO 9001 may publicly state that it is “ISO 9001 certified” or “ISO 9001 registered.” Certification to an ISO 9000 standard does not guarantee the compliance (and therefore the quality) of end products and services; rather, it certifies that consistent business processes are being applied. It provides a number of requirements which an organization needs to fulfill if it is to achieve customer satisfaction through consistent products and services which meet customer expectations. It includes a requirement for the continual (i.e. planned) improvement of the Quality Management System, for which ISO 9004:2000 provides many recommendations. ISO 9004:2000 Quality management systems - Guidelines for performance improvements. covers continual improvement. This gives you advice on what you could do to enhance a mature system. This standard very specifically states that it is not intended as a guide to implementation.

Identifying and Reporting on a Series of Construction Leading Indicators — A fundamental goal of FDOT’s construction cost initiatives is the monthly publication of a ‘Morningstar’ like report for FDOT executives that provides insight into the current state and direction of Florida’s construction market. The Construction Leading Indicator Report can be found on FDOT’s Web site at www.dot.state.fl.us/planning/policy/costs/. At this time, the report is comprised of four pages and includes a total of 13 main indicators divided between four groups. The first page provides a simple statement indicating how favorable (or not) conditions are for FDOT project lettings, the direction that the market is heading, and four pertinent notes, one for each group of indicators. The second page of the report presents a table of the 13 indicators, organized into four groups: national cost indicators; residential construction and sales activity; labor statistics; and national economic drivers and indicators. The table shows the latest values, percentage changes since the last month and the same month last year, as well as the trend direction for each of the past three months. The third and fourth pages provide line graphs of four key indicators by month, and residential permit/home sales statistics by district, respectively.

FDOT is using a number of strategies to increase competition and attract more bidders. Florida found that single bids were 20 percent higher than the engineer’s estimate and that three or more bids are needed to get close to the estimate. In FY 2004 - 2005, bids were 12 percent higher than estimates, on average. The 15 percent contingency pot was used, but that was also intended to cover change orders. In FY 2005-2006 low bids were 20 percent above the budgeted amount. Normally FDOT lets 400-450 contracts in a fiscal year, but FDOT rejected 71 contracts because of high bids that year. After efforts to address the issue, only 11 contracts were rejected because of high bids in FY 2006-2007.

Because of FDOT’s improved understanding of the construction market dynamics in Florida, the agency now knows that it must carefully consider a number of competing factors when determining an appropriate target letting value each year. If FDOT’s letting level in any given year is too high, it may contribute to returning Florida’s construction market to the point at which it is close to capacity. This condition in turn stands to:

- Impact project delivery (i.e., project schedules will be longer than anticipated)
- Overstretch the supply of key materials (i.e., forcing suppliers to institute allotments and raise prices)
- Overstretch the supply of labor, driving up labor costs
- Reduce competition because of the volume of work already contracted with the qualified contractors.

On the other hand, there are legitimate reasons why FDOT might want to push the target letting value up, including:

- Transportation needs are growing
- A desire to capitalize on the slowdown in residential construction, which should increase the availability of materials and labor
- The risk of maintaining a high balance in the transportation account, which may be seen by the legislature as available for expenditure elsewhere
- The belief that costs will continue to rise, therefore a project will cost less this year than next
- A desire to encourage the growth of construction capacity

This careful consideration of competing factors, combined with its improved understanding of the dynamics of Florida’s construction market, were critical inputs to FDOT’s decision about the
target letting level for the current fiscal year (2006–2007), an approach FDOT plans to use in the future.
6 Current Status of Strategy Implementation and Plan for Long Term Implementation

Efforts to improve cost estimating within the individual DOTs range from reengineering to combining the integral specialties under a single manager to more subtle changes in process and policy. Changes, whether large or small, are frequently met with resistance and it can be difficult to get people to change the way they have historically done their job.

