TECHNICAL ASSISTANCE
REPORT

HIGHWAY PROJECT COST ESTIMATING METHODS USED IN THE PLANNING STAGE OF PROJECT DEVELOPMENT

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TRANSPORTATION RESEARCH COUNCIL

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Virginia Transportation Research Council
(A Cooperative Organization Sponsored Jointly by the
Virginia Department of Transportation and
the University of Virginia)

October 2001
VTRC 02-TAR3

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INTRODUCTION

Highway project cost estimation methods that are used in the planning process have recently become a significant concern for the Virginia Department of Transportation (VDOT) because of the impact that these estimates have on the final cost of a project. Furthermore, metropolitan planning organizations (MPOs), local and federal government agencies, and the news media have increased their oversight regarding the *accuracy* of the results. The purpose of this report was to conduct a literature review of the methods used in highway cost estimation and to identify the state of the practice used by state DOTs for estimating highway project costs in the planning phase of project development.

In recent years, increases in highway project cost estimates on VDOT projects have received attention from the news media and elected officials. For example, cost estimates of the Springfield Interchange Improvement Project, the junction of Interstates 95, 395, and 495 in Fairfax County, increased by more than 60% between 1994 and 2000. The Joint Legislative Audit Review Commission of the General Assembly and the Office of Inspector General in the U.S. Department of Transportation investigated this project and the results were widely reported in the media. Fortunately, the Springfield interchange is not representative of most VDOT projects. Nonetheless, the factors influencing the increases in its cost estimates provide insight that may be transferable to more typical projects.

This study is envisioned as a first step in an examination of practices for estimating highway project costs; therefore, its focus is on the initial cost estimate made for a project, typically during the planning stage. At this stage, only general information is known about the ultimate form a project will take and precise estimates of the quantities of project bid items (e.g., cubic yards of excavation) are not known.

PURPOSE AND SCOPE

The purpose of this study was to obtain and present information on available methods of estimating costs of highway projects during the planning process and for development of transportation improvement programs. The scope of this study was limited to methods for estimating highway project costs prior to the design phase of the project. This report does not present an evaluation of the methods used by VDOT or other state DOTs to develop project cost estimates. The study did not obtain data about the accuracy and efficacy of the processes used by state DOTs but intended simply to ascertain and synthesize the current state of the art and state of the practice regarding highway project cost estimating efforts made during the transportation planning process.

METHODOLOGY

The methods used in this study included a review of the literature pertaining to estimating transportation project costs, a review of current VDOT practice and of publications pertaining to VDOT's project cost estimates, and a survey of selected state DOTs to obtain information on their practices. The survey of state DOTs was conducted by telephone. For each state DOT, after the appropriate respondent was identified, the questionnaire, included as Appendix B, was provided for review prior to the interview.

BACKGROUND

This section of the report addresses the following topics: (1) definition of planning stage as used in this report, (2) definition of cost estimation, (3) basic elements of highway project costs, (4) common problem areas in highway cost estimation, (5) current VDOT practice, (6) a case study of cost estimate increases, and (7) a literature review of highway cost estimation methods.

Planning Stage Definition

This report focuses on cost estimates made for highway projects at any point from the process by which a project is added to the transportation improvement program (Virginia Transportation Development Program) through the project location and environmental impact processes, prior to commencement of design activities. The project development process employed by VDOT is: (1) project authorization and funding, (2) location study and environmental impact statement, (3) preliminary design, (4) final design and right-of-way acquisition, and (5) award.[1] The major deliverables from the second phase are the location decision and the environmental impact documentation. The next step in project development is commencement of the preliminary design phase, at which point a project has moved beyond the planning stage of development as defined for this study.

Cost Estimation Definition

A cost estimate is defined for this report/project as the initial projected highway construction cost figure. Cost estimation is the process by which, based on information available at a particular phase of project development, the ultimate cost of a project is estimated. This quantification of cost is the initial figure that allows the project to proceed to the next phases for final design and construction. It is also often thought of as the first estimate used for budgeting purposes and allocation of funds within a Transportation Improvement Program. Each successive phase of the project life cycle is more influential as the focus narrows on the amount each project will cost.

Basic Elements

The process for obtaining cost estimates usually consists of many individual elements combined together to achieve the final cost figure output. Although the methods used throughout the United States vary, there are certain elements and variables that are present in most, if not all, methods.

The primary elements in a highway project cost estimate can be broken down into the following groups:

- preliminary engineering (PE)
- right-of-way and utilities (ROW)
- construction costs (CN).

Preliminary Engineering

Preliminary engineering is the development of a project and the expenses to be incurred when a project advances from planning to design to when the project design is complete. This includes all aspects of designing a project excluding right-of-way and construction costs. The pricing of preliminary engineering can be refined either through practical experience or through use of a percentage applied to the estimated construction cost, which will further help in the summing of each element (PE, CN, ROW) to produce a quality cost estimate.

Right of Way

Right of way is defined as the purchase of land, from a landowner, which provides the available space needed to properly and safely build and construct a road project. Once the route is set and the land plot information is at hand, the next stage of appraising and purchasing the land (ROW) becomes the focus of the project. The process of pricing ROW falls into many categories.

Construction Costs

Construction costs are the expenses incurred during the construction process from project bidding to purchasing materials to the completion of project construction. Furthermore, these expenses are functions of project features ranging from pavement width and length to number of lanes to location (urban vs. rural). Because these features vary from one project to another, construction costs are often estimated using cost-per-mile and cost-per-item tables. Such tables are used by VDOT's Transportation Planning Division and are included as Appendix A of this report.[1]

Problems Encountered

Competent application of the cost estimation process throughout the highway project life cycle is vital to obtaining the goal of a quality cost estimate. Although extremely important and often overlooked, project cost estimating has many obstacles to overcome throughout the process. Some common obstacles include:

- cost overruns
- schedule delays
- changes of scope
- contingencies
- inflation.

Cost Overruns

Cost overrun is defined, for this report, as the amount of money expended on a project at the conclusion of the job that exceeds the initial project cost estimate. Cost overrun can be simply defined as the difference between the final, completed cost of a project and its initial cost estimate.

Overruns generally occur when there are flawed initial designs and/or changes in the scope of the project as it progresses. Flawed initial design simply means insufficient or incorrect planning and skewed conceptualization. For each dollar that is ultimately spent over the initial cost figure, the same dollar must come out of funds allocated for another project. The result of a project that has gone over budget may be a shortage of funds and/or possible cancellation or delay of one or many other projects. If this continues for a period of time, cost overruns could affect numerous projects, resulting in budgetary mayhem and the deterioration of infrastructure. More problems would likely arise, such as where money will come from for future project developments and the extent to which can borrowed capital be minimized and needed projects completed without delay.

Schedule Delays

Schedule delay is the time extended from the original projected completion date to the actual date of completion. Schedule delays can result from numerous factors and can happen at any time during project construction. Some of these problems are design based, ranging from faulty designs to ROW complications. Other problems occur at the construction phase, including changes in scope; unforeseen circumstances, such as bad weather; defective products; and complications or disagreements with the designer, contractor/builder, and inspectors. All of these factors may result in project delays. Some of the problems cannot be removed from the construction process and must be dealt with. Public frustration over the loss of money and incurred price increases and traffic congestion due to construction are also related issues not likely to be removed from the construction process any time soon. Schedule delays are time constraints that consistently cause increases in cost, either through penalty clauses, wasted time and effort, or both.

Changes in Scope

Changes in scope, for the purpose of this report, means additions and/or amendments to the initial plan or concept for a project not initially discussed or considered part of the original plan or concept. Many state DOT employees surveyed have stated that these additions typically result from local/municipal inputs asking for more project elements. The possibility that additional items may be added at any time throughout the project's life cycle causes serious concern. For example, an intersection, a left-turn lane, or 2 more miles of roadway may be added to a project. This, of course, adds more money and time needed to complete each project, resulting in increased costs and schedule delays. The only hope for minimizing this problem is to have quality initial designs along with reasonable contingency elements in the cost estimate.

