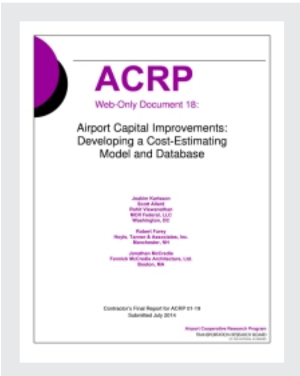
ACRP

Web-Only Document 18:

Airport Capital Improvements: Developing a Cost-Estimating Model and Database

Airport Capital Improvements: Developing a Cost-Estimating Model and Database

DETAILS

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ACRP Web-Only Document 18 is a companion publication to *ACRP Report 120: Airport Capital Improvements: A Business Planning and Decision-Making Approach* and *ACRP CD-158: ACCE: Airport Capital Cost Estimation Tool*. These products are available on the TRB website (www.trb.org).

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AUTHOR ACKNOWLEDGMENTS

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ABSTRACT

The objective of this project was to develop and test a cost estimating model and database intended for use during airport capital planning. The Research Team categorized and identified a range of possible types of airport construction projects, reviewed best practices for cost estimating, surveyed stakeholders to review existing cost modeling practices, developed a cost estimating methodology, collected data, and developed Cost Estimating Relationships that form the core of the cost model. The study deliverables are a guidebook to cost estimating for airport capital planning and an accompanying Microsoft Excel-based cost model. The guidebook and tool are intended to help airport operators, aviation/transportation agencies, and other stakeholders to understand cost estimating practices, including risks and sources of uncertainty. The main conclusion of the study is that parametric cost estimating methodology is a suitable approach for developing an effective cost model, but that limited data availability significantly constrains the scope and robustness of the model.

CHAPTER 1: BACKGROUND

The objective of this project was to develop and test an analytical approach to prepare cost estimates for airport construction projects, both in the horizontal and vertical domains. The proposed cost estimating model is primarily intended for the capital planning phase, when uncertainty is high, but good cost estimates are necessary to optimize the use of scarce airport funding resources.

This report describes the research process and findings of ACRP Project 01-19, “Airport Capital Improvements: Developing a Cost Estimating Model.” This work consisted of ten tasks, which were defined in the Amplified Work Plan prepared by the Research Team and reviewed by the ACRP 01-19 Project Panel:

Task 1: Review and evaluate existing construction industry practices in developing and applying cost estimating models

Task 2: Identify candidate airside and landside types for inclusion

Task 3: Define and develop a framework for the model

Task 4: Establish standard input/output format for database

Task 5: Create a prototype model and database

Task 6: Implement three representative case studies

Task 7: Prepare interim report

Task 8: Refine cost estimating model and populate database

Task 9: Validate refined model

Task 10: Prepare and submit Guidebook and Final Report

Problem statement

Cost estimates for Airport Capital Improvement Plans (ACIPs) are prepared early in the stage of project planning, when design data available is limited and conceptual. The time frame for construction of the facility being estimated can vary from a few months to 20 years or more. At this point in the process, a simple rough order of magnitude estimate is usually the best that can be expected, due to the limited data available.

Airport projects are often complex: “Airport projects have a whole series of special systems which are seen nowhere else, on an enormous scale” (Merkel and Cho, 2003). Two separate but related problems must be addressed: (1) improving the accuracy of the cost estimate as calculated from current and relevant cost data; and (2) improving the specificity of the project scope and unique conditions which must be entered into the model by the user. The problems are linked: The accuracy of the result is completely dependent upon the specificity of the scope. The dual challenges of providing sufficient accuracy and specific scoping vary in their characteristics, depending on the type of project. Some project types have greater potential for significant deviations, and therefore more potential for improvements.

Another significant problem in cost modeling for the airport capital planning phase is the lack of standards. Combined with the frequent failure to employ accepted best practices for cost estimating, this results in large uncertainties and the inability to compare costs for projects across different airports, which may compete for the same source of limited capital funds. There is a need for a standardized cost model that allows for rapid development of cost estimates, incorporating best practices and a robust analytical methodology.

CHAPTER 2: RESEARCH APPROACH

The research approach can be broadly categorized into three phases: (1) Understanding the problem, (2) developing cost modeling approach, (3) data collection, (4) implementing the approach in a cost model, and (5) validating and refining the model. Several of the activities within these broad phases occurred in parallel as, understanding of the problem, the approach, and the framework of the cost model matured together.

Understanding the problem

As described above, there is currently a lack of standards in establishing cost estimate for the capital planning phase. The resulting cost estimates are therefore likely to result in large variations with actual costs. This can result in cancellations of projects or inefficient use of limited airport funding. The problem is particularly challenging since many small and regional airports do not have in-house staff dedicated to cost estimating. Other ancillary issues further complicate the problem. In particular, the use of contingency factors adds another layer of uncertainty to the estimate, especially since there are no established standards for their application.

