Research Report
KTC 94-9

COST ESTIMATING AND FORECASTING
FOR HIGHWAY WORK IN KENTUCKY

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in cooperation with Kentucky Transportation Cabinet

and

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There is a need for a better cost estimating and forecasting for highway work in the Commonwealth of Kentucky. KRS45.245 grants the Interim Joint Committee on Transportation oversight of the biennial highway plan, including a review of all authorized highway project phases that exceed their estimates by 15%. In recent years, the Kentucky Transportation Cabinet has suffered the loss of many resources necessary to produce good cost estimated.

Estimates developed using current methods are not sufficiently accurate to preclude cost overruns in excess of 15%. During the biennium 134 overruns, totalling over $69 million, have been submitted to the Committee. All have been approved for additional funding.

Current estimating practices in Kentucky and other states were studied, and the causes for cost overruns greater than 15% during the current biennium were analyzed. Preliminary recommendations, based on the first eight months of this three year study are presented.
EXECUTIVE SUMMARY

There is a need for better cost estimating and forecasting for highway work in the Commonwealth of Kentucky. The objective of this study, approved July 1993, is to investigate current practices and to recommend improvements for the estimating process. This report details the finding of the first eight months of the research effort and outlines the path forward.

The Kentucky Transportation Cabinet (KyTC) is responsible for the creation of a six-year highway construction plan listing proposed projects which reflects the highway needs of the state. The Legislature approves those projects that will be funded in the coming biennium. This biennial element must be fiscally balanced by matching projected annual funding against estimated project costs. Funding decisions are based on the estimated cost of the work scope as defined at the time the estimate was prepared. Reasonable cost forecasts for new and ongoing projects are required to ensure that funding is available and projects can be advanced on an orderly schedule.

KRS45.245, effective 1 July, 1992, grants the Interim Joint Committee on Transportation (IJCT) oversight of the biennial highway plan. Any phase of an authorized highway project—design, right of way, utility relocation, or construction—that exceeds the estimate shown in the plan by 15% must be reviewed by the IJCT. In recent years the KyTC has suffered the loss of many resources—personnel, funding, and experience—necessary to produce good cost estimates.

Estimates developed using current methods have not proven sufficiently accurate to preclude cost overruns in excess of 15%. During the current biennium to date (7/1/92 - 2/13/94) 134 overruns, totaling $69,503,094, have been submitted to the IJCT. All have been approved for additional funding. No concerted effort was made to track the number of cost underruns. The main cause of cost overruns was project scope changes after initial estimates were made.
Estimates for highway projects are usually the responsibility of the 12 District Highway Offices, which have neither funds nor resources allotted to estimating. Initial estimates, based on very little information, don't statistically support a ±15% confidence level. Unless these estimates can be updated before they appear in the biennial highway plan they are likely to be the cause of IJCT action later.

Other states face many of the same problems with cost forecasting as Kentucky does. A noticeable difference is that most states have no legislative control after budget approval, and poor estimates aren't considered a problem as long as total project overruns and underruns are approximately equal. Many states have better estimating procedures than does Kentucky, primarily attributable to more resources and better funding.

There are three ways to mitigate the problem of poor cost forecasting. The first is for the Legislature to either forego the oversight or to modify it so the KyTC can meet the requirements with current staffing levels, the second is for the KyTC to change how the highway plan is developed, and the third is for the KyTC to staff up as necessary to improve its estimating ability. All of these options have financial and political implications.

Currently, a feeling of mistrust exists between the Legislature and the KyTC. To date, the IJCT has summarily approved all overruns presented to it; preparing justifications for these overruns has consumed valuable KyTC resources. Estimators are now padding estimates to reduce the likelihood of having to justify future overruns. This practice leads to having to haphazardly advance new project phases into the biennial plan to avoid losing available federal funds.

This study offers an opportunity to make improvements to the KyTC's cost forecasting ability and to the relationship between the KyTC and the Legislature. To seize this opportunity both the Legislature and the KyTC must communicate openly with each other, and with the researcher, in an effort to find a workable solution which considers both political and fiscal realities.
The KyTC should be proactive in looking for innovative ways to improve both estimates and relations with the Legislature. Some promising areas involve more study prior to adding a project to the highway plan, better use of historical data through computer technology, and creating a budget for estimating.

The Legislature should be proactive by passing laws to mitigate scope growth of projects and by explaining to the KyTC exactly what is expected of them. Two important issues are ways to reduce escalation of right of way costs after project routes are determined, and the funding of unanticipated environmental costs. Relaxing the requirement that the KyTC document, in detail, and formally present, all phase cost overruns >15% would lessen the burden of Cabinet personnel—the same ones that should be producing better estimates. Phase overruns which are actually caused by poor practices and/or might be subject to other than summary approval by the IJCT, should continue to be formally reported.

Emphasis for the remainder of this year and for Year 2 of this study will be on new and/or modified procedures and tools to improve the estimating and cost forecasting ability of the KyTC. In Year 3, KyTC personnel will be trained on the new/modified procedures.
INTRODUCTION

There is a need for better cost estimating and forecasting for highway work in the Commonwealth of Kentucky. This need has been recognized by the Kentucky Transportation Cabinet (KyTC), the Kentucky Legislature and the Federal Highway Administration (FHWA). A research project was approved by the KyTC and the FHWA, starting in July, 1993, to study current practices and to recommend improvements for the estimating process. The project timetable specifies the following annual goals:

- Year 1 (7/93-6/94) - Study current practices and problems, and make preliminary recommendations for potential improvement areas.
- Year 2 (7/94-6/95) - Develop and/or modify procedures and tools to improve the estimating process.
- Year 3 (7/95-6/96) - Implement improvements and train KyTC personnel in their use.