As with many other DOTs, no major organizational changes occurred at PennDOT, Mn/DOT or Ohio DOT; however, Mn/DOT reported that it took considerable support from upper management to begin to turn around an established mindset and Virginia DOT spoke about the difficulty of “turning the ship around” and bringing the message to unwilling recipients. When studies brought to light cost estimating problems, VDOT started the Project Manager Office (PMO) office and shifted the responsibility for delivery of the program to the districts and instituted performance measures. They shifted to a project management process that was more like the private sector with responsibilities split between design and construction managers and their internally developed Project Cost Estimating System (PCES) tool, helping to ensure that expensive engineering components were not left out. Maine DOT did not reorganize bureaus or offices, but responsibilities changed and Planning and Project Development co-chaired an estimating process improvement effort.

A few states invested in notable organizational changes, developed guidance and added staff. MoDOT was one that tackled cultural change issues in some big ways, and generated very impressive results without boosting staff resources, though the agency already had an estimate auditing process in place. MoDOT accomplished change through a couple big shifts that garnered staff attention: performance measurement, quarterly meetings with the CEO where he used an air horn to interrupt them if they weren’t talking about what they are doing to address shortfalls in performance, radical cost control guidance and cost and estimate management incentives. MoDOT’s spectacular improvements did not involve either an involved cost estimating and estimate management improvement process, but it did involve the practical and theoretical aspects of managing change, which generally include:

- Setting and communicating a vision
- Attention to the organization’s culture
- Attention to how people respond to change, understanding motivation, and re-directing incentives.

Few DOT efforts involved change management as a functional discipline. Thus principles from change management may represent an untapped resource.


While DOTs and NCHRP research generally focus on the quality of the solution, change management recognizes that

\[ \text{Results} = \text{Quality of the Solution} \times \text{its acceptance} \]

Acceptance can be very small, rendering the change almost nil and causing the quality of the solution to almost not matter. The value of change management is to gain and optimize results by not overlooking the importance of gaining acceptance.
Resistance may be seen as a natural, normal, or logical protective mechanism. In Six Sigma process improvement methodology, a key element of the DMAIC process is a systematic identification of the people who will have to change, the potential reasons they might resist the change and the design and deployment of a set of action steps to reduce that resistance.

A change management process to explicitly address change issues and risks often identifies the current and the desired state, addressing structure, process, culture, and people. To avoid, minimize, and mitigate resistance, the effort may also develop a key role map to identify cross-cutting roles. For example,

<table>
<thead>
<tr>
<th>Sponsors</th>
<th>Change Agents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Own the Change</td>
<td>Facilitate the Change</td>
</tr>
<tr>
<td>Make it clear that resistance will be addressed</td>
<td>Systematically identify the target(s) and the sources of potential resistance</td>
</tr>
<tr>
<td>Commit the resources that are required to reduce the resistance</td>
<td>Identify the actions required to reduce the resistance and build the plan of action</td>
</tr>
<tr>
<td>Do the communicating</td>
<td>Write the speeches</td>
</tr>
<tr>
<td>Provide the rewards and reinforcements</td>
<td>Determine what those need to be</td>
</tr>
</tbody>
</table>

In some cases, change agents may also be sponsors because the people who have to change report to them. A change management process may analyze the targeted staff orientation to change—blocking it, neutral, or supporting. Without finding the reason behind that orientation, the project team cannot unblock the blocker, move someone from neutral to supporter, or take maximum advantage of supporters. When people find it difficult to change it is usually for some combination of the following reasons:

- They don’t want to change from the way they do things now.
- They don’t want to go through the effort of getting to the new way.
- They don’t trust the leadership’s ability to get them to the new way.
- They don’t trust the Project Team’s ability to get them to the new way.
- They have been there and done that before and don’t believe it will be any more successful this time than the last time……or, if it is successful, the way it will be done is too painful.

In addition to the above, change management support might include conducting a change impact analysis and developing the following: sponsor/change agent job description and sponsor/change agent assessments, governance charters, communication plan, current state analysis and desired state design, history assessment, learning/reward plans, and a change sustainment plan.

The following questions should be addressed for each group--targeted staff, change agents, and sponsors. The answers will help to assess the resistance potential.