Contingencies

Another problem being encountered is that estimates do not always include contingencies. Contingencies are defined as money that has been added in addition to the final cost estimate as a precaution for unforeseen instances, such as weather delays and/or changes in scope. The reasons for not including a contingency fund are not always clear. Some public agencies and legislative audit organizations believe that it is left out to protect and minimize the initial estimate, creating a financial picture that is smaller in scope than what is realistically needed. In other words, the political entity wants to keep estimates low in order to obtain project approval. A contingency fund adds to a cost estimate, typically between 5% and 15%, to the final estimate, depending upon the size and difficulty of the project. With the goal being to achieve a more realistic cost estimate, along with reducing cost estimate errors, a certain contingency fund should be included in the initial project cost estimate. This in turn will create a "cushion" for potential project growth.

Inflation

Inflation is defined as an increase of expenditure levels resulting from a considerable and prolonged rise in prices and other costs through time without changes in project scope. Since most projects take on average between 3 and 6 years to complete, inflation plays an important role in the planning process. For instance, it is not unheard of to have a project "sitting on a shelf" for many years before being put into action. But during this time, the value of the dollar changes, even though the project's estimate remains the same, in turn, causing the project's price estimate to be low according to the new time frame.

A Hypothetical Application of Current VDOT Practice

VDOT has a statewide format for calculating cost estimates early in the development process. VDOT's Transportation Planning Division, along with state contractors and consultants, relies heavily on project pricing with the use of Planning Cost Estimates Tables,[2] shown in Appendix A. These tables supply cost figures that are created to help simplify the mathematical procedures needed to calculate each individual cost, before the summing of each variable to obtain the total cost estimation. The values shown in Appendix A are adjusted periodically to help keep estimates current to the present day market costs.

Application of the VDOT method is illustrated through the following example. Construction and right-of-way costs are estimated. Information known about the hypothetical project includes reconstruction of a 2-mile segment of road, two lanes, 20 feet of pavement, and rural design. A traffic signal is to be added at an unsignalized intersection and a 5-foot bike path is to be provided for the entire segment.

The steps in applying VDOT's method are as follows:

1. Formulate project concept
   2-mile stretch of road (reconstructed) ➔ 20-foot pavement
   2 lanes
   rural
   2-mile 5-foot bike path
   1 new traffic signal

2. Estimate quantities
   2-mile 5-foot pavement bike path
   2 miles of reconstructing pavement—20-foot pavement
   1 intersection (new)

3. Multiply quantities by cost-per-mile from tables (CPM, sq. ft., …)
   2 miles * $580,000 (22-lane, rural 20-foot pavement) = $1,160,000
   2 miles * $170,000 (5-foot pavement bikeway) = $340,000
   1 new traffic signal * $180,000 = $180,000

4. Add cost figures ➔ Construction cost estimate
   Construction cost estimate = $1,160,000 + $340,000 + $180,000
   = $1,680,000

5. Adjust cost estimate figures, if necessary, to reflect local conditions or other known factors unique to the project (no adjustments made)

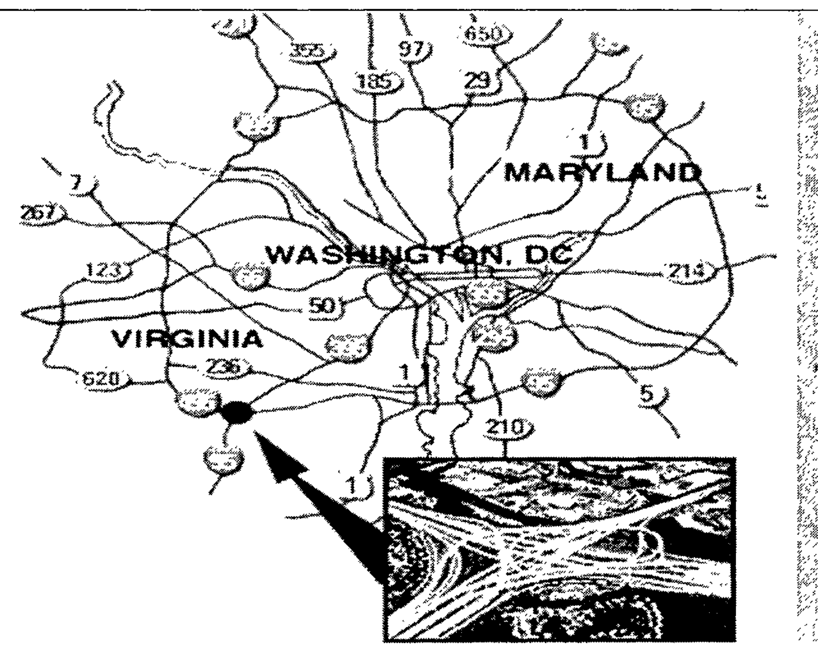
6. Compute ROW costs through percentage table in Transportation Planning Division: Planning cost estimate tables (shown in Appendix A).
   ROW cost estimate = $1,680,000 * 25% (rural road) = $420,000

The estimated construction cost is $1,680,000, and the estimated right-of-way cost is $420,000. To estimate preliminary engineering costs, a percentage of construction cost is typically used. For a project of this size, 10% of the construction cost is typically used by VDOT as the preliminary engineering cost estimate. Therefore, preliminary engineering is estimated at $168,000 and the total cost (sum of PE, ROW, and CN) is $2,268,000. Typically, VDOT does not make adjustments to a planning-stage cost estimate to allow for contingencies. The estimate is presented in current dollars.

Case Study of Cost Estimate Increases: Springfield Interchange Improvement Project

One of the largest projects with cost estimation problems presently being encountered in the Commonwealth of Virginia is the Springfield Interchange Improvement Project. The project involves a Washington, D.C., metropolitan area highway interchange. The problems encountered stem from changes in scope, financial growth, and continuing public protest. The project is located in Fairfax County, at the intersection of Interstates 95, 395, and 495. The project, when completed, will include 24 travel lanes at its widest point, 50 bridges, and more than 41 miles of roadway. A map of the location can be seen in Figure 1.[3]

Figures 2 and 3 show before and projected after pictures, respectively, of the Springfield Interchange Improvement Project.[3]



Source: www.springfieldinterchange.com Virginia Department of Transportation. *Fact Sheet: Springfield Interchange Improvement Construction Phases.* November 1, 2000. (For Figures 2 and 3.)

Figure 1. Springfield Interchange Improvement Project

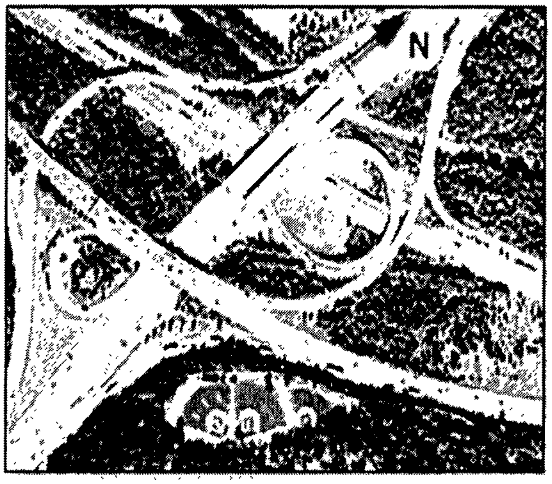


Figure 2. Before

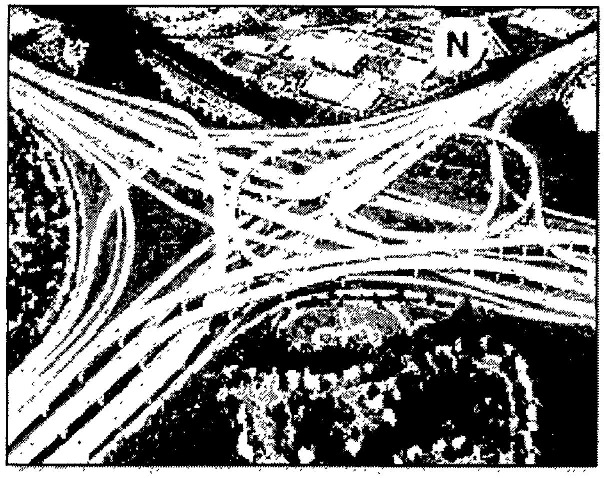


Figure 3. After

This project is the largest highway construction project ever undertaken by Virginia and is, therefore, not a typical project. Although this complex project is not amenable to simple cost-per-mile approaches to estimating costs, it does illustrate many of the occurrences that lead to project cost overruns. Due to various problems, including change of scope, inflation, contingencies, unforeseen circumstances, increasing congestion management, increased right-of-way costs, and refined design estimates, the Springfield Project's total estimated cost has increased from the initial estimate of $350 million, at a point when the design was 30% complete, to its current estimate of $584 million, as of May 3, 2001.[4] This equates to almost a $234 million increase, with the distinct possibility of the total rising higher still.