This report discusses the findings of the first eight months of the project:
- The need for good cost estimates
- Estimates during the current biennium
- Estimating practices in Kentucky
- Estimating practices in other states

The impetus for improving cost forecasting for highway work comes from a recent law passed during the 1992 General Assembly session. KRS 45.245, effective July 1, 1992, mandates that the amount authorized for expenditure on any project phase—design, right-of-way, utility relocation or construction—cannot exceed that stated in the current biennium highway plan by more than 15% without being presented by the KyTC to the Legislature’s Interim Joint Committee on Transportation (IJCT) for review. The presentation to the IJCT must include written certification from the State Highway Engineer that the overrun was caused by unanticipated circumstances, and provide specific details on the reasons for the cost overrun. The IJCT determines if the proposed additional money is reasonable and
necessary, and also, if any alteration made or planned since its consideration by the General Assembly materially changed the project.

Methodology used by the researchers during the period covered by this report consisted of:

- a literature search to investigate published material on estimating and cost forecasting for highway projects,
- visits to the twelve district highway offices where discussions were held with district preconstruction engineers, and others, on the strengths and weaknesses of current estimating practices,
- a follow-up questionnaire to elicit responses to commonly voiced problems and potential solutions,
- interviews with KyTC top appointed officials and two key legislators to obtain their perceptions of needed changes,
- a joint meeting with district preconstruction engineers, several KyTC department heads, and others to discuss common problems and potential solutions,
- phone contact with preconstruction personnel in all 50 states and the District of Columbia to ask about current practices for estimating highway costs in their areas,
- an analysis of cost overruns approved by the IJCT during the current biennium, and
- the development of a preliminary cost per mile database.
THE NEED FOR GOOD ESTIMATES

The KyTC is responsible for the creation of a six-year highway construction plan (6YP). This plan is a listing of proposed projects which reflects the highway needs of the state. The Legislature approves those projects that will appear in the biennial element—in this report called the two year plan (2YP). The 2YP is fiscally balanced by matching projected annual funding against estimated project costs.

The Program Management Office (Programming Staff) of the KyTC is responsible for creating the draft 6YP that is submitted to the General Assembly for approval. In preparing the 6YP, the Programming Staff balances estimated project costs with the projected budget for highway construction over the following six years. Proposed projects, in order to be considered, must have a cost estimate, by phase, to allow the Programming Staff to balance the draft 6YP. Funding decisions are based on the estimated cost of the work scope as defined at the time the estimate was prepared.

A cost estimate is a forecast of the actual costs to be incurred in completing a given scope of work. Estimates are used for planning, budgeting and controlling projects. Reasonable cost forecasts for new and ongoing projects are required to ensure that funding is available and projects can be advanced on an orderly schedule.

A necessary first step in producing a good estimate is to define what a good estimate is. Generally, a good cost estimate is one that is approximately equal to the final cost. There can be other definitions as well. If an estimate is used to set a maximum or minimum cost, then a good estimate is one that sets a limit which the final cost does not exceed. For example, the IJCT might consider a high estimate, which has little likelihood of being exceeded by actual costs, a good estimate. This greatly reduces the number of cost overruns and enhances the probability that all project phases in the 2YP get completed during the biennium. KyTC’s Programming Staff might think a low estimate, which has a great likelihood of being exceeded by actual costs, a good estimate. This lessens the probability of
For this study, a good estimate is one that tries to forecast the actual cost, based on the information available.

All estimates are based on experience. The accuracy of an estimate is determined by the information available from previous projects and how closely that relates to the current project. No two projects are exactly alike, and even those that are very similar can vary considerably in cost. Some reasons for this are inflation, job conditions, land prices, presence of utilities, environmental and historic concerns, and the economy. The first estimate for a new project is a conceptual estimate. For highway work in Kentucky, this usually means a quick estimate based on a brief description of the project, often no more than a road classification with starting and ending points. Under these circumstances, the accuracy of the estimate will be low, i.e., the variability of the actual cost will be high.

As an example, a certain project has a conceptual estimate of $10M(illion) with a standard deviation (σ) of 10% (roughly equivalent to a ± 30% estimate). The graph in Figure 1 shows the probability distribution associated with the expected actual cost vs. the estimated cost.

![Figure 1. Expected Actual Cost vs. Estimated Cost](image-url)
The probabilities of the actual cost as related to the estimated cost ($10M) are as follows:

- Probability of going over estimate = 50% (area right of c)
- Probability of coming in under estimate = 50% (area left of c)
- Probability of actual being within ± 10% of estimate = 68% (area between b & d)
- Probability of going over estimate by 15% = 7% (area right of e)
- Probability of coming in under estimate by 15% = 7% (area left of a)

Therefore, if the conceptual estimate reflects the expected cost ($10M), and if the standard deviation (σ) of 10% is reasonable, a cost overrun exceeding 15% should be expected 7% of the time. Also, a cost underrun should be expected 7% of the time.

Is this acceptable, given the 15% limitation? If the answer is no, there are two ways to attack the problem. The first is to reduce the variability with better project information for the conceptual estimate and the second is to purposely provide an estimate higher than the expected cost, i.e. pad the estimate. Both ways have their drawbacks. Better information requires more resources and a better scope of work. Padding the estimate, while reducing the chance of exceeding the estimate by 15%, increases the chance of major underruns, thereby underutilizing available funds.
ESTIMATES DURING THE CURRENT BIENNUM

Estimates developed using current methods have not proven sufficiently accurate to preclude cost overruns in excess of 15%. During the current biennium to date (7/1/92 - 2/13/94), 134 overruns, totaling $69,503,094, have been submitted to the IJCT. All have been approved for additional funding.

The following analysis is based on information compiled from all past copies of the Notification to Legislature's Interim Joint Committee on Transportation Concerning Project Phase Cost Overruns > 15%. This document, an overrun summary, is submitted by the KyTC to the IJCT for a phase overrun >15% and is identified by a tracking number.