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**Six Sigma Process**

- **Define**: Identify change, set goal, define requirements
- **Measure**: Validate problem/process, Refine problem/goal, Measure key steps/inputs
- **Analyze**: Develop causal hypothesis, Identify vital few root causes, Validate hypothesis
- **Improve**: Develop ways to remove root causes, test solutions, standardize solution/measures
- **Control**: Establish standard measures to maintain performance, correct problems as needed
Who will resist in target groups affected by and affecting the change?

Why would they resist? Mapping the various target populations and laying over it the predicted potential resistance will give you a clear idea of where strong resistance could have a major or minor impact.

How will this resistance be exhibited?

Being able to predict that resistance ahead of time, both its source and its intensity, helps DOT leaders put in place a set of action steps to mitigate that resistance before it threatens the success of the change effort. It is then possible to minimize the drag on and risk to the change effort that comes from people refusing to change, spending excessive amounts of time complaining, stalling, and even sabotaging the change. As a sponsor of change, understanding the change process and managing that change will result in a dip in performance that is shorter and less severe and ultimately will result in a more successful and more sustainable change.

Questions to ask and answer with regard to the Current State (prior to change), include:

- Do the various target groups see a need to make a change—any change?
- Are there sufficient problems in the current state to cause discomfort or even pain?
- Are the targeted staff sophisticated enough to anticipate that even if the current situation is okay, there is great risk if they do not make a change?

The Delta State (the period during the change process)

- How many other changes is each organization undergoing besides this one?
- Has each change been considered in relation to the others in terms of importance, prioritization, and resource requirements?
- How much tolerance will the organization have for losses in customer satisfaction, productivity, and other key measures during the integration phase?

Six Sigma recognizes that if the changes identified in the improvement projects are to be successful, the process is not the only thing to change; the people who use the process must choose to change and to follow the new process. A Six Sigma Process applied to minimizing organizational resistance entails:

**Define**

- Prepare a framework for data collection
- Determine the willingness and ability of leaders and the project team to play their roles as sponsors and change agents
- Examine the burden of too many changes
- Design and implement the communication plan

**Measure and analyze**

- Gather a full set of data regarding the current state
- Determine the source and degree of resistance for the various target populations
- Update and review the key role map
- Continue to implement the communication plan

**Improve**

- Gather a full set of data regarding the desired state options
- Assess the impact of previous attempts to change
- Update and review the source and degree of resistance for the various target populations
- Determine the potential loss in productivities while transitioning to each desired state option, and assess likelihood, worth, and needs
- Update and review the key role map
- Design the learning and reward plans
- Continue to implement the communication plan

**Control**

- Implement the learning and reward plans
- Continue to implement the communication plan
- Design the sustainment plan
The Desired State (the goal after the change)
- Do the people see that this change will be a good solution?
- Can they see the change from an organizational perspective?
- What about from an individual or departmental or operational perspective?

When targeted staff face a change, they often ask whether management—from the immediate supervisor all the way up the chain—wants and supports the change. A positive answer does not necessarily mean that all resistance will disappear, but if the answer is no, it does mean that resistance will probably increase dramatically. Sponsors are key; is everyone in management supportive of the change? Are they willing to demonstrate that support? Do they know how to demonstrate that support?

Change agents and the way targeted staff perceive them can create either a willingness to change or a source of resistance. If the targeted staff see that the change agents are knowledgeable about their issues and trust them to deal with those issues appropriately, the chance for a quick and effective change is increased. If the targeted staff do not trust the change agents to recognize and address their issues, resistance will increase.

In too many organizations, the experience with change in the past teaches the targeted staff that all changes are to be resisted.

The team needs to determine the ability and the willingness of sponsors to perform the sponsorship role. They need to assess sponsor capability against a predetermined job description that identifies those behaviors required of an effective sponsor to reduce resistance to change. These behaviors might include being available to explain the changes and the reasons for the change to the people affected. The sponsors must also be willing and able to change the performance metrics and be ready to praise and thank the targeted staff for their efforts. Where the sponsor is lacking in ability, an improvement plan is required. Where the sponsor is unwilling, the project plan needs to be re-evaluated.