Methods in the Literature

Cost estimation, by its own definition, is an inexact science. This section discusses two techniques found in the transportation literature: a parametric, regression-based cost estimation model and a neural network model.

Parametric Cost Estimation Model

The parametric cost estimation model is a linear regression function.[5] It is a mathematical function that employs a defined set of variables related to the features of a proposed highway project. The variables are divided into two categories: objective and subjective. Objective variables included in the model are length, number of lanes, earthwork volume, number of intersections, number of grade-separated interchanges, and construction cost index. The subjective variables used in the model include functional classification, location, work type, and incorporation of technology.

For someone to make quality estimates based on these variables, there are three conditions that must be met to create a reliable cost estimation function. The first condition focuses on the selection of the variables. Each project will need to be reviewed and adjusted to properly calculate pre-design costs. The second condition relies on the collection and retention of historical data, along with its accessibility. For this method to work properly, there must be past data to construct the pre-design cost function. This function seems, however, to be a problem in the United States because project data are still mainly recorded on paper and are available principally within the district where the project took place. The final condition is to test and to calibrate the regression equation using data from relevant projects to ensure proper results. As with any equation and testing, precautions should be taken.

There are significant benefits that regression-based cost estimation methodologies produce. The main benefits of the regression cost function method include the following: (1) encouraged storage and utilization of data and (2) an automated execution of the function. The importance of past projects' information is critical to the success of any project's cost estimation. Once the data have been reviewed and installed into the regression function, the ease of this method is readily apparent. As engineers using the technique become more familiar with the system involved, more reliable and accurate results will become available and in turn will make the process more user-friendly.

This method has received criticism; these criticisms explain why the use of this method is limited. The three main reasons often cited as to why this method should not be applied are (1) the mathematical functions are not readily available when needed; (2) poor instructions are given when functions are available; and (3) there is a psychological reluctance to use this technology to arrive at cost estimates. Although these are valid reasons to argue for discontinuation of the parametric method, reasonably accurate results have often persuaded critics to continue to use this system.

Parametric Cost Estimation Model—Example

A linear regression analysis was performed to develop a cost estimation model defined by 12 independent variables. Using these variables, an example was created in 1974 using 18 projects from Michigan. The linear regression analysis yielded the following output function for estimated project cost.

$$C = 5{,}515 + 246\ V_1 - 334\ V_2 + 4.386\ V_3 + 162\ V_4 + 576\ V_5 + 63.67\ V_6 - 1{,}246\ V_7 - 2{,}217\ V_8 - 4{,}342\ V_9 - 1{,}118\ V_{10} + 104\ V_{11} + 1{,}044\ V_{12}$$

The cost function is not directly applicable to Virginia for two primary reasons. The first concern is that the project data used to develop the linear regression model are from Michigan. Furthermore, the data were collected and tested in 1974. Since no background information was given, added concern arises with the questions as to how the information was collected and what guidelines were set when selecting the projects. The second concern is the limited number of project samples. With only 18 projects, the range of data covered may not fully address the range of projects found in Virginia. Any state DOT wishing to use this model should collect data from recent projects, within that state, and recalibrate the linear regression format.

Neural Network Model

The neural network model is a computer/mathematical function-based tool, rooted in artificial intelligence.[6,7] This method is used for difficult problems/projects that involve intuitive decisions or projects requiring the model to find patterns within the data that often elude conventional analytical techniques. The creation and use of such a method would help eliminate human error when using the cost estimation process.

The neural network model consists of three basic layers, which are connected between successive layers. The three layers include input nodes, hidden nodes, and output nodes. The input nodes accept the data that are supplied to the network. The hidden nodes internally interpret or analyze the relationships in the data. The output nodes produce the network results.

A neural network filters erroneous cost estimates, so that successive answers will be more accurate. Because of the "brain-like" structure of the neural network, these models have the capability to activate a function based on "only the strong survive." These high-tech models have the capability to be used with either historical information and/or present data. Furthermore, training allows the computer to recognize certain patterns and to then adjust values and factors accordingly, producing a model that can estimate the price of future construction projects more accurately. This structure of the models could help to eliminate the problems currently encountered in the estimation process.

The main benefits that occur from using neural networks are (1) easier access and uniformity; (2) storage of data; and (3) use of data. The first advantage for using the neural network is the uniformity of the model, along with the ease of access. After an initial format is created through the use of a spreadsheet format, a fill-in-the-blank application is available for future use. With each new project, the project information database continues to grow, in turn, strengthening the output results (eliminating the negative problems). At this stage of the model, a sensitivity analysis has been adapted and applied to the neural network model. The sensitivity analysis is used to determine the relative significance of each input parameter within the model, giving the engineer greater capability to see how each input variable affects the overall status and feasibility of a project. The second benefit is the capability to store and file data. Information about the project and other projects will grow, producing better results, as well as creating a computer catalog based on project information. Finally, the ability to use the knowledge through mathematical tools may produce a constant and reliable answer to cost estimation. Once this model is in place, the repetitive use and education of the neural network will be fully utilized because of its easy fill-in-the-blank application and technique.

The main problems encountered when using the neural network cost estimation mathematical models are (1) inputting past data into the database and obtaining current data to store and use, and (2) the difficulty of learning and initial start-up of this complex computer method. This first negative can be solved simply by first transitioning and storing all past project data into a computer database and simply using the neural network system to become familiar with the technology, as well as to create and build project data. This will help create a basic database that will help prevent or eliminate the first problem. The second complaint is a problem similar to that encountered with any new technology or software. The implementation and start-up time is complex and lengthy, reinforcing the reluctance to consider this method fairly when choosing an estimation model.

Summary of Background

Cost estimation is the process by which the ultimate cost of a project is estimated. Since the value of the dollar fluctuates each day, careless spending is not an option for the government or, more specifically, highway transportation divisions. As a result, cost estimation must become a major focus during the initial project development phase. This will, in turn, force the transportation agency to better manage its budget, causing projects to remain in scope and on time throughout the development process.

The need to solidify the estimation process can be seen through four areas: (1) the state financial plan; (2) the creation of public satisfaction and a positive response; (3) project control; and (4) the problems presently being encountered. The first area of focus lies within the financial arena. As cost estimates are being used to obtain and allocate funding, project budgets are growing above stated values. The deviation of cost figures from budgeted estimates is causing money to be taken away from other needed and important projects, causing public dissatisfaction when projects are delayed or canceled. This leads to the second reason for the need for cost estimates: influencing public opinion. If the transportation division begins to show and to prove to the general public that it is efficiently and effectively doing its job, public satisfaction will ease the pressure of growing demand in many fields of transportation. As dollar figures are being publicly printed and discussed, greater care needs to be taken within the cost estimating methods so as to produce better results. The third reason for cost estimation is to help keep projects within appropriate boundaries. Although not necessarily a "check and balance" format, the existence of the original estimate will, it is hoped, keep the project from growing and expanding beyond its spending limit. Finally, as projects and their cost estimates are "under fire" due to numerous problems and obstacles within their methods and results, the need to solve these factors will become more evident and critical to the projects' success.

The primary problems facing the cost estimating process include the following: (1) data storage; (2) changes in scope; (3) unforeseen field conditions; (4) schedule delays; and (5) lack of a constant estimating process. Problems associated with data storage could be minimized by a statewide effort to consolidate and organize all vital project information into one central location within the state. This effort should also focus on converting transportation project cost data from paper format to a computer system. Once the information is input into the computer, each district within the state can and will have access to every state project. The second stage of solutions that should be achieved is controlling changes in scope and schedule delays and limiting the range of estimates. Transportation agencies could then be more confident in their estimates since the cost figures would be more accurate, providing better results. Minimizing these errors with safety checks within the process will likely reduce the possibility that any surprises will arise. Furthermore, if a unified system is created, not only statewide but eventually nationwide, greater knowledge and information would become available, creating a larger database for more research and accuracy throughout the entire United States. Once these problems are addressed, either separately or in conjunction with one another, fewer errors will occur. By concentrating either solely within the cost estimating process or on the entire design and construction phases, reduction of errors can only benefit the project's outcome.