Figure 2 shows a breakdown of the number of overrun occurrences, by phase. Figure 3 shows a breakdown of overrun costs, by phase.
Table 1 shows the cost and frequency breakdown, by phase, of the 134 overruns to date. Tables 2-5 show specific overrun causes for each phase and the number of occurrences of each. Because some overruns have more than one cause listed, the total number of cause occurrences may be higher than the total number of overruns for a phase. Entries in the column, Contributing Track Numbers, refer to the specific documents where a cause is used as justification for an overrun. A brief synopsis of the impact of the overruns in each phase is also provided.

Table 1: Breakdown of Highway Cost Estimate Overruns by Phase.

<table>
<thead>
<tr>
<th>Phase</th>
<th>Number of Occurrences</th>
<th>% Occurring *</th>
<th>Total Cost of Phase Overruns</th>
<th>% Cost **</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design</td>
<td>13</td>
<td>9.7%</td>
<td>$1,690,000</td>
<td>2.4%</td>
</tr>
<tr>
<td>Right of Way</td>
<td>30</td>
<td>22.4%</td>
<td>$6,646,000</td>
<td>9.6%</td>
</tr>
<tr>
<td>Utility Relocation</td>
<td>38</td>
<td>28.4%</td>
<td>$14,808,000</td>
<td>21.3%</td>
</tr>
<tr>
<td>Construction</td>
<td>53</td>
<td>39.5%</td>
<td>$46,359,094</td>
<td>66.7%</td>
</tr>
<tr>
<td>Totals =</td>
<td>134</td>
<td>100%</td>
<td>$69,503,094</td>
<td>100%</td>
</tr>
</tbody>
</table>

* percent of the 134 overruns that occurred in each phase
** percent of the total cost of the 134 overruns ($69,503,094) attributable to phase

**Design Phase Overruns**

Overruns in the design phase accounted for 9.7% of the total number and 2.4% of the total cost of all overruns: thirteen (13) overruns @ $1,690,000. Table 2 shows that underestimation because consultant fees were higher than the estimated *in house* design costs, underestimation of the complexity of the project, and scope changes due to worse than expected site conditions were the three primary causes for design phase overruns. These causes accounted for 69.3% of all design phase overruns.
Table 2: Breakdown of Design Phase Overruns

<table>
<thead>
<tr>
<th>Cause/Justification of Overrun</th>
<th>Number of Occurrences as Causes for Design Phase Overruns</th>
<th>% Occurrence (of All Design Phase Overruns)</th>
<th>Contributing Track Numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>underestimation of complexity of project necessitating further design effort over what was originally envisioned</td>
<td>3</td>
<td>23.1%</td>
<td>5, 88, 89</td>
</tr>
<tr>
<td>underestimation because consultant fees were higher than the estimated in-house design costs</td>
<td>3</td>
<td>23.1%</td>
<td>98, 99, 106</td>
</tr>
<tr>
<td>scope changes due to site conditions being worse than expected</td>
<td>3</td>
<td>23.1%</td>
<td>53, 96, 109</td>
</tr>
<tr>
<td>scope changes due to local and public pressure &amp; involvement</td>
<td>1</td>
<td>7.7%</td>
<td>67</td>
</tr>
<tr>
<td>shift in alignment necessitating a greater design effort than what was initially estimated</td>
<td>1</td>
<td>7.7%</td>
<td>2</td>
</tr>
<tr>
<td>underestimation of design cost for large scale landscaping project</td>
<td>1</td>
<td>7.7%</td>
<td>25</td>
</tr>
<tr>
<td>initial estimate based on preliminary plans, maps, and data</td>
<td>1</td>
<td>7.7%</td>
<td>37</td>
</tr>
<tr>
<td>Totals =</td>
<td>13</td>
<td>100%</td>
<td></td>
</tr>
</tbody>
</table>

Right of Way Overruns

Overruns in the right of way phase accounted for 22.4% of the total number and 9.6% of the total cost of all overruns: thirty (30) overruns @ $6,646,000. Table 3 shows that the leading cause for right of way overruns were changes in project scope made during the design phase and after the initial estimate was made. Scope changes in design arose for a variety of reasons. Oftentimes, changes were made to provide an improved facility over what was originally envisioned. Other times design calculations (i.e. hydraulic analysis, sight distance requirements, traffic impact studies, etc.) led to design changes involving more or different right of way parcels than originally anticipated. These design changes included shifts in roadway alignment, widening of the proposed roadway and lengthening of bridges and
approaches. The second leading cause of right of way overruns was estimates based on preliminary plans, maps, and project information. This accounted for roughly a third of the right of way overruns.

Table 3: Breakdown of Right of Way Phase Overruns

<table>
<thead>
<tr>
<th>Cause/Justification of Overrun</th>
<th>Number of Occurrences as Causes for ROW Phase Overruns</th>
<th>% Occurrence (% of All ROW Phase Overruns)</th>
<th>Contributing Track Numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>changes in project scope as a result of decisions made in design</td>
<td>16</td>
<td>40%</td>
<td>3, 24, 51, 51, 55, 62, 63, 70, 71, 76, 83, 86, 95, 108, 117, 118</td>
</tr>
<tr>
<td>changes in project scope as a result of worse than expected site conditions</td>
<td>2</td>
<td>5%</td>
<td>38, 59</td>
</tr>
<tr>
<td>initial estimate made with very preliminary plans, maps, and generalized data: estimate updated based on more design detail</td>
<td>13</td>
<td>32.5%</td>
<td>3, 6, 7, 9, 10, 16, 40, 59, 69, 71, 102, 105, 117</td>
</tr>
<tr>
<td>inadvertent omission</td>
<td>4</td>
<td>10%</td>
<td>1, 58, 70, 76</td>
</tr>
<tr>
<td>new or modified legislation enacted after initial estimate made</td>
<td>3</td>
<td>7.5%</td>
<td>16, 51, 64</td>
</tr>
<tr>
<td>improvement made to right of way after initial estimate was made</td>
<td>1</td>
<td>2.5%</td>
<td>72</td>
</tr>
<tr>
<td>rise in land values in vicinity of proposed right of way</td>
<td>1</td>
<td>2.5%</td>
<td>16</td>
</tr>
<tr>
<td>Totals</td>
<td>40</td>
<td>100%</td>
<td></td>
</tr>
</tbody>
</table>

Utility Relocation Phase Overruns

Overruns in the utility relocation phase accounted for 28.4% of the total number and 21.3% of the total cost of all overruns: thirty-eight (38) overruns at $14,808,000. Table 4 shows that the most frequent cause for utility relocation overruns, like that for the right of way phase, came from changes made in the project scope during the design phase. Similarly, the second leading cause for utility relocation phase overruns was due to initial estimates being
made based on very preliminary plans, maps, and project information. Combined, these two causes accounted for two-thirds of all the utility relocation phase overruns.