In order to better understand the scope and the nature of the research problem, the Research Team completed extensive background research. This effort included a literature review, identifying and documenting best practices for cost estimating in general and as applied to airport construction specifically. It also identified and reviewed existing cost estimating models. Another focus of the background research was stakeholder outreach. The Research Team conducted a stakeholder survey to identify existing practices and cost estimating needs.

Developing the cost estimating approach

The objective of this research project is to develop an interactive construction cost estimating model and associated database for airport capital projects, along with a guidebook documenting its use and best practices. The model should cover common airport construction projects, both in the horizontal and vertical domains. The model should make use of existing databases and take into account regional cost factors and inflation. The model should be flexible in its use, for example, by allowing for database updates and the ability to generate reports in Excel, PDF, and other formats.

The proposed approach is to use a parametric cost estimating technique in which costs are correlated to observed (i.e., historical) data from actual construction projects. In this approach, multivariable regression analysis is used to model cost through mathematical functions known as Cost Estimating Relationships (CERs). The CERs model cost as a function of key cost drivers known as Candidate Independent Variables (CIVs). The variables are considered candidates because they are selected using subject matter expert input and are then tested for statistical validity and reasonableness.

The output of the model is a cost estimate for a single project or a portfolio of projects, with both a point estimate and a high/low range that represents risk. The costs are inflation adjusted and take into account regional variations. The inputs to the model that are necessary to derive these costs are the cost drivers represented by a set of CIVs that is unique to each type of project. The CIVs are the independent variables in the CERs, which represent the analytical component of the model.

Data collection

Two separate data collection templates were developed, one for horizontal and one for vertical construction projects. The templates matched the structure of the cost estimating database, by including a series of sub-templates, one for each project type. For each historical observation, fields for basic descriptive information were provided, such as a project description, location, and year of completion. Other data fields were used to store values for the dependent variable (i.e. construction costs) and all independent variables (i.e. CIVs) required by the proposed CER for the project type in question.

Due to lack of usable data in electronic format, the data collection was conducted into two phases: an initial data collection effort, followed by targeted, supplemental effort. The results of the two data collection efforts are described in more detail below.

Developing the cost model

After reviewing best practices, the Research Team identified several guidelines for the model, including that it should:

- Be implemented in Microsoft Excel, or similar. The model should not require proprietary software and should be based on a platform that is ubiquitous and likely to be in use at most airports (e.g. Microsoft Office).
- Provide a guided approach in which the user is prompted to select pre-defined choices and/or enter required data along a logical path.
- Combine pre-defined data populated in the model by the Research Team and airport- and project-specific data entered by the user.
- Include the ability to review inputs.
- Allow flexibility in reporting and exporting the output of the cost estimating model, to support distribution of the results and exporting to other applications.
- Provide a what-if cost modeling capability.

Following these guidelines, the Airport Capital Cost Estimation (ACCE) tool was developed in Microsoft Excel. The main interface of ACCE, shown in Figure 1, provides the interface to enter input required by the user, review interim results, and generate the cost estimating report.