In this section of the report, three cost estimation methods were discussed. These include the main procedures that are documented in the literature: (1) parametric cost estimation model; (2) the neural network model; and (3) a hypothetical application of current VDOT practice. Although these methods may have performed sufficiently to date, transportation engineers and agencies understand and recognize the need for improvement within the cost estimation process. Hopefully, further research will prove beneficial and the suggestions discussed will be taken into consideration to help alleviate problems within the estimation process.

SURVEY OF STATE PRACTICES

Survey Background

In order to ascertain the state of the practice in highway project cost estimating, during the planning stage of project development, a survey of selected state DOTs was conducted during the spring of 2001. The survey process consisted of telephone conversations with representatives of the selected state DOTs. Initial contacts were made to determine the most appropriate state DOT personnel to interview; the survey respondents were then sent a copy of the survey in advance. The survey instrument is located in Appendix B of this report.

The purpose of the survey was to obtain information regarding the procedures by which project costs are estimated during the planning stage of project development. For the purpose of the survey, *planning stage* was defined as beginning with the point at which a cost estimate is first made (typically for budgeting purposes in a transportation improvement program or work program) through the point at which project design has commenced. However, the procedures identified in the survey are often used in the early stages of project design until sufficient detail has been developed in project design to allow for precise estimates of project quantities. The focus of the survey was not on cost projections for long-range transportation plans (e.g., 20-year horizons) but on project-specific estimates made as projects move from long-range plans into work programs (typically these programs cover a span of 3 to 6 years).

Nine state DOTs participated in the survey. States were selected based on proximity to Virginia, size of state-maintained highway systems, and a range of geographic conditions. Delaware, Florida, Kentucky, Minnesota, Pennsylvania, Tennessee, Texas, Washington, and West Virginia responded to the survey. Several other state DOTs were contacted repeatedly but did not respond to the survey. Survey respondents are listed in Appendix C. A brief overview of the responses to each question and a summary of responses are presented here.

Survey Responses

Responsibility for Planning-Stage Cost Estimates

The function of developing cost estimates for highway projects during the planning stage is typically performed either by a centralized transportation planning office or in a decentralized manner, at a district or regional level. Among the states surveyed, three states (Delaware, Tennessee, and West Virginia) perform this activity in their central offices or headquarters, and two states (Minnesota and Texas) perform this activity in a district or regional office. Four states indicate that this responsibility is shared between the central and district or regional offices; in three of these states (Florida, Pennsylvania, and Washington), the lead responsibility is decentralized; in the other state (Kentucky), the central office leads the effort.

Delaware

The Delaware DOT's (DelDOT) Planning Division, in Dover, develops the initial cost estimates for the 5-year capital improvement program. For each project, the estimate is then passed to the Division of Pre-Construction for review and any adjustments that may be necessary. At this "hand-off," the Division of Pre-Construction assumes responsibility for future cost estimates.

Florida

In Florida, the responsibility for cost estimates is dispersed through the Florida DOT (FDOT), with the eight districts assuming a lead role when a project is added to the work program. Prior to development of the 5-year work program, the Office of Policy Planning in FDOT headquarters, in Tallahassee, is responsible for developing long-range estimates. A district typically has two people (a project manager and an estimates engineer) responsible for developing cost estimates for insertion into the work program.

Kentucky

The Kentucky Transportation Cabinet's (KYTC) Division of Planning, located in Frankfort, calculates cost estimates for both work program development and long-range planning in conjunction with input from each of the agency's 12 district offices.

Minnesota

The planning-stage cost estimate function is highly decentralized in the Minnesota DOT (MnDOT), with each of the eight districts (seven districts and the Metro Division) performing this function. MnDOT is moving toward having a designated person and office in each district responsible for cost estimates.

Pennsylvania

Within the Pennsylvania DOT (PennDOT), the Planning and Programming Section in each of the 11 district offices are responsible for developing planning-stage project cost estimates. The Center for Program Development and Management in Harrisburg works with each of the district offices to develop the 12-year transportation improvement program.

Tennessee

Within the Tennessee DOT's (TDOT) Planning Directorate, the Functional Design Office is responsible for developing cost estimates. Within this office, one of three interdisciplinary project teams produces an Advanced Planning Report, on a project-specific basis, prior to commencement of preliminary engineering work.

Texas

The planning-stage cost estimate function is highly decentralized in the Texas DOT (TxDOT), with each of the 25 district design offices perform this function. Estimates can be revised and updated in the transportation improvement programs (TIPs) monthly based on revisions to preliminary engineering estimates.

Washington

The Washington State DOT (WSDOT) has a Program Management Office, located in Olympia, which is responsible for coordinating development of the 6-year program; however, the six regional offices are responsible for developing cost estimates for projects entering the work program and within the program development phase, prior to commencement of design. Regarding longer-term estimates, the centrally located Transportation Planning Office develops cost estimates for the 20-year horizon. Survey responses from WSDOT pertain to cost estimates generated in the Project Definition Phase that commences upon delivery of a project concept from the Transportation Planning Phase to the Program Development Office.

West Virginia

The Preliminary Engineering Section in the Planning and Research Division of West Virginia's Division of Highways (WVDOH) is responsible for developing cost estimates during the planning stage and until design begins.

Summary

The work unit typically responsible for this function is a subset of a greater unit responsible for transportation planning and/or programming. This unit can reside either in the DOT central office, or at the district/regional level, or units at both such locations can share aspects of the functional responsibility. Table 1 shows the name and organizational location of the office responsible for generating planning-stage estimates for highway project costs in the

Table 1. Organizational Units Responsible for Developing Planning-Phase Cost Estimates

State	Office
Delaware	Project Development Group (in Planning Div.); Pre-Construction Group (in Design Div.)
Florida	District Offices; Office of Policy Planning
Kentucky	Division of Planning; District Offices
Minnesota	District Offices
Pennsylvania	District Offices (Planning and Programming Sections); Center for Program Development and Management
Tennessee	Functional Design Office (in Division of Planning)
Texas	District Offices
West Virginia	Preliminary Engineering Section (in Division of Planning and Research)
Washington	Regional Offices; Program Management Office

states surveyed. Information pertaining to survey participants in these offices can be found in Appendix C.

Cost Estimate Methodology

A wide range of methodologies for developing estimates of highway project costs, prior to commencement of preliminary engineering or design activities, exists among the states surveyed. The responses received pertaining to these methodologies fall into one of three general categories: simple methods that employ tables of generic "cost-per-mile" values by typical highway section (e.g., rural four-lane divided), more involved methods that entail estimating "rough" quantities of all major items and incidentals on a project-specific basis, and the lack of any uniform or documented method.

The classification of methods listed here is based on cost estimating methods employed upon a project's insertion into a work program for development or immediately prior to commencement of preliminary engineering activities. Some states provided additional information about how long-range estimates are developed; that information is included but was not used to group the states into the following categories. Two states (Texas and West Virginia) employ a method that applies generic values to specific projects (often with mechanisms for project-specific conditions or engineering judgment); typically these methods are based on cost-per-mile tables, as is the case in Virginia. Three states (Delaware, Florida, and Tennessee) use methods for which component cost values are generated using project specific information; these methods typically involve estimating quantities of major items and incidentals, multiplying these values by unit prices based on recent construction costs, and then developing a total estimated project cost. Four states (Kentucky, Minnesota, Pennsylvania, and Washington) indicated that either no standard method or guidance exists or that cost estimates are based primarily on engineering judgment or other informally kept data.

Delaware

DelDOT's Planning Division creates the initial cost estimates for the capital improvement program. A conceptual plan, prior to the detailed field survey, is developed and quantities of major items and incidentals in both preliminary engineering and construction phases are estimated. These quantities are inserted into a six-page worksheet that, in conjunction with cost estimates for most bid items (generated from recently completed projects), is used to develop the cost estimate.

Florida

In Florida, cost estimates for projects inserted into the 5-year work program are performed at the district level using the Long-Range Estimate System (LRE). This information system is updated regularly using bid item prices on recent contracts. A range of typical sections is available in the LRE to select for application in its generation of a cost estimates. For long-range (20-year) planning, the Office of Policy Planning uses the annual *Transportation Cost Report* to develop cost estimates. This document provides general-use cost estimates on a cost-per-mile basis and supplies unit costs for major incidental items.