The team also needs to assess its own ability and willingness to perform the role of change agent. Members need to be aware of the requirements of an effective change agent—know what can potentially cause resistance, step up to contract with and coach the sponsors on their role in the changes, write the speeches and make sure the sponsors deliver them. As with the sponsors, where the change agents are lacking in ability, an improvement plan is required. Where the change agents are unwilling, their continued membership on the project team needs to be reviewed. Each “supplier” and “customer” group may be viewed as a target and ask:
- Does each target group understand the need for a change?
- Is each target group unhappy with the way the process works today?
- Does each target group understand why the customer is unhappy?
- Does each target group understand the consequences of not changing?
- Does each target group have a sense of urgency to change?

In other words, will they accept the need to stop doing things the way they are currently doing them, or will they resist the team’s efforts to change. Capturing this information early in the process helps determine the potential for successful change and dictate what needs to be done to turn a blocker into a supporter.
6.1.1 Communication Plan for Why, What, and How — Seeing the Change

Communication is not a one-time thing. As it has been said, communicate the message until your audience mouths your words along with you. Newsletters, intranets, workshops, meetings and more can be used to communicate the initial and subsequent messages and to keep people abreast of progress and review:

- Why we can’t stay in the current state and why we must change.
- What each individual’s job, location, process, and tools will look like.
- What the change process will be, what each individual’s role will be, how the status of the change will be tracked and, most importantly, what the management of the organization is willing to do to effect the change.

Staff targeted for change want and need to hear from their management, not just the change agents. This has been very effective in the change MoDOT has been effecting under the leadership of CEO and AASHTO leader, Pete Rahn.

In addition, people need to see the change and beneficial results. If people see progress they are much more likely to stay the course and help to reach the desired state and to sustain the change. Thus agencies are tasked with “getting the word out” about progress in meeting targeted staff.

Finally, communication plans should be developed for each target group, building on their needs dealing with why the change needs to be made, what it will look like, how it may change their role/work, and how it will be done.

6.1.2 Learning Plans

If the resistance comes from a lack of sufficient information about why the changes are necessary, what the changes will be, or how they will be made, communication is necessary. Learning plans fill the gap when the problem is knowledge about the benefits of the new approach. Many DOTs took preliminary steps in addressing these through identifying, understanding, and communicating the need for change, but such communication is an ongoing work, until everyone can describe what is needed and why, and understands why it is good for them to do it.

If the resistance comes from a lack of ability to perform in the way now required, the action step is learning. DOTs have begun to develop training and guidance resources to fill this need. If the source of resistance is a lack of willingness to change despite being fully informed and trained, the action steps are built into a reward plan.

6.1.3 Incentive Plans

Incentives are an important part of risk mitigation in change management, because even after providing sufficient information about the need to change, the description of the improved state, and the ability and willingness of change sponsors and agents, there may still be reluctance to change based on a bias against change either inherent in the target population or learned by them over time. People respond to reward systems, which help reinforce the choice to change and spur creativity in that direction. Personnel evaluation and performance metrics must be modified to fit the new scheme, and feedback systems must entail negative consequences for not playing according to the new program.

Communication and reward systems need to continue, in order to sustain the change and satisfy continuing information needs as to why the change was necessary, what it should look like now.
that the program is implemented, and how the changed state will sustain itself over time. Targeted staff also need continuing reinforcement for the effort they are making to keep the improved state as the new current state.

6.2 DOT Accomplishments

Although most states acknowledged that implementation of a comprehensive cost estimating and cost management process is still evolving, the following highlights the changes several DOTs have already accomplished, with particular attention to states discussed less in previous chapters.

6.2.1 Maryland

MDSHA’s objective in its cost estimating and estimate management improvement efforts was to increase consistency and avoid having to delay one project because another project over-runs its budget. MDSHA has noted that two years is an eternity to elected officials; they may be out of office by then. Hence, local and state officials need to be able to count on when a project is going to move ahead.

Maryland’s estimating improvement strategies encompass planning, scoping and project management.