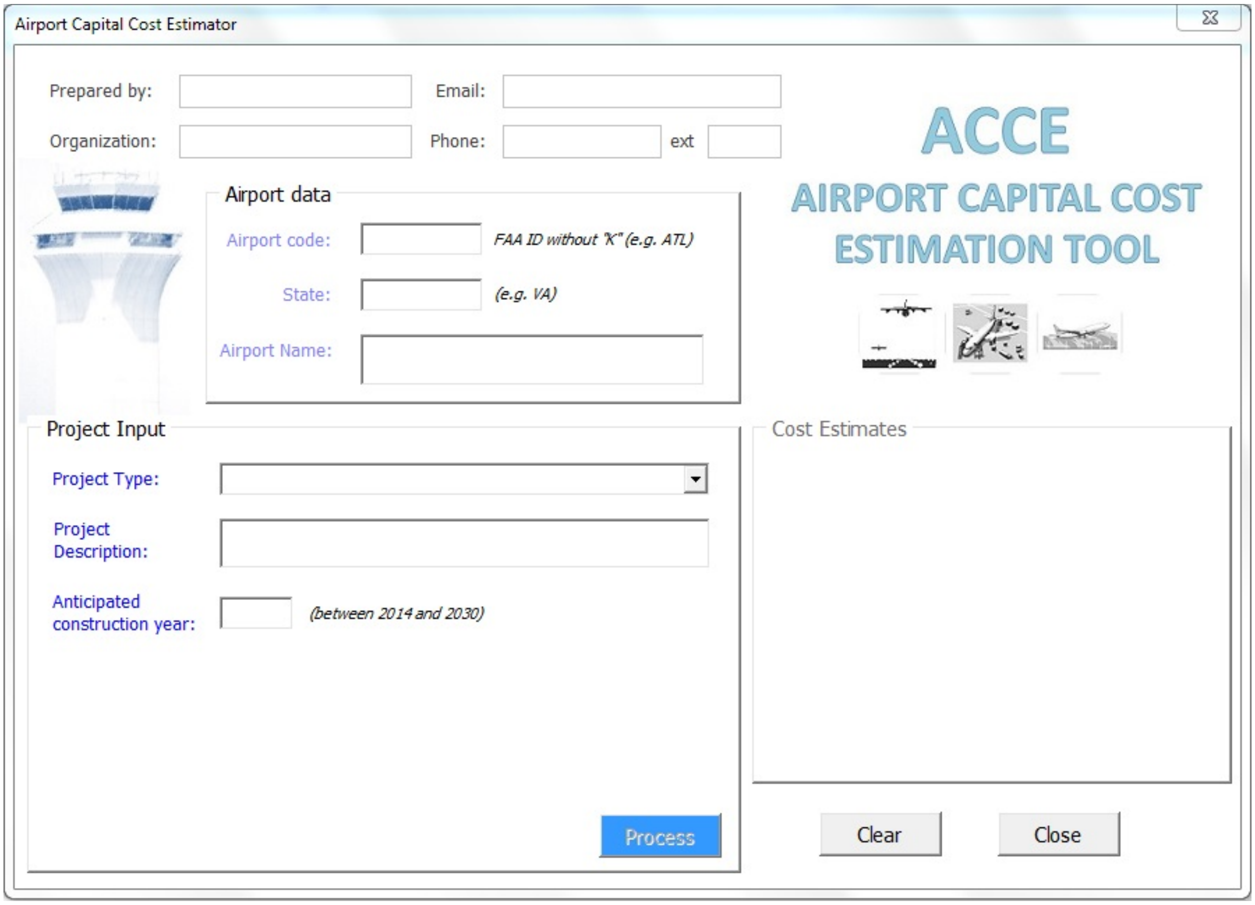

Figure 1: ACCE main user interface

Validating and refining the model

Validation is a critical component of evaluating the performance and robustness of the cost model. The validation is an iterative process in which initial results are used to refine the model. Final validation serves to evaluate the quality of the model and identify needs for future work. Several validation techniques were used in this project:

- Statistical measures: The linear regression analysis used to develop the cost model results in the calculation of a number of metrics that can be used to evaluate the quality of the model and identify weaknesses. Key measures include the coefficient of determination (R^2 and adjusted R^2, the t-statistic for each coefficient in the model, and the F-statistic.

- Case study validation: In case study validation, an additional set of historical construction projects are collected for testing purposes. For each case study, the predicted cost per the model is compared against the actual cost. Conformance between predicted and actual cost across several case studies is a measure of the model's effectiveness and robustness. The case studies can also be analyzed in more details to better understand underlying factors that affect model performance.

- Subject Matter Expert (SME) feedback: The Research Team included two subcontracts that served as SMEs for horizontal and vertical construction projects respectively. The SMEs tested the model and evaluated it against their professional experience with cost estimating, to see how well the results matched expectations.

CHAPTER 3: FINDINGS AND APPLICATIONS

This section describes key findings from the research project. The discussion is broken down into the findings from the background research, the data collection and model development, the model validation, and the user interface implementation.

Background Research

Prior to establishing the framework for the cost estimating model, the Research Team surveyed the existing literature to document existing best industry practices. A stakeholder survey was also conducted in order to document cost estimating practices and needs. The results of these efforts are presented in the sections below.

Literature Review

The Research Team conducted a review of existing literature related to cost estimating. The review is reproduced in Appendix A in the form of an annotated bibliography which documents best practices. The review covers publications on cost estimating practices, as well as existing databases and cost estimating software. The works are listed in alphabetical order within each category.

Stakeholder Survey

As part of the review of existing cost estimating practices and needs, the Research Team surveyed stakeholders such as airport directors, industry groups, and transportation agencies. The outreach effort was implemented as a web-based survey combined with some telephone follow-up. The goal of the survey was to evaluate current practices in airport construction cost estimating, define key issues and challenges, and identify sources of data. The questions asked were intended to provide a holistic sense for how cost estimating is currently being accomplished in the airport industry. The questions also solicited input on where the process could be improved, sources of cost data, and the types of projects that are estimated. The survey instrument is reproduced in Appendix B. Key results from the survey are summarized below.