Kentucky

In Kentucky, cost estimates are based on costs of similar projects completed in the past few years in the district within which the proposed project is located. Cost-per-mile tables are informally kept, typically in district offices. No general guidance exists.

Minnesota

The procedure used to estimate project costs during the planning phase varies by district in MnDOT, with some districts using cost-per-mile tables, some districts developing rough estimates of quantities and applying recent average bid item prices and adding inflation and contingency factors, and the Metro Division applying the LWD method. The LWD (length, width, depth) method involves estimating pavement volume, estimating its cost, and then adding costs for other items. MnDOT has established a committee that is currently developing a method for statewide application to ensure uniformity across the state. The LWD method is being considered for this purpose, with project-specific factors related to complexity added.

Pennsylvania

In PennDOT, this function is managed at the district level. No uniform statewide methodology exists. Districts generally maintain cost-per-mile tables for some types of projects. These offices also maintain bid item cost summaries of recent projects as an additional source of information.

Tennessee

Within TDOT, cost estimates are developed through a site visit and a preliminary estimate of quantities applied to a worksheet and recent bid item unit prices. With the use of aerial photography and topographic sheets, a proposed centerline is drawn and measured. Based upon the typical section envisioned and the site visit, quantities for 20 major items are estimated on a worksheet, and in conjunction with the previous year's average bid item unit prices and other costs for incidental items, the cost estimate is developed.

Texas

The Design Offices in the 25 Districts, or the Area Offices within the districts, develop initial estimates when programming the planned improvements. Cost data from similar projects recently completed near the proposed project are used if available; otherwise, tables with cost-per-lane-mile are used. Tables with generic estimates for bridges and incidental items are also available.

Washington

In WSDOT, this function is performed at regional offices; WSDOT uses no standard methodology for estimating highway project costs during the planning stage of development. In some cases, informal cost-per-mile tables are used to supplement engineering judgment and estimates made during long-range planning to develop cost estimates for program development.

West Virginia

The process for developing planning-stage cost estimates in West Virginia is not highly structured; cost-per-mile and cost-per-incidental-item tables are updated annually. This methodology is reviewed about every 3 years. Cost estimates are supplied to decision makers both within and outside WVDOH; in project development, these estimates are typically followed by an environmental review and the development of a design report, after which project design commences.

Summary

A wide range of methods is used by the surveyed states to develop highway project cost estimates during the planning phase. Most states apply a methodology uniformly across the state. Most states use either a methodology that involves estimating quantities for a specific project based on available mapping, anticipated typical sections, and engineering judgment or reference tables of cost information (i.e., cost-per-mile tables) averaged across many projects that may have similar typical sections.

Factors for Developing Cost Estimates

Each highway construction project can be described using many factors, such as terrain, projected number of lanes, and rural or urban setting. Table 2 contains a list of factors that are typically used by state DOTs that employ planning-stage cost estimating methods that use a worksheet or other means to estimate quantities of major items.

Table 2. Common Project Factors

Length	Seeding
Pavement Type	Lighting
Width	Signalization
Clearing and Grubbing	Guardrails
Earthwork	Signage
Drainage	Contingencies
Structures	Right of Way
Maintenance	Inflation
Retaining/Sound Walls	Preliminary Engineering
Number of Intersections	Bridges
Number of Lanes	Urban vs. Rural

Summary

The responses from the states concerning cost estimation factors vary from detailed planning sheets with worksheet formats for estimating quantities to cost estimates based solely on crude preliminary planning designs, experience, and engineering judgment. State DOTs that employ worksheet-based methods that employ information specific to the location of a proposed improvement use many of the factors shown in Table 2; the range of factors allows each state DOT to discuss and interpret logically what is needed for each unique project. State DOTs that rely mainly on cost-per-mile and cost-per-item tables use a much smaller set of factors that can be incorporated into general reference tables. The values given in cost-per-mile and cost-per-item tables can be modified for specific projects based on engineering judgment and experience.

Right of Way and Preliminary Engineering

ROW and PE are the states' most difficult cost categories to estimate and often present the greatest challenges and deviations within the cost estimation process. With the ability to choose pricing formats for these two variables, the scopes of methods available among the states surveyed are broad. The easiest method is the use of percentages of the estimated construction cost. These methods range from the simplest, which is percentages, to the most time-intensive and labor-driven approach of appraising real estate and calculating personnel-hours required to design a project.

Delaware

ROW—DelDOT gives a set of conceptual plans with a rough right-of-way line to the Real Estate Section, who then uses recent appraisals for the area, along with experience and judgment to formulate a cost figure.

PE—After the hand-off of the initial cost estimate to the Pre-Construction Division, a six-page form is used to calculate the PE costs. The size of the project will further determine the exact procedure used; for instance, on large projects, percentages of the estimated construction cost are used, whereas for smaller projects, personnel hours are estimated. The separation and use of both techniques, depending on size, have been shown to produce more accurate costs.

Florida

ROW—FDOT calculates ROW through percentages applied to construction cost estimates derived from the *Transportation Cost Report*.

PE—FDOT calculates design costs through percentages applied to estimated construction costs.

Kentucky

ROW—KYTC ROW costs are estimated based on past projects near the proposed project that are similar in scope. At other times, percentages are used to calculate ROW costs.

PE—PE is generally estimated as a percentage of the construction cost. Most often a value of 10% of the estimated construction cost is used, but with some projects, the percentages vary slightly depending on size of project construction cost estimate.

Minnesota

ROW—The ROW office within MnDOT calculates estimates based on experience.

PE—MnDOT has historically not included PE costs in the overall cost estimate. However, they are attempting to change this trend by developing a new method.

Pennsylvania

ROW—ROW costs are typically estimated through either a site visit or a roadway video log of the project site.

PE—PE costs are assigned based on the scope and type of work to be performed. Typically, a percentage figure between 10% and 20%, based on projected construction cost is used to set up initial cost estimates for preliminary engineering.

Tennessee

ROW—TDOT goes through a vigorous process starting with transferring aerial photography into a CAD system scaled plan sheet, where a rough layout of the road is produced. Next, the Utility Section performs a site visit to inform the ROW office of any potential problems. The information is then sent to the ROW office where appraisals and acreage values are computed. The final stage is to send this packet of information to the Functional Design Office for cost approval.

PE—Preliminary engineering costs are typically estimated as 10% of the estimated construction cost.

Texas

ROW—ROW estimates are based on "drive-through" site visits, along with experience and judgment, performed by the ROW Office.

PE—PE costs are estimated most commonly as percentages of the estimated construction costs. On some projects, estimates are developed through a function of estimated ROW width.

Washington

ROW—WSDOT obtains ROW costs through the regional real estate sections within each district based on experience.

PE—WSDOT estimates PE costs by using a percentage of the estimated construction costs.

West Virginia

ROW—WVDOH calculates ROW using percentages. On complex projects, a site visit is often warranted to examine the land involved and to determine if adjustments to the cost are necessary.

PE—Preliminary engineering is a percentage of estimated construction costs, usually calculated at 8%.

Summary

The calculation for pricing the items of ROW and PE, based on the responses from the states surveyed, cover a wide range of techniques, as shown in Table 3. PE costs are typically estimated as a percentage of estimated construction cost, with most state DOTs typically using between 5% and 20%, based on project size and scope.

Availability of Written Procedure

The principal reason for surveying the states on this issue was to find out if the entire state conforms to and calculates estimates by a written method. Table 4 presents the results from the responses concerning the issue of written manuals.

Summary

The written "manuals" used in the cost estimate process cover a wide range of formats. This can be seen from Table 4. Two states (Delaware and Tennessee) employ cost worksheets that calculate estimates based on key variables that run constant throughout each project, and one

Table 3. Summary of ROW and PE Techniques

State	ROW	PE
Delaware	Appraisals, experience, and judgment	Percentages of personnel hours
Florida	Percentage of estimated construction cost	Percentage of estimated construction cost
Kentucky	Estimated on history of similar projects	Percentage of estimated construction cost
Minnesota	Experience	Costs have not historically been included
Pennsylvania	Experience using site visits or video log	Percentage of estimated construction cost
Tennessee	Calculate through step-by-step process (air photos, proposed alignment, utility division, and then ROW office)	Percentage of estimated construction cost
Texas	Calculate, then check against actual costs from similar projects	Percentages of estimated construction cost, or function of estimated ROW width
Washington	Experience (Real Estate)	Percentage of estimated construction cost
West Virginia	Percentages of estimated construction cost	Percentage of estimated construction cost

Table 4. State Manual Developed for Cost Estimation Guidance

State	Yes/No	Manual Explanation (if needed)
Delaware	Yes	Six-page estimate form (in process of writing estimates manual)
Florida	Yes	A work program instructions form for generating estimates
Kentucky	No	
Minnesota	No	Effort is being made to develop estimates manual
Pennsylvania	No	
Tennessee	Yes	A one-page form with 20 key variables
Texas	No	However, there are estimates forms available to assist in development of preliminary costs
Washington	No	
West Virginia	Yes	Cost per mile and cost per item tables are "written manuals" used

state (West Virginia) uses cost-per-mile and cost-per-item tables as its written manuals. One state manual (Florida) was written to be a guide and a tutorial tool for beginning estimators. The remaining five states (Kentucky, Minnesota, Pennsylvania, Texas, and Washington) have no specific manual to assist in the cost estimation process.