Planning, Initial Estimate, and Management Strategy

- MDSHA has 100-page cost guidance for Planning and Design, which is updated yearly with average bid prices.
- MDSHA has cost estimation training for all engineers, but has no separate estimation section or estimators due to flat and diminishing staff levels.
- MDSHA has a policy-based 20-year plan. The Planning Division takes projects to approximately 10 percent of design for programming in the 6-year Consolidated Transportation Program, with reviews of all capital project costs by the Deputy Administrator. Once funded for construction, reviews occur quarterly on funded phases.
- More design is occurring earlier, including utility, environmental, and stormwater design, to minimize cost risk in these areas.
- MDSHA is one of only a few states with a published definition of “contingency” and a sliding scale accompanying the level of information. For example, MDSHA does not lower the contingency just because the project progresses from one phase to the next but rather because more information is available.
- MDSHA’s goal is that the cost given at the end of the Planning phase is greater or equal to the winning bid.

Scope Strategy

MD’s strategy is to define the scope as early as possible and keep the amount tight, via a high level of control, once funded. Before a project is fully funded, MDSHA ensures the project meets purpose and need. If add-ons are requested the designer and project management team determine if the addition addresses purpose and need; if not, a funding source must be identified.

Project scoping is assisted by constructability reviews, VE studies (already required by FHWA if project is $25 million or more) and Maintenance of Traffic Alternatives Analysis (can cost as much as the project in urban areas), as well as planning-environmental linkages and early environmental commitments.
Schedule Strategy
For project costs, MDSHA always inflates out to the midpoint of construction. This is particularly important as not all projects go through without delay in the schedule or receipt of funds. All public costs are rounded and put in ranges. The longer it takes to get a project funded, the more likely the higher end of the range will be the cost.

Risk Strategy
MDSHA considers development of a risk strategy their biggest area of need; however, MDSHA does have some risk related guidance:

- Identify some design/cost risks related to stormwater management; e.g. they predict twice as many stormwater ponds as needed then see which ones will ultimately work with the design.
- A risk checklist is established and used.
- MDSHA has guidance on setting contingencies, which can vary for each cost category. Contingencies go down only as more detail is developed. Things that are or can be known are not included in the contingency.
- Real estate professionals complete ROW estimates with relocation and damage estimates.
- For communications with the public, with regard to costs:
  - Costs are presented in ranges, inflated, and rounded.
  - Ranges are wider the earlier in Planning and narrows by the Public Hearing.
  - Ranges start at the developed cost and go up (range not yet defined by risks).

Delivery and Procurement Strategy
General Engineering Contractor costs and environmental stewardship costs are included in the planning estimate for mega projects.

Document Quality Strategy
MDSHA developed a comprehensive Construction Cost Guidance to improve consistency. The Office of Materials and Research updates the guidance every year.

Estimate Quality and Quality Control Strategy:
MDSHA’s estimate review process includes more experienced estimators in each office. Besides annual reviews, costs are reviewed at milestones or “gates.” External reviews are conducted on mega-projects

MDSHA does not have quality control team(s); individuals in each office take on this duty at the time the Capital Transportation Program is developed and at other times throughout the year, when needed. Management review occurs at increasing detail from Deputy Administrator, to Director, Division Chief, Supervisor, and Project Manager. Reviews mainly focus on changes from the previous year’s estimate and the reason for the change.

Integrity Strategy
Pressure is only applied to keep costs at the same level as budgeted after funded for construction. Prior to that, “the cost is what it is.” The planning goal is a high but reasonable cost. If the cost is too high, it is considered not the wrong cost but the wrong project; it may go back to the drawing board. The key is the final engineers’ estimate versus the bid price.

MDSHA is placing increased emphasis on being able to phase a project into useful segments, fundable by breaking the larger project into pieces.
6.2.2 New Jersey

In conjunction with having a well-defined scope of work and realistic project schedules, one of the ingredients for reducing project delivery cost is having a reliable cost accounting system. NJDOT has in place a comprehensive financial management system to track all costs associated with the delivery of the highway program by project. In addition, their unit managers closely monitor the schedule, budget, and staff progress and alert management of any potential problems, cost growth, or delays. Project managers are responsible for maintaining both consultant and in-house project budgets.