Table 4: Breakdown of Utility Relocation Phase Overruns.

<table>
<thead>
<tr>
<th>Cause/Justification of Overrun</th>
<th>Number of Occurrences as Causes for Utility relocation Phase Overruns</th>
<th>% Occurrence (% of All Utility relocation Phase Overruns)</th>
<th>Contributing Track Numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>changes in project scope as a result of decisions made in design</td>
<td>20</td>
<td>37%</td>
<td>3, 4, 50, 51, 51, 52, 55, 62, 71, 75, 77, 86, 87, 90, 95, 103, 104, 117, 119, 120</td>
</tr>
<tr>
<td>initial estimate made with very preliminary plans, maps, and generalized data. Estimate updated based on more design detail</td>
<td>16</td>
<td>29.6%</td>
<td>3, 6, 7, 9, 22, 23, 39, 60, 68, 69, 71, 82, 95, 102, 105, 117</td>
</tr>
<tr>
<td>inadvertent omission</td>
<td>3</td>
<td>5.6%</td>
<td>11, 49, 52</td>
</tr>
<tr>
<td>accidental transposition of two estimates in development of Y</td>
<td>2</td>
<td>3.7%</td>
<td>8, 91</td>
</tr>
<tr>
<td>upgrade in utility line not realized at time of estimate</td>
<td>1</td>
<td>1.9%</td>
<td>36</td>
</tr>
<tr>
<td>new installed in proposed ROW after estimate made</td>
<td>2</td>
<td>3.7%</td>
<td>48, 120</td>
</tr>
<tr>
<td>utility line thought to be privately owned is actually publicly owned (this required full relocation reimbursement)</td>
<td>1</td>
<td>1.9%</td>
<td>48</td>
</tr>
<tr>
<td>increase in relocation costs over what was expected</td>
<td>1</td>
<td>1.9%</td>
<td>49</td>
</tr>
<tr>
<td>new laws enacted necessitating higher utility relocation costs</td>
<td>2</td>
<td>3.7%</td>
<td>51, 62</td>
</tr>
<tr>
<td>no inflation factor on estimate</td>
<td>1</td>
<td>1.9%</td>
<td>82</td>
</tr>
<tr>
<td>underestimation of state force involvement cost</td>
<td>1</td>
<td>1.9%</td>
<td>120</td>
</tr>
<tr>
<td>changes in scope due to worse than expected site conditions</td>
<td>4</td>
<td>7.4%</td>
<td>38, 71, 82, 82</td>
</tr>
<tr>
<td>Totals =</td>
<td>54</td>
<td>100%</td>
<td></td>
</tr>
</tbody>
</table>

10
**Construction Phase Overruns**

Overruns in the construction phase accounted for 39.5% of the total number and 66.7% of the total cost of all overruns >15%: fifty-three (53) overruns @ $46,503,094. The majority of overruns to date have occurred in the construction phase. In addition, the construction phase comprised the largest percent of the total overrun cost, doubling that of the other three phases combined. Table 5 shows that the two leading causes for construction overruns were higher than expected unit bid prices and/or individual work item costs, and changes in project scope as a result of changes made in the design phase. These two causes were listed 58.5% of the time. Changes in project scope due to worse than assumed site conditions were also common causes for overruns.

Table 5: Breakdown of Construction Phase Overruns.

<table>
<thead>
<tr>
<th>Cause/Justification of Overrun</th>
<th>Number of Occurrences as Causes for Construction Phase Overruns</th>
<th>% Occurrence (% of All Construction Phase Overruns)</th>
<th>Contributing Track Numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>higher than expected unit bid prices and/or individual work item costs</td>
<td>23</td>
<td>29.9%</td>
<td>12, 12, 15, 19, 20, 21, 26, 28, 34, 35, 35, 42, 43, 44, 46, 47, 54, 54, 56, 57, 57, 66, 79</td>
</tr>
<tr>
<td>changes in project scope as a result of decisions made in design</td>
<td>22</td>
<td>28.6%</td>
<td>13, 18, 21, 26, 30, 31, 34, 35, 41, 46, 54, 56, 61, 66, 74, 79, 80, 101, 107, 110, 111, 112</td>
</tr>
<tr>
<td>changes in scope due to worse than expected site conditions</td>
<td>16</td>
<td>20.8%</td>
<td>14, 17, 27, 32, 33, 65, 73, 74, 78, 84, 85, 92, 94, 97, 112, 113</td>
</tr>
<tr>
<td>initial estimate made with very preliminary plans, maps, and generalized data: estimate updated based on more design detail</td>
<td>4</td>
<td>5.2%</td>
<td>15, 29, 57, 81</td>
</tr>
<tr>
<td>inadvertent omission</td>
<td>6</td>
<td>7.8%</td>
<td>19, 42, 43, 85, 93, 101</td>
</tr>
</tbody>
</table>