Cost Escalation

Within the cost estimation function, there are many variables that can cause substantial increases from the initial estimate to the final cost figure. However, in some states, these variables apparently are being left out or minimized to help keep cost estimates low in order to get projects approved and into the next phase of the development life cycle. The survey question specifically asked about two major variables to find out if and how these variables are calculated and used, those being (1) contingencies, to address unforeseen field conditions, changes in project scope, and other unforeseeable circumstances, and (2) inflation.

Delaware

Contingencies—Contingency factors are computed as a separate line item using a value of 5% of the total cost estimate.

Inflation—Delaware does not account for inflation. Estimates are good for 1 year, then revisited and re-calculated to be in current dollars.

Florida

Contingencies—Contingency funds are set aside for all ongoing projects in the long-range cost feasible plan for the Florida Intrastate Highway System but are not specifically incorporated into the initial cost estimate.

Inflation—Costs are estimated in current base year figures and are automatically adjusted and applied annually.

Kentucky

Contingencies—KYTC adds a 10% factor to the estimated construction cost to account for unforeseen circumstances.

Inflation—Cost estimates are made for the current year, with updates completed annually.

Minnesota

Contingencies—No specific adjustment factor or percentage is used to account for changes in scope or other contingencies. However, the project is revisited and revised annually when the project is in the 3 upcoming years of the improvement program.

Inflation—Costs are estimated in current dollars.

Pennsylvania

Contingencies—Normally a 10% to 15% contingency factor is included in preliminary construction cost estimates.

Inflation—Project costs are estimated in current dollars. Beyond the first 4 years of the program, projected revenues are adjusted downward (deflated) for comparison with estimated project costs.

Tennessee

Contingencies—Contingencies are accounted for using a line item within the cost estimate sheet by applying a factor of 10% to the total initial cost estimate figure.

Inflation—Projects are designed and priced by current year base prices.

Texas

Contingencies—On some projects, a factor of 5% to 10% of estimated construction cost is added to account for contingencies.

Inflation—TxDOT does not account for inflation but relies upon updating estimates periodically when more current project design information becomes available.

Washington

Contingencies—No factors are specifically included within the cost estimation process. However, there are many checkpoints throughout the procedure that help to detect any changes in scope, allowing for adjustments to be made before construction completion.

Inflation—Inflation is incorporated by WSDOT using a construction inflation index for a 6-year period. The cost estimates are applied to the inflation index as current dollars and are updated monthly.

West Virginia

Contingencies—No factors are taken into consideration to account for changes in scope. However, planning capital cost estimates are revised periodically during the design process and when the project is bid for construction.

Inflation—Costs are estimated in current dollars.

Summary

Contingency and inflation factors play important roles in the equation for obtaining quality cost estimate figures. Because there is no defined process, states have flexibility in calculating these numbers. Six states (Delaware, Florida, Kentucky, Pennsylvania, Tennessee, and Texas) use percentages applied to estimated construction costs to estimate contingency costs, and three states (Minnesota, Washington, and West Virginia) revise and check estimate figures prior to start of construction. Seven of nine states surveyed (with the exceptions being Texas and Washington) address inflation by keeping estimates in current year prices and updating the cost figures annually or monthly. The methods by which state DOTs address contingencies in the total project cost estimate are noted in Table 5. Table 6 addresses the issue of whether inflation is explicitly included in project cost estimates.

Table 5. State Methods for Calculating Contingency Factors

State	Methods Used
Delaware	5% of estimated construction cost
Florida	General contingency fund for all projects
Kentucky	10% of estimated construction cost
Minnesota	Adjustments made annually 3 years prior to start
Pennsylvania	10%-20% of estimated construction cost
Tennessee	10% of estimated construction cost
Texas	Contingencies not explicitly addressed
Washington	Contingencies not explicitly addressed
West Virginia	Revised when more data are available and during construction phase

Table 6. State Methods for Incorporating Inflation

State	Methods Used
Delaware	Estimate kept in current dollars, adjusted annually
Florida	Estimate kept in current dollars, adjusted annually
Kentucky	Estimate kept in current dollars, adjusted annually
Minnesota	Estimate kept in current dollars, adjusted annually
Pennsylvania	Estimate kept in current dollars, adjusted annually
Tennessee	Estimate kept in current dollars, adjusted annually
Texas	Adjusted project pricing when data become available
Washington	Construction Inflation Index applied quarterly to estimated cost
West Virginia	Estimate kept in current dollars, adjusted annually

Comparisons of Estimates With Bid or Final Construction Costs

Focusing on comparisons between the initial cost estimate and the final construction cost can lead to many insights. An evaluation of the cost estimating method along with the actual results will help in determining steps for future improvements. Such a review can demonstrate to the public, state legislature, or other inquiring parties that costs are not expanding at a significant rate. In Table 7, the results from the states surveyed indicate the growing importance and focus being applied to the accuracy of planning-stage cost estimates and the steps taken by states to improve their results.

Summary

Table 7 shows which states make a regular effort to maintain or improve previous practices. Three states surveyed (Washington, Tennessee, Texas) compare results either by planning estimate figures and bid/final construction costs or by tracking their individual item costs. The other five states (Delaware, Florida, Kentucky, Minnesota, and West Virginia) do not make the effort to compare costs at a regular interval.

Table 7. Regular State Efforts to Compare Cost Figures

State	Yes/No	Brief Explanation (If Needed)
Delaware	No	Project must be reviewed for additional funding when estimates costs increase by 15% or more
Florida	No	No formal evaluation for long-range planning estimates. (However, the costs in the Transportation Cost Report are revised annually.)
Kentucky	No	Isolated comparisons
Minnesota	No	
Pennsylvania	No	Isolated comparisons
Tennessee	Yes	Evaluated regularly by comparing bid and final costs to planning estimates
Texas	Yes	Tracks all average item costs for each district, and a statewide average item cost for the year
Washington	Yes	On a quarterly basis (project summary estimates, engineers' estimates, as-bid costs, and final costs)
West Virginia	No	Only when warranted are costs compared

Scrutiny of Cost Estimation Processes

As project cost estimates become a focal point in the eyes of the media, public, and government officials, greater care needs to be taken to estimate project costs. Some states, such as Delaware, employ an oversight process developed partly in response to attention given to project cost increases. In this process, when an estimate increases by more than 20% between any two stages of project development (or within a stage), the cost increase is reviewed by the Project Development Committee (PDC), which makes the final decision as to whether additional funds should be allocated to the project to cover the increase or components of the project must be changed or eliminated to offset the cost increase. The PDC is composed of several high-level DOT and elected officials. Although this process has been in place for less than 2 years, it has resulted in greater emphasis of development of project concepts during the planning stage to allow for more accurate estimates. It is expected that the existence of this process will provide greater incentive to refine project scope earlier in project development and incorporate sufficient funds for unforeseen circumstances in the initial cost estimate.

Table 8 indicates that only three of the surveyed states (Washington, Kentucky, and Minnesota) receive regular scrutiny with respect to project cost estimates.

Survey Findings

General

- There is a wide variation in the degree to which cost estimation functions are centralized among state DOTs. Some state DOTs fully perform planning-stage cost estimates in their central offices, whereas in some state DOTs, this function is handled at the district/regional level. Yet in other state DOTs, a process exists for developing these estimates requiring substantial involvement at both the central and district levels.