At NJDOT, once a baseline schedule is set, it cannot be changed. In addition, New Jersey has adopted a rating system where one of the factors is project completion ahead of schedule, which pays the prime contractor up to a 5 percent bonus. Poor performance, on the other hand, can penalize the contractor with a 6-month suspension. Other rating factors include safety, environmental compliance, pavement smoothness, and air voids. It should be noted that only the prime is rated and held accountable for the quality of the project and for their subcontractors. New Jersey’s vigorous project tracking system coupled with its performance rating system has resulted in an overall 90 percent on-time rate.

NJDOT released improved Cost Estimating Guidelines and a Construction Cost Estimation Review Manual (Preliminary and Final Design). NJDOT’s Guidelines describe the use of the new Cost Estimation System software, which is part of the Trns*Port suite of software. Included is a new method of handling non-standard pay item numbers. Additional information is available at www.state.nj.us/transportation/business/trnsport/.

6.2.3 New Mexico

New Mexico DOT’s Office of Infrastructure Program Management Division has a Project Production and Scheduling Bureau, which manages the transportation improvement program including maintaining and supporting the DOT’s multi-project scheduling system (Program Project Management System – PPMS). The scheduling component of PPMS is driven by Primavera scheduling software. The products of PPMS are varying types of scheduling and production reports that allow the DOT to assess the status of the program and make key decisions regarding program delivery. These reports also serve the construction community, which allows them to plan their resources and opportunities for bidding.

In addition, the Bureau administers Governor Richardson’s Investment Partnership (GRIP) projects. Specific duties include managing and reporting proposed and actual cash flow expenditures for all projects. The reporting and tracking of cash flow expenditures is critical to timely execution of the bonding program that serves as the revenue base for GRIP. Other administrative elements include tracking and reporting on the progress of the entire GRIP program as well as projects identified in the DOT’s STIP.

The Bureau continuously updates project information, identifies issues that might hinder project delivery, and coordinates resolution of these issues. Staff analyzes program/project data and produces reports for the Governor’s Office, Legislature, and NMFA, as well as NMDOT management/personnel, and others. The office produces monthly reports as well as reports on GRIP Status (at various levels to include statewide, District, Corridor, Project, etc.), GRIP Cash Flow, GRIP Bid Summary, Production Schedule, Required Actions on Projects, Letting Schedule, and Quarterly Performance. The Bureau provides Information Systems and services to support PPMS in the areas of project scope, schedule, cost estimation, and training.
6.2.4 New York

New York is decentralized, with Regional Directors accountable for costs, including supplying shortfalls out of Regional budgets. NYSDOT Districts utilize Trns*Port’s Cost Estimation System (CES) and Estimator systems. The combination of CES and Estimator replaced the PC-PES system, starting in 2005. NYSDOT and NYCTA made the transition because CES is an integral part of the Trns*Port system, using historical cost information from DSS, and providing the cost estimate to the proposal and letting system. It provides the security and data-sharing advantages of a server-based system for those that have access to the NYSDOT network and works with Estimator for those who do not. The change affected Main Office Planners, Regional Designers, Regional Estimations Engineers/Liaisons, Regional Planners, and Structures staff.

6.2.5 North Carolina

In 2006, NCDOT produced guidance on a process to monitor the scope, cost, schedule and budget for a project during its development and construction. The guidance established cost estimate milestones mirroring NCDOT’s merger process for widening and new location projects and the plan and permit review process for bridge replacements. A key change with the policy was identification of all costs (construction, right of way, utility, ITS, mitigation, etc.) in a common reporting mechanism so that all parties have the total project cost available in one place.

In NCDOT’s new process, scope is monitored and documented through the use of scoping information sheets, used at a projects inception and updated throughout the project development process. Cost is monitored and documented through updated estimates beginning at project inception and established milestones in the project development process. In order for inflation to be captured in the estimating process, estimates are updated on a yearly basis even if a project milestone has not been in a year.