(continued on next page)
<table>
<thead>
<tr>
<th>Cause/Justification of Overrun</th>
<th>Number of Occurrences as Causes for Construction Phase Overruns</th>
<th>% Occurrence (% of All Construction Phase Overruns)</th>
<th>Contributing Track Numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>higher than expected unit bid prices and/or individual work item costs</td>
<td>23</td>
<td>29.9%</td>
<td>12, 12, 15, 19, 20, 21, 26, 28, 34, 35, 35, 42, 43, 44, 46, 47, 54, 54, 56, 57, 57, 66, 79</td>
</tr>
<tr>
<td>changes in project scope as a result of decisions made in design</td>
<td>22</td>
<td>28.6%</td>
<td>13, 18, 21, 26, 30, 31, 34, 35, 41, 46, 54, 56, 61, 66, 74, 79, 80, 101, 107, 110, 111, 112</td>
</tr>
<tr>
<td>changes in scope due to worse than expected site conditions</td>
<td>16</td>
<td>20.8%</td>
<td>14, 17, 27, 32, 33, 65, 73, 74, 78, 84, 85, 92, 94, 97, 112, 113</td>
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<tr>
<td>initial estimate made with very preliminary plans, maps, and generalized data: estimate updated based on more design detail</td>
<td>4</td>
<td>5.2%</td>
<td>15, 29, 57, 81</td>
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<td>inadvertent omission</td>
<td>6</td>
<td>7.8%</td>
<td>19, 42, 43, 85, 93, 101</td>
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<td>complexity of construction underestimated</td>
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<td>21</td>
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<tr>
<td>utility work done in construction phase</td>
<td>2</td>
<td>2.6%</td>
<td>45, 116</td>
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<tr>
<td>bonuses for minimal traffic impact given</td>
<td>1</td>
<td>1.3%</td>
<td>85</td>
</tr>
<tr>
<td>sporadic contractor activity led to higher than expected state supervision costs</td>
<td>1</td>
<td>1.3%</td>
<td>97</td>
</tr>
<tr>
<td>two separate construction phases combined to minimize overall cost to state</td>
<td>1</td>
<td>1.3%</td>
<td>100</td>
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<tr>
<td>Totals</td>
<td>77</td>
<td>100%</td>
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The following conclusions can be drawn from the data presented in Tables 1-5.

- Design phase overruns account for only 2.43% of the total cost of all overruns reported. Design phase overruns are not a major problem.

- Based on the 134 overruns to date, the following would likely have occurred if estimates had been subject to the 15% overrun limitation only after the design phase was completed:
  - 72.5% of the right of way overrun causes would have been eliminated.
  - 66.6% of the utility relocation phase overrun causes would have been eliminated.
  - 35.1% of construction overrun causes would potentially have been eliminated.

- Changes in project scope as a result of worse than expected site conditions contributed 23.1% of the causes listed for design phase overruns; 5% for right of way overruns, 7.4% for utility relocation overruns, and 20.8% for construction overruns. Increased site investigation by designers and estimators might have reduced these overruns, however, some soil conditions and contamination will always present problems.

- Construction phase overruns accounted for 2/3 of the total cost of all overruns. It was stated that 35.1% of construction overrun cause occurrence could potentially be eliminated if estimates were made after design was complete. An additional 29.9% of overrun cause occurrence could be reduced if accurate unit bid price data were used.

- Causes for overruns resulting from omissions in the estimates, transposing of numbers, or switching of work between phases cannot be avoided unless estimates are updated periodically.
Twelve (12) District Highway Offices, representing 120 counties, are responsible for providing estimates, on request, for projects in their respective areas. Estimates for highway work typically start with a conceptual estimate and are updated several times during the preconstruction phases. A given estimate is classified by the amount of information available when the estimate is made. Depending on the phase involved, estimates may be classified as Class A, B, C, D or E, with Class A being the one based on the most information.

The State Highway Engineer Guidance Manual contains a classification system for each phase of a project based on information available at the time of an estimate. The following estimate classifications generally apply to the four project phases in the 6YP.

**Preliminary Engineering (Design) Cost Estimates**
- Class A - based on man hours
- Class B - based on per mile and class of road (adjusted for complexity)
- Class C - based on percentage of construction cost
- Class D - based on a prestudy estimate

**Right of way Cost Estimates**
- Class A - parcel-by-parcel estimate for right of way and relocation costs, plus administrative and any court costs, based on complete right of way plans for programming purposes
- Class B - parcel-by-parcel estimate of right of way and relocation costs, plus administrative and court costs, based on joint inspection plans
- Class C - right of way acreage costs and damages, plus improvements, relocation assistance, and number of parcels, based on plans available for preliminary line and grade inspection
Class D - right of way acreage costs and damages, plus improvements, relocation assistance, and court and administrative costs, with approximate number of parcels, based on limited studies of quad sheets, aerial photos, etc.

Class E - based on prestudy estimate

Utility (Relocation) Cost Estimates
- Class A - based on agreements with utility companies
- Class B - based on final joint inspection plans
- Class C - based on preliminary line inspection plans
- Class D - based on study of quad sheets, planning reports, and available aerial photographs
- Class E - based on prestudy estimate

Construction Cost Estimates
- Class A - plan quantities or quantities for resurfacing, initial treatment, and Force Account
- Class B - based on joint inspection plans
- Class C - based on preliminary line plans
- Class D - based on limited studies of quad sheets, aerial photographs, etc., or on limited studies for projects without plans, such as initial treatment, Force Account, and resurfacing

Engineer's Prebid (Engineer's) Estimate
- Class A - based on plan quantities actually advertised for letting - This estimate is prepared by the Estimating Branch and is privileged information which will be released only to those persons authorized by the State Highway Engineer.

Typically, an estimate request for a potential project is presented to the district office which will oversee the project if it is authorized. Usually, at this time, the project is in the conceptual stage and no design work has yet been done. Even though project elements,
quantities, and geographical route and alignment are unknown, a conceptual estimate must
be made in order to advance the project to the 6YP and the promise of funding.

The District Preconstruction Engineer usually makes the initial estimate based on project
type and beginning/ending termini, using a very rough cost per mile calculation, adjusted by
an experience factor. There are no budgeted funds or time for making the initial estimate,
which leads to a dilemma; i.e., the development of an accurate cost estimate requires time
and funding, but a project can not receive funding without a cost estimate. The choice must
be made whether to do some study before making the estimate or to produce a quick estimate
with no study. If the decision is to do a small study, estimators charge their time to another,
open project. This practice can contribute to a cost overrun in the wrongly charged project.
The true cost of the charged project then becomes difficult to determine, thereby affecting
historic data for use in future estimates. If the decision is to make the estimate without
study, then the accuracy of the estimate is likely to be very poor.