Table 8. Scrutiny from Media or Elected Officials

State	Yes/No	Scrutinizing Parties
Delaware	No	
Florida	No	(Time completion more important issue)
Kentucky	Yes	Media and elected officials
Minnesota	Yes	Media
Pennsylvania	No	
Tennessee	No	
Texas	No	
Washington	Yes	Legislative branch, broadcast media
West Virginia	No	

- The practices used by state DOTs to estimate highway project costs at the planning stage can be grouped into three categories:

  1. Use of rough estimates of major item quantities coupled with unit prices to produce a project-specific cost estimate. The unit prices typically come from a list of prices culled from recent or current construction contracts.

  2. Use of cost-per-mile and cost-per-item tables that contain generalized costs for several project design concepts (e.g., four-lane divided in a rural setting). Engineering experience and judgment are sometimes used to modify values obtained from these tables for project-specific conditions with the goal of improving the accuracy of cost estimates. Attaching a disclaimer to these tables should ensure that their use is in accordance with their intent.

  3. Lack of a uniform statewide cost estimating methodology. In such states, DOT district/regional offices use any method they choose, including the two approaches described above or methods based solely on engineering judgment and experience.

- Some state DOTs attempt to account for unforeseen circumstances by adding a contingency factor that is a percentage of estimated construction costs (typically 5% to 20%). Some state DOTs do not incorporate any allowances into project cost estimates for unforeseen circumstances such as changes in project scope, unforeseen field conditions, or other contingencies.

- Most state DOTs do not attempt to account for inflation in their planning-stage project cost estimates but simply maintain estimates in current dollars and update them annually or on an as-needed basis.

- Most state DOTs do not have a process to evaluate regularly the quality of their planning-stage project cost estimates. Some state DOTs perform spot checks on their procedures by comparing costs of a sample of recently completed construction projects with estimates made during the planning stage.

Additional Findings

A few unique characteristics of state DOT approaches to cost estimation and associated programming issues stand out as important factors to consider in a review of processes for estimating highway project costs during planning and programming activities. First, the oversight process used in Delaware (Project Development Committee) to review projects with increases of 20% or greater in cost estimates appears to encourage more investment in the initial definition of project concepts, and therefore more accurate estimates. Additionally, this process has been reported to reduce media scrutiny associated with the accuracy of cost estimates.

Second, the few states that dedicate a relatively large amount of resources, such as site visits or use of aerial photography, seem to have greater confidence in their initial cost estimates. For example, the Tennessee DOT has a staff equivalent to 16 full-time employees, organized into three interdisciplinary work teams, devoted to developing a functional plan and cost estimate for each project expected to be added the transportation improvement program. An additional staff of 12 develops an Advance Planning Report for each of these projects, of which the cost estimate is a major part. The Delaware DOT is also increasing resources dedicated to the planning process, including cost estimation. In conjunction with its oversight process, this effort has resulted in greater satisfaction with the cost estimates produced.

Third, the survey uncovered numerous methods in use to allow for fluctuations within the cost estimates due to unforeseen circumstances. The most controlled method for accounting for contingency funds is in Florida, where a pool of contingency funds is set aside for every ongoing project. This allows the state to accurately control and monitor where the money is being spent. This places a high degree of importance on the initial cost estimates, forcing them to be more accurate within the long-range plan, so that each project can be funded properly.

CONCLUSIONS

Several conclusions can be drawn about how state DOTs estimate costs of proposed highway projects during the planning stage of project development.

- No consensus exists among state DOTs regarding cost estimating methodologies, and there appears to be no national effort to achieve uniformity among state DOTs. This may be due to a number of reasons, including the diversity among the states in factors affecting project costs (such as terrain, economy, and material costs), state DOT organizational structures, and extent of attention and related emphasis placed on the accuracy of these estimates.

- The survey responses clearly indicate the importance of engineering experience and judgment used in developing cost estimates. Although the states surveyed differed in techniques used and extent of resources allocated, the same basic principles, requiring expertise in the highway engineering field, underpin all techniques encountered in the survey.

- None of the state DOTs surveyed employs sophisticated techniques such as mathematical models to estimate highway project costs. This could be due to long-term reliance on the skills and experience of planners and engineers who perform this function or to a resistance to use computer-driven procedures in place of engineering judgment.

- State DOTs that invest a relatively large amount of resources in planning-stage cost estimates report little scrutiny regarding the quality of their estimates. Some of these DOTs employ methodologies that front-load the cost estimation process by requiring rough estimates to be made of major item quantities, requiring greater staff and time than other methods. However, these state DOTs report that their methods perform satisfactorily and that they face little scrutiny of their methods.

- State DOTs that employ an oversight process to control increases in cost estimates also report little scrutiny of their processes outside of state government.

- Although the number of state DOTs surveyed is limited, additional surveys may ascertain other unique characteristics of cost estimation and management approaches; however, the overall trends identified from this study are expected to be sustained.

SUGGESTIONS FOR FURTHER ACTION

1. *VDOT should consider studying the potential benefits of implementing an oversight process, possibly based on the format used by the Delaware DOT, with the purpose of investigating increases in highway project cost estimates and their determining if such increases, and additional funds, are justified.* Such a process would apply not only to cost increases made during the planning process but throughout design and construction as well. As in Delaware, Virginia could set a minimum percentage cost increase above which the review committee must hear a presentation on the increase and decide if additional funds should be allocated to the project, thereby focusing on specific projects that have substantial financial growth after the initial cost estimate. Over the long term, such an oversight process would provide a greater incentive to accurately estimate project costs and provide sufficient funds for contingencies.

2. *State DOTs that invest greater effort in planning-stage cost estimates, thereby front-loading the process, have expressed satisfaction with the robustness of their processes.* As VDOT examines the distribution of resources required to perform transportation planning functions, consideration should be given to employing a more rigorous process, and allocating more resources (front-loading) to the development of cost estimates during the planning process, thereby yielding more refined and more accurate project concepts. The processes used by the Delaware and Tennessee DOTs can serve as examples.

3. *VDOT's Transportation Planning Division should consider creating and distributing a disclaimer concerning the use of the Transportation Planning Division: Planning Cost*

Estimates tables. Since contractors and government officials use these tables statewide, improper usage is often seen. Simply adding a disclaimer to the tables or teaching workshops on the proper usage, ultimately could help in the understanding and the context as to when these table values should be used. An example of this can be seen in the notes at the end of Appendix A.

4. *The survey of state DOT practices could be expanded and attempts made to contact every state to gain further knowledge and understanding of cost estimation processes used.* By continuing the survey, more state methods would be known, allowing for a complete analysis of field methods to be conducted. Furthermore, a complete list of problems affecting the process could be created, allowing another study to concentrate on alleviating those problems through development of new methods.

5. *Further study into the causes of cost increases and the relative contribution of various factors (such as changes in project scope and unforeseen field conditions) to increases in project cost estimates could lead to targeted efforts to mitigate the impacts of certain contributing factors.* For example, if it were found that changes in project scope, after the initial planning-stage cost estimate is developed, accounted for more increases in project cost estimates than any other factor, efforts could be made to develop a more refined project scope earlier in project development. Such efforts could include earlier contacts with local governments and concerned citizen groups that yield an agreed-upon concept for a project, clearly indicating which potential features are included in the concept.

6. *A thorough evaluation of the accuracy and efficacy of the process currently used by VDOT may reveal weaknesses in the existing process that account for substantial inaccuracies in estimated costs.* Although it appears that the methodology employed by VDOT is fairly consistent with those of several other state DOTs, there may be room for improvement within the general process currently used.

7. *The potential for a research effort intended to develop new models for estimating highway project costs based on project concepts should be assessed.* Such an effort could consider the limited information available during the planning stage of development, and through use of cost estimates and completed cost data for a large number of projects, a mathematical model could be developed to generate highway project cost estimates.

ACKNOWLEDGMENTS

The authors thank Joe Orcutt, Milton Watkins, and Jimmy Vaughn of VDOT's Transportation Planning Division for their assistance with this study. The review comments provided by John Miller, Wayne Ferguson, and Gene Arnold of the Research Council are also appreciated. Finally, the authors particularly appreciate the time and effort given to this study by respondents to the survey of state DOT practices.

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APPENDIX A

VDOT PLANNING COST ESTIMATES TABLES[2]

Transportation Planning Division
Planning Cost Estimates

Updated April 2000 by VDOT TPD

Original cost estimates developed by TPD – November 22, 1993
Cost includes 20% for engineering and contingencies.