NCDOT uses a tool called PMii to monitor the schedule. The budget is monitored through the establishment of a Scope Approval and Cost Containment Policy, which provides for a formal approval of the scope and cost for a project. Approval occurs after the Final Scoping Meeting, which establishes the final scope and cost for a project as project development is completed. This meeting also establishes project cost containment procedures to be utilized whenever project costs exceed prescribed amounts.

Ultimately, NCDOT identified 15 areas where potential cost savings could be made. They include constructability reviews, waste sites, balancing earthwork, advertisement length, VE, use of GPS, resident engineer authority, relocation of utilities prior to bidding, increase RAP use, alternate bid items, group/ bundle small projects, pre-bid meetings, traffic control, A+B bidding and use of road closures for fast-track construction.

6.2.6 Ohio

ODOT has made a commitment to cost accounting because data-based decision-making is one of its stated core values. “An effective cost accounting system is essential to showing that tax dollars are being maximized.” In the late 1980’s ODOT developed a work order-based cost system to capture data for equipment and fleet management, called EMS (Equipment Management System.) In the 1990’s it added the TMS (Transportation Management System) to capture project cost data. In 2002-03, it adopted the ODOT Business Plan with a strategic initiative to “Improve ODOT’s accounting information system for more effective decision making.” The goal of this initiative was to develop a sound and consistent activity-based cost accounting system on a statewide basis. To spread the cost accounting system statewide, experts from the districts were involved in
establishing and revising business rules. They created a manual and provided training in all 12 districts. Then they began to conduct Quality Assurance Reviews (QARs) to insure the accuracy and timeliness of data. For the first year, the Cost Accounting staff conducted monthly QARs. Now the districts conduct these QARs quarterly. The cost accounting staff conducts a site QAR on a biennial basis.

6.2.7 Caltrans

Robust process improvement efforts at Caltrans resulted in noticeable progress. Observed improvements included:

- Districts establishing cost estimating centers of expertise
- Districts developing and implementing Quality Control, Quality Assurance processes
- Districts utilizing consultant contracts for independent analysis of cost estimates
- District Directors accountable for accuracy of cost estimates

Caltrans also has a number of continuous improvement actions underway:

- Industry Capacity Expansion Initiatives
- Infrastructure Delivery Council Task Force
- Peer exchange with construction industry
- Enhancements to cost estimating tools, guidance, training and best practices through industry peer review
- Revisions to Deputy Directive 60 (Transportation Management Plans) to balance congestion mitigation and cost
- Improved Constructability Review process to better ensure consideration of construction work schedules and TMPs in development of cost estimates

A wide variety of resources, available on the Caltrans web site, were developed as part of the agency’s cost estimating and estimate management improvement efforts. These can be found at [www.dot.ca.gov/hq/oppd/costest.htm](http://www.dot.ca.gov/hq/oppd/costest.htm).

6.2.8 Minnesota

Mn/DOT assigned a Project Manager for the Cost Estimating Process Improvement effort, the goal of which is to achieve accuracy, consistency, and accountability in cost estimation and cost management efforts during the planning, programming, and preconstruction phases of program delivery. The agency has determined cost estimating functions in planning; Mn/DOT considers cost estimation in planning necessary to make good policy decisions. The agency is simultaneously implementing improvement of the scoping process. All data records are in the state’s document management system, which allows better preservation of work done in planning, including initial ideas of the cost estimate. The approach requires a NEPA-like notification step and early notification of interested parties and external agencies. Accountability is built into the process. A scope amendment process is built in, but changes are requested very thoughtfully.
7  Conclusion, Next Steps, and Further Research

The importance of thorough and reliable cost estimates in the project development process at state DOTs cannot be overstated. Cost estimates play a crucial role in the planning, programming, design, and delivery of projects. Outdated estimation methods, combined with rising delivery costs, are a primary cause of fiscal overruns in project delivery. Fiscal overruns, in turn, hurt DOT’s credibility with the public and other government agencies and elected officials.

Improving cost estimation and cost management procedures is one of the most effective ways that DOTs can address the problem of project cost overruns. Many DOTs are aware that their cost estimation procedures can be improved, but how procedures should be improved is not as clear. Available guidebooks tell how to properly estimate project costs, but not how to implement improvements in cost estimation procedures within the highly complex structure of a state DOT. DOTs must largely develop their own implementation plans.