These estimates, which are submitted to the Programming Staff, may or may not be skewed
to either increase the likelihood of having the project approved by the General Assembly (a
low estimate), or to avoid the likelihood of incurring a 15% cost overrun in the future (a high
or padded estimate). Indications are that projects in the past were often underestimated, but
that current estimates are frequently padded.

Some barriers to better initial estimates are:
• Project scope is limited at the time the initial estimate is made.
• Good historical data are not available in a readily useable form.
• District Offices are often called on to make conceptual estimates on the spot. In spite of
  being extremely inaccurate, these estimates often end up in the 6YP.
• There is no planning staff or planning budget in most district offices. Estimating duties
  fall to some staff member who has to charge his or her time to overhead or another, open
  project. This has the effect of overcharging an open job and losing accountability of the
effort put into estimating the new job.
• Environmental concerns cause many overruns, yet the district offices have no environmental staff and little way to account for potential impact.

• Bridge costs are very difficult to estimate until drainage calculations are complete. These calculations are made during the design phase.

• Many of the district offices rely on large scale, USGS maps for laying out a proposed project when preparing an estimate. The scale on these maps is not sufficient to insure a reasonable amount of accuracy; the width of a pencil line can cause a variance of ±25 feet, making it very difficult for right of way and utility relocation estimates to be within 15%.

• In the past, there has been little accountability for estimates. Today, there is accountability but the incentive is to pad the estimates so that the projects are unlikely to overrun.

Once an estimate has been submitted, the Programming Staff may place the project into the 6YP. Frequently, however, a proposed project is delayed, and is placed on an unscheduled needs list which serves as a feeder for future editions of the 6YP. Another estimate should be produced at the time the project is advanced to the 6YP, but often is not, because of the lack of resources in the district offices.

When phases of a project on the 6YP are advanced to the 2YP, updated estimates should be made for those phases. In the past, this was not always done; however, recent efforts by the KyTC have improved this situation. Once a project becomes part of the 2YP and funding is approved, it is then subject to the 15% overrun limitation.

There are numerous causes for estimates to change after projects are placed into the 6YP. By far the most common cause of changes from the initial cost estimates for all phases arises from changes in project scope. The problem of scope changes is an inevitable result of the limited design effort made prior to the initial estimate. A frequently occurring justification for overruns given by the KyTC is that only very preliminary maps and project information were available at the time the initial estimate was made. Often, key information like right of
way limits, number of lanes, final roadway alignment, etc., only becomes known as the design matures. Changes in pavement design, shifts in alignment, and increases in the originally assumed quantities are only a few of the reasons, resulting from making initial estimates based on a limited design effort, that have been cited by the KyTC as causes for phase cost overruns.

Some of the common causes for estimates to change after the initial estimate are:

- Some initial 6YP estimates advance to the 2YP without being updated. Even very good initial estimates are subject to changes caused by inflation, changes made to the proposed site while the project progressed through the six year plan, or new harsher environmental legislation passed after the estimate was made.

- Some estimates appearing in the 6YP were changed after being submitted by a district office or were not produced by a district office at all.

- Changes during the design phase:
  - engineering work required to develop a preferred solution
  - environmental work which was unknown at the time of initial estimate
  - geotechnical work based on final project location
  - less experienced personnel borrowed from other districts, the central office and/or consultants

- Changes during the right of way phase:
  - amounts of property and improvements needed
  - location of access controls
  - negotiations with landowners
  - appreciation of property during project development
  - high court awards
• Changes during the utility relocation phase:
  • poor utility company records showing actual utility locations
  • poor records of type of materials used in the past
  • congestion of areas affected
  • cost of property adjacent to project, if needed
  • geotechnical conditions at site
  • availability of materials
  • changes in law which affect minimum standards

• Changes during the construction phase:
  • changes made in the previous phases
  • amount of competition for the job
  • the local economy

In the past, too many projects got into the 6YP, primarily because low estimates allowed more projects to be authorized than available funds could cover. The result was that many projects got pushed out of the 2YP. Often, the reason for low estimates was to increase the probability of getting projects into the 6YP, and authorized. KRS45.245 represents an effort to stop this practice. Accountability, such as that imposed by the law, effectively addresses these past practices but causes a new set of problems by allowing too few projects into the 2YP.

A stated purpose of the legislative oversight is to increase the KyTC’s accountability for good estimates. True accountability and continuous improvement of cost estimates requires limitations on both overruns and underruns. When either of these occurs, the oversight should be to determine the cause and improve the process, not to assess blame.
The real results of the legislative oversight, as seen in practice today, are the following:

- On the whole, a feeling of mistrust exists between the Legislature and the KyTC. This is unfortunate because only with both sides working toward the same goal can continuous improvement be realized.

- A lot of time is being spent unnecessarily by the KyTC. Since all overruns presented to the IJCT have been summarily approved, many in the KyTC consider the whole matter of oversight a power play between the Executive and Legislative branches of government.

- Estimators now pad estimates in an effort to avoid overruns. This will surely lower the number of overruns but will considerably increase the need to pull outyear projects into the current biennial plan.

- High estimates actually create a reverse incentive: since the project is authorized at an inflated level, there is no reason to try to save money on the project.
The following discussion centers on information received from Departments of Transportation in other states. This information is sketchy and requires considerable follow-up and verification. The quest for additional information is ongoing.

Phone contacts have been made in all 50 states and Washington D.C. In response to the fifty-one calls the researchers:

- made good contact with valuable information obtained and a promise of documentation (examples, cost per mile data, etc.) to be sent (31 states),
- made contact with the apparent proper office, but the information obtained is sketchy (10 states and D.C.), or
- are waiting for a return call from the appropriate party within the state's DOT (9 states).