Urban Typical Sections

Bikeway		5' pavement		CPM	378,000
2 lanes	U2	26'-30' pavement	Reconst or New	CPM	2,100,000
3 lanes	U3	36'-40' pavement	Reconst or New	CPM	4,000,000
4 lanes	U4	40'-48' pavement	Reconst or New	CPM	4,800,000
4 lanes divided	U4D	48' pavement w/16' raised median	Reconst or New	CPM	5,300,000
4 lanes divided	U4D	48' pavement w/28' raised median	Reconst or New	CPM	5,700,000
6 lanes divided	U6D	72' pavement w/16' raised median	Reconst or New	CPM	6,900,000
6 lanes divided	U6D	72' pavement w/28' raised median	Reconst or New	CPM	7,400,000
8 lanes divided	U8D	96' pavement w/16' raised median	Reconst or New	CPM	8,600,000
8 lanes divided	U8D	96' pavement w/16' raised median	Reconst or New	CPM	9,000,000

Right and Left Turn Lanes on a Four Lane Road

Right turn lane	100' parallel and 100' taper	@	74,000
Left turn lane	200' parallel and 200' taper	@	90,000
Crossover			68,000
Provide new crossover with two right and two left turn lanes.		@	395,000

Rural Typical Sections

Bikeway		5' pavement		CPM	170,000
1 lane	R2	12' pavement		CPM	230,000
2 lanes	R2	18' pavement	Reconst or New	CPM	350,000
2 lanes	R2	20' pavement	Reconst or New	CPM	580,000
2 lanes	R2	22' pavement	Reconst or New	CPM	690,000
2 lanes	R2	24' pavement	Reconst or New	CPM	1,000,000
3 lanes	R3	36' pavement	Reconst or New	CPM	2,000,000
4 lanes divided	R4D	48' pavement w/dep. Med.	Reconst	CPM	2,700,000
4 lanes divided	R4D	48' pavement w/dep. Med.	New		4,100,000
4 lanes divided	R4D	48' pavement w/dep. Med.	Parallel		2,100,000
4 lanes divided	R4D	48' pavement w/16' R med.	Reconst or New	CPM	2,900,000
4 lanes divided	R4D	48' pavement w/28' R med.	Reconst or New	CPM	3,400,000

6 lanes divided	R4D	72' pavement widen 4-6 lanes	Reconst	CPM	3,800,000
6 lanes divided	R4D	72' pavement w/dep. Med.	New	CPM	5,000,000
8 lanes divided	R4D	96' pavement widen 6-8 lanes	Reconst	CPM	3,800,000
8 lanes divided	R4D	96' pavement widen 4-8 lanes	Reconst	CPM	7,500,000

Right and Left Center Turn Lanes on a Two Lane Road

Design speed 55 M.P.H.

One lane turn lane	500' parallel and two 700' taper	0.36mi.	@	549,000
Two left turn lanes	900' parallel and two 700' taper	0.44mi.	@	625,000
Right and left turn lane			@	623,000
Two right and two left turn lanes			@	772,000

Bridge Cost

Over 25' to 200' in length	Widen Reconst or New	per sq ft	84
Over 200' in length	Widen Reconst or New	per sq ft	105

Other Improvement Cost

Eliminate parking; restripe (both sides)	CPM	60,000
Provide Signal at unsignalized intersection	@	180,000
Improve, replace Signal at intersection	@	90,000
Improve phasing of system, signalized intersections	@	120,000
Provide pedestrian signal phase	@	24,000
Provide pedestrian crosswalk	@	700
Downtown signage	CPM	18,000
Close open ditch drainage and provide curb & gutter	CPM	1,000,000
Widen radius for truck turning	@	25,000
Install railroad warning lights (no gates)	@	25,000
Lower railroad bed by 2 ft. for a 1,000 ft.	CPM	2,000,000
Provide park and ride facility	CPS	1,800
Fixed route shuttle service	@	600,000
Provide 5' ft. sidewalk	CPM	64,000
Provide 8' hike/bike trail off road	CPM	101,000
Improve grade separated interchange	@	24,000,000
Provide grade separated interchange	@	36,000,000
Provide new grade separated interchange	@	36,000,000

Right of Way & Utilities Cost % of Cost Estimate

Rural	25 %
Residential / Suburban low density	50 %
Outlying business / Suburban high density	60 %
Central business district	100 %

Replacing Railroad Bridge over Roadway

R2	Number of tracks	1	5,900,000
R4D, R4R, U4R, U4	Number of tracks	1	6,900,000
R6D, R6R, U6R	Number of tracks	1	8,200,000
R8D, R8R, U8R	Number of tracks	1	9,200,000
R2	Number of tracks	2	6,900,000
R4D, R4R, U4R, U4	Number of tracks	2	8,200,000
R6D, R6R, U6R	Number of tracks	2	9,200,000

R8D, R8R, U8R	Number of tracks	2	12,200,000
R2	Number of tracks	3	8,200,000
R4D, R4R, U4R, U4	Number of tracks	3	9,200,000
R6D, R6R, U6R	Number of tracks	3	12,200,000
R8D, R8R, U8R	Number of tracks	3	12,800,000

	Box Culv. (Per Structure)	
2 lanes	1'-10'	183,000
2 lanes	10'-14'	210,000
2 lanes	15'-19'	220,000
2 lanes	20'-24'	278,000
2 lanes	25'-29'	300,000
2 lanes	30'-35'	367,000
4 lanes	1'-10'	278,000
4 lanes	10'-14'	325,000
4 lanes	15'-19'	368,000
4 lanes	20'-24'	488,000
4 lanes	25'-29'	557,000
4 lanes	30'-35'	645,000
6 lanes	1'-10'	315,000
6 lanes	10'-14'	368,000
6 lanes	15'-19'	415,000
6 lanes	20'-24'	557,000
6 lanes	25'-29'	609,000
6 lanes	30'-35'	735,000

Source: Virginia Department of Transportation: Transportation Planning Division.

Note: The values shown within this figure are adjusted periodically to help keep all estimates current with actual, present day, market costs. This figure is used statewide in Virginia by various entities, including VDOT, state contractors and consultants.

These cost estimate values are merely an abridged technique and should be used only as a guide. It is designed for experienced professionals to interpret the final values obtained from the tables, and then conclude if a deviation/adjustment is needed when analyzing the final cost estimation figures.

Definitions:
- U2 = Urban 2-lanes
- R4 = Rural 4-lanes
- R6D = Rural 6-lanes Divided
- CPM = Cost-per-Mile
- Reconst = Reconstruction
- Dep. Med. = Depressed Median

Disclaimer: Planning cost estimate tables must be used with caution. These numbers were created solely by the VDOT Transportation Planning Division and should be reviewed, analyzed, and altered by experienced professionals. As in every project, certain details should be added or deleted, depending on the individual situation. The cost figures obtained from these tables should be used with discretion, until further information is provided from the actual design data. Again, this method is intended only as a guide for planning purposes only.

APPENDIX B

SURVEY INSTRUMENT: SURVEY OF STATE DOT PRACTICES IN ESTIMATING HIGHWAY PROJECT COSTS IN THE PLANNING PROCESS

VIRGINIA TRANSPORTATION RESEARCH COUNCIL

SURVEY OF STATE DOT PRACTICES IN PLANNING-STAGE HIGHWAY PROJECT COST ESTIMATING

1. What is the name of your office or division within your state DOT (who is responsible for estimates prior to commencement of preliminary engineering / design activities)?

2. How are cost estimates developed for proposed highway projects (in the planning phase, prior to design) to be inserted into the transportation improvement program (TIP)?

3. In the method for developing these cost estimates, what factors are taken into account? (e.g. system classification (functional or administrative), number of lanes, lane width, median type, location, urban vs. rural, terrain, soil type, etc.)

4. How are preliminary engineering and right-of-way costs accounted for? How are complex elements such as interchanges estimated? Are other items (beside PE and RW) accounted for separately?

5. Is there a written procedure or manual used in this process?

6. Are any cost escalation factors or contingencies that attempt to account for inflation, changes in project scope ("scope creep"), etc., used in these estimates?

7. Has any effort been made to compare costs estimated at the planning phase with project costs as bid or with final construction costs?

8. Have project cost estimates on projects in your state been subject to scrutiny recently in the media or by elected officials?

APPENDIX C

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