A total of 272 survey recipients were identified, of which 52 completed the survey, for a response rate of 24%. Table 1 summarizes all questions that could be answered with a “yes” or “no” answer (“N/A” indicates that the respondent answered “not applicable”; “NR” indicates no response). The computation of percentage shares of “yes” and “no” answers excludes respondents who did not respond.

When asked what types of construction cost estimating issues were found to be most difficult to deal with and what respondents would like to see this model do to help solve those issues, the answers varied widely. One answer that was repeated numerous times addressed the issue estimating the cost of mobilization. It is also clear that the majority of responses spoke to the need for estimators to know more about the cost of specialty project elements and the bidding environment, rather than to challenges with quantification of standard project elements. This may suggest the need to focus more on specific parts of the cost estimating process, versus the modeling the process as a whole.

Table 1: Survey responses to "yes/no" questions

Question	Yes	% Yes	No	% No	N/A	NR
4. Is construction cost estimation at your facility performed in-house?	14	27%	30	58%	8	0
5. Do you use outside consultants to perform construction cost estimating services?	45	87%	5	10%	2	0
6. Do you access online cost data for generating construction cost estimations?	9	17%	30	58%	13	0
7. Do you store historical construction cost estimations?	32	63%	19	37%	0	1
8. Do you store construction project bid tabs?	36	73%	13	27%	0	3
9. Do the quantities in your construction cost estimates include a round up or contingency?	24	51%	14	30%	9	5
10. Do you use an overall contingency factor at the end of a construction estimate?	20	43%	14	30%	12	6
12. Do you use standard construction cost estimating factors such as dollars per square feet of runway?	15	34%	20	45%	9	8

When asked "*what are the most common types of construction projects that you estimate*" the answers reflected a broad range of common types of airfield improvement projects. The most common project types indicated are summarized into broad categories in Table 2.

Table 2: Common types of cost estimates by project type

Project Type	Responses
Runway	24
Terminal Upgrades	24
Airfield lighting	18
Other airfield pavements	17
Taxiway	15
Equipment storage facilities	14
Roadways	7
Utilities	7
Navigation aids	5

Fourteen respondents indicated that they perform in-house construction cost estimating, twelve of whom use software. Nine respondents noted that they utilize Microsoft Excel, and one each uses AASHTO's Trns•port Estimator, RSMeans, and Success Estimator. Four respondents indicated that they have in-house engineering staff to assist with or perform construction cost estimating.

When asked what sources respondents use to obtain online unit cost data, the answers included the following broad categories:

- Construction cost data from RSMeans or NECA.
- Vendors.
- Previous bids.
- Tabulation of bids by state transportation or highway agencies.

Fifteen respondents indicated that they use standard construction cost estimating factors such as dollars per square feet of runway. Of these, eight said they would be willing to provide those factors and, if documented, the rationale for selecting them.

When asked "*Do you store historical construction cost estimations and what format is the data in?*" the answers were varied and ranged from Microsoft Excel to hard copy to PDF format. Of the 17 responses to this question, 11 indicated data was stored in Excel format.

When asked "*Do you store construction project bid tabs, for how long, in what format, and in what type of database*?" the answers ranged considerably in both time span and data format. A total of 19 of 32 respondents indicate that they store construction project bid tabs in hard copy format. Of those who use an electronic format, Microsoft Excel was the most common format.

When asked "*Do the quantities in your construction cost estimates include a round up or contingency?*" 24 respondents answered "yes" to the question. Of these, 11 provided specific values or ranges of values, whereas one responded by saying they did not use a contingency factor. Reported contingency factors ranged from 5% to 40%.

When asked "Do you use an overall contingency factor at the end of a construction estimate?" 20 respondents answered "yes" to the question. Of these, 12 provided specific values or ranges of values, generally ranging from 5 to 30%.

When asked "Please provide any rules of thumb for applying construction cost adjustments for your local region" 23 respondents provided answers. Of these, ten provided specific values or ranges of values, whereas four responded by saying they did not have any rules of thumb for applying construction cost adjustments. The rule of thumb percentage adjustments ranged from 5% to 25%.

Data Collection and CER Development

Limited data availability led the Research Team to request change to Phase II of the Amplified Work Plan to incorporate supplemental rounds of data collection and scale back the user interface development and software capabilities. After the completion of the supplemental efforts, the database consisted of 251 observations. The data were examined for statistical outliers, by inspecting data visually and comparing unit costs (e.g., cost per square foot of floor space) against typical costs. After the removal of statistical outliers 183 observations remained, for a total yield of 73%. The results of the data collection are summarized in Table 3.

Table 3: Results of data collection

Project Type	Total Data Points Collected	Total Data Points Used	Yield
Horizontal Construction Projects			
Construct or rehabilitate taxiway	