Formal questions were posed to all of the contacts about several areas of interest to this study. Findings to date are presented in Table 6.

All contacts were queried about difficulties they face in their states when forecasting highway costs. Not surprisingly, most of the problems stated are similar to those found in Kentucky. The following are general statements of how some states are addressing problems in forecasting highway costs. These data are presented for information only, and are not intended to be statistically significant. Further research is required, and planned, on how other states address problems of forecasting highway costs.

- Most states have some sort of cost per mile information that ties historical data to specific road classifications, which is used for initial estimates.
- Most states have no legislative oversight after budget approval.
- Many states have standard estimating procedures which are used by all districts, with help from the central office.
- Many states update estimates on a specific schedule, some do so annually.
• Some states do not make separate estimates for right of way and utility relocation.
• Some states allocate highway funds by district or region rather than based on statewide needs.
• Some states require preliminary engineering work to be completed before a project enters the highway construction plan.
• Some states do all planning work on state funds in order to have a good estimate before projects are put into the highway plan.
• Some states require that the central office submit all estimates to the Program Management Office.
• Some states use packaged software, off-the-shelf or developed in-house, to assist in estimating.

It is important to note that Table 6 indicates that nearly all states use some sort of cost per mile data in conjunction with road classifications to develop initial estimates, but Kentucky does not. This may or may not be significant since it is not known exactly how, and to what extent, these data are used by other states. Some district offices in Kentucky do have their own historical data to use for estimating but there is not a formal, statewide database available. This may also be the case in some other states.
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<th>STATE</th>
<th>COST/C</th>
<th>INIT. EST.</th>
<th>EST. INST.</th>
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**LEGEND EXPLANATION**

- **COST/MILE** - Do you have a formal cost per mile database available for estimators?
- **CLASS.** - Do you have a uniform road classification system for cost per mile data?
- **INIT. EST.** - What tools are used for conceptual estimating?
- **EST R/W** - Is right of way a separate estimate?
- **EST. UTIL.** - Is utility relocation a separate estimate?
- **EST. PROC.** - Do you have a standard estimate procedure used throughout your organization?
- **ENG. EST.** - Do you publish the engineer's estimate prior to bid?
- **STIP YRS.** - Length of state highway construction plan?
- **BUDG. YRS.** - Length of time covered in the appropriations budget?
- **EST. SCOPE** - Project estimate published by project or by phase?
- **# DIST.** - Number of highway districts or regions in state?
- **DIST. FUND** - Are highway funds earmarked by district or region?

Table 6 - Survey of Estimating Practices in Other States

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**Legend Explanation**

- **Cost/Mile**: Do you have a formal cost per mile database available for estimators?
- **Class**: Do you have a uniform road classification system for cost per mile data?
- **Init. Est.**: What tools are used for conceptual estimating?
- **Est. R/W**: Is right of way a separate estimate?
- **Est. Util.**: Is utility relocation a separate estimate?
- **Est. Proc.**: Do you have a standard estimate procedure used throughout your organization?
- **Eng. Est.**: Do you publish the engineer's estimate prior to bid?
- **Stip. Yrs.**: Length of highway construction plan?
- **Budg. Yrs.**: Length of time covered in the appropriations budget?
- **Est. Scope**: Project estimate published by project or by phase?
- **Dist.**: Number of highway districts or regions in state?
- **Dist. Fund**: Are highway funds earmarked by district or region?

Table 6 - Survey of Estimating Practices in Other States
CONCLUSIONS

The current process of forecasting costs for highway work in Kentucky isn’t satisfactory to either the KyTC or the Legislature. The reason seems to be not so much that the cost forecasting ability of the KyTC has declined of late but that the Legislature has voted itself more oversight of the 2YP execution. The reporting requirements of the oversight law, KRS45.245, impose additional burdens on an already seriously understaffed highway department. The limits imposed, whereby reporting is required, are in some cases impossible to meet, and in other cases possible to meet only with additional staffing and/or by not performing current duties.

The choice seems to be to either accept the status quo or to try to mitigate the problem; solving the problem entirely—insuring that no project phase overruns its estimate by 15%—is not feasible. There are three ways to mitigate the problem of poor cost forecasting. The first is for the Legislature to either forego the oversight or to modify it so the KyTC can meet the requirements with current staffing levels, the second is for the KyTC to change how the 6YP and the 2YP are developed, and the third is for the KyTC to staff up as necessary to improve its estimating ability. All of these options have financial and political implications.

The current oversight requirement has resulted in 134 overruns worth over $69 million being presented to the IJCT for review during the current biennium to date (7/1/92 - 2/13/94). All of these overruns have been approved. The IJCT makes no concerted effort to track cost underruns, which would provide as much evidence of poor cost forecasting as overruns do. The oversight seems to be used not so much to improve KyTC’s cost forecasting ability as it is to make a political statement about who is in charge of getting highways constructed in the Commonwealth. If this is indeed the case, and if blanket approval of all overruns is assured, then perhaps a continuation of the status quo is acceptable. However, currently the KyTC is trying to appease the IJCT by increasing estimates to reduce the possibility of having to report phase overruns in the future. This practice makes the development of a realistic 6YP and 2YP impossible, and has the potential of causing the loss of federal funds if and when
there aren't enough projects in the 6YP ready to be advanced into the 2YP to utilize approved federal aid.

The Legislature could either forego the oversight or modify it so the KyTC can meet the requirements with current staffing levels. A statute change would be required to forego the oversight or to change its provisions. Modifications that could mitigate the current problem include setting a realistic limit for both overruns and underruns based on the class of estimate in the 2YP, not 15% across the board; track overruns by overall project cost instead of by project phase; and/or establish a review process that requires the KyTC to inform the IJCT by report of all overruns and underruns, but to formally respond with backup data to only those overruns the IJCT truly thinks may need to be terminated, not those that will be summarily approved.