Nonetheless, state DOTs across the U.S. have made improvements of various scales to their cost estimation procedures. At the organizational level, DOTs have included improved cost estimation in strategic visions and performance measures, and have reorganized cost estimation functions within departments. At the program level, DOTs have focused staff resources and training on cost estimation and have improved communication among departments involved in cost estimation. At the project level, DOTs have improved risk management as it relates to project costs, initiated auditing of cost estimates, improved management of project scopes and schedules, and found ways to reduce project costs.

This review of experiences with cost estimation improvement at state DOTs has covered a wide range of agencies and approaches. As such it should provide a useful menu of options for any state DOT. Future research might compare in

Next Steps in Cost Estimating Improvements at the Georgia DOT

Next Steps in Cost Estimating Improvements at the Georgia DOT

GDOT’s new estimating handbook, to be completed by late 2008, will identify how to use GIS and other tools in the estimating process. GDOT is also developing a user-friendly, interactive Web-based tool for planners and engineers to use when developing cost estimates that will be shared with all offices, local governments, and MPOs, so they can all use the same starting point and enter information from multiple offices. Responding to many states need for estimating tools at the planning level, GDOT is also developing a Planning Level Cost Estimation Tool that will integrate and complete the following databases to accurately consider and incorporate Preliminary Engineering, ROW, Utility Relocation, and Construction—BAMS/DSS. The tool will document the process and allow tracking and updates of project costs beginning at the planning level up to construction letting. Due to changing variables of Trns*Port the Planning Level Cost Estimation Tool can incorporate regularly updated PE, ROW, Utility and Construction Databases and unit costs. GDOT is also linking the construction database with Trns*Port BAMS/DSS, to assist in generating construction costs by taking the information from BAMS. GDOT is also identifying risk, uncertainty, and contingency; updating procedures and responsibilities; and providing enhanced documentation for planning level cost estimates. After development of the above, Georgia DOT will apply the process to 18 pilot projects statewide. Next steps for GDOT are adding a contingency to planning and documenting what they do not know, in their estimates, as well as what they do.
more detail the kinds of approaches that state DOTs have taken to cost estimation improvement. It could examine the degree of success of different approaches at DOTs with different organizational structures, resources, and working cultures. Based on this analysis, a compendium of best practices could be developed, to provide more specific recommended approaches for a range of DOTs.

DOT activities to improve cost estimating and estimate management are occurring and beginning to show notable results. Among the notable developments underway at the time of this writing, GDOT is developing a handbook on how to develop project cost estimates that will describe a standard and consistent process and developing a Planning Level Cost Estimation Tool, an unfulfilled need expressed by many state DOTs. DOTs that have already implemented process improvements are showing tangible and often substantial improvements, on an outcome basis.

As noted, a number of DOTs have been making significant investments in upgrading their internal project management systems. WSDOT’s effort has risen to $15 million in cost, including a team of expert project management consultants and a system that will primarily rely on Commercial-Off-the-Shelf (COTS) products. Virginia DOT has developed most of the agency’s information systems in house. Virginia DOT’s iPM system is an award-winning software application, developed in-house, that allows many users to log in to the program and work at the same time on various projects, which allows the project manager to track a project schedule instead of micromanaging the staff. As various systems are upgraded, DOTs information and decision support needs are integrally intertwined with the need for integration of various systems, ideally within an enterprise framework.

Of particular need are tools and methodologies to link budget requirements and decisions with desired performance measures or levels of service for performance-based budgets, which will serve as a starting point for the project selection and estimating processes. These tools should allow decision makers to quickly evaluate the consequences associated with different investment strategies by predicting expected outcomes so reasonable performance targets can be established. Tools for trade-off analyses are particularly needed as well as strategies for linking customer expectations with budgeting decisions, to anticipate the later demands which can lead to scope creep. Earlier integration of environmental conservation and transportation planning holds significant promise in the latter area.


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