The KyTC can change how the 6YP and the 2YP are developed. The most effective change would be to complete either an in-depth scoping study and/or preliminary design prior to adding a project to the 6YP. This would require that work performed prior to authorization of the 6YP be funded by state funds.

The KyTC can staff up to improve its estimating ability. Increased staffing would require either the Executive Branch's approval for hiring additional personnel and/or KyTC's commitment to reallocate resources. The increased staffing would primarily include right of way and utility personnel to be involved in preliminary estimating. Also, demands for on-the-spot estimates would have to be curtailed so the increased staff could scope the proposed project prior to submitting the initial estimate.

The three ways to mitigate the current problem are being used, to some degree, by other states. The largest notable difference between Kentucky and most other states is the legislative oversight requirement. While many states have some sort of progress review of the highway plan, almost none have legislative involvement after budget approval. Many states are better staffed for estimating than Kentucky and some states do a considerable amount of preliminary design work prior to a project being placed on the highway plan.
Regardless of which of the above-mentioned options, or combinations thereof, are selected to mitigate the current problem, improvement of the current estimating and cost forecasting process is possible. Areas this study will address during the next year are how to better use existing data, what unused data sources are available, and how to improve current estimating procedures.

Estimates are a product of experience and information. Estimating experience has been disappearing rapidly in the KyTC. It is vitally important to develop databases and make them available to personnel throughout the state. These databases will not only improve estimating ability but will serve to help justify estimates that later turn out to be inaccurate.

This study offers an opportunity to make improvements to the KyTC's cost forecasting ability and to the relationship between the KyTC and the Legislature. To seize this opportunity both the Legislature and the KyTC must communicate openly with each other, and with the researcher, in an effort to find a workable solution which considers both political and fiscal realities.
PRELIMINARY RECOMMENDATIONS

The following preliminary recommendations are made, based on the findings of the first eight months of this three year study. It should be understood that the entire problem of cost forecasting will be considered more fully during the next two years. Substantial changes might be made to these preliminary recommendations.

Areas where the KyTC should be proactive in improving the estimating process include:

- Look for innovative ways to improve both estimates and relations with the Legislature.
  - Educate legislators in the art/science of estimating and the limitations of what can be done with current resources.
  - Empower and encourage employees to find better ways to estimate, reward them, then standardize the improvements throughout the KyTC.
  - Add a front-end phase called Planning and include it in the 6YP.

- Have more information available when making an estimate.
  - Delay adding a project to the 6YP until a scoping study is complete.
  - Develop statewide and regional databases from historical costs for all facets of estimating highway costs.
  - Assign more resources to estimating, with a method to account for their utilization.
  - Create regional databases for design, right of way, utility relocation and construction based on cost per mile and/or other parameters.

- Provide planning resources in all district offices.
  - Set up a budget from either new or reallocated funds for the estimating effort, so that a cause and effect relationship can be established.

- Develop a standard estimating procedure and train all estimating personnel on its use.
  - Establish a formal review policy and schedule for all estimates.
• Require an estimator's name, date and estimate class for all estimates appearing on
  the *Project Authorization Form* (TC-10).

Areas where the Legislature should be proactive in improving the estimating process include:
• Reduce cost increases for right of way after route has been selected.
  • Prohibit development in the project corridor.
  • Require that local governments provide right-of-way or a guaranteed price.

• Reduce unanticipated, and unknowable, environmental costs.
  • Fund environmental problems, unknown at time of initial estimate, from a source
    other than authorized project funds.
  • Require those who cause the environmental problems to clean them up.

• TJC adapt the oversight implementation to better track performance and reduce the
  added burden on the KyTC.
  • Explain to the KyTC personnel exactly what KRS45.245 aims to accomplish and
    work with them to reach the goal.
  • Track project phase underruns of >15% as well as overruns.
  • Limit formal reports of overruns to those that have a potential of being disapproved.
  • Instead of a flat >15% limit, use different limits based on class of estimate
  • Let projects be carried through Phase I design without the 15% limitation.

A small group, representing both legislators and the KyTC, should work with the researcher
  to articulate details of a process that meets political and fiscal realities. This would facilitate
  the implementation of needed improvements and lead to better relations within state
government.
Emphasis for the remainder of this year and for year 2 of the study will be on new and/or modified procedures and tools to improve the estimating and cost forecasting ability of the KyTC. Specific goals for year 2 are:

- to develop statewide and regional cost-per-mile databases for conceptual estimating and for each of the project phases,
- to continue contact with selected states which seem to have found effective ways to improve cost estimating for highway work and to investigate these methods for ideas worth adapting for the KyTC,
- to spend extended periods in several district highway offices to better understand the problems encountered in initial estimates, and
- to maintain contact with officials within the KyTC and the Legislature in an effort to develop a cost forecasting strategy that will satisfy both parties and will benefit the citizens of Kentucky.

An example of a cost-per-mile database format for construction costs is shown in Table 7. This is just a preview of some preliminary work that will receive considerable attention during the second year of this study.
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**Legend Explanation**
- **PROJCODE** - project code, in numerical order by fiscal year
- **DISTRICT** - highway district assigned project
- **STATUS_RPT** - identification number of project status report
- **DATELET** - bid letting date, year-month-day
- **STATUS** - current status, A-active
- **COUNTY** - location of project
- **PROJNO** - project number used by construction
- **ROADNAME** - descriptive name of road
- **MILES** - miles of road involved in project
- **PROP** - proposals, number of prospective bidders obtaining contract documents
- **BIDS** - number of bids turned in
- **LOW_BID** - lowest bid submitted
- **SECOND_BID** - second lowest bid submitted
- **AVG_BID** - average of all bids submitted
- **CONTRACTOR** - contractor awarded bid
- **LOW_C/M** - cost per mile based on lowest bid
- **AVE_C/M** - cost per mile based on average bid
- **TYPE_OF_WK** - description of work type
- **NO_LANES** - number of lanes involved, where applicable
- **PROJNO_2** - project number used in other phases for same project
- **PROJNO_3** - project number used in other phases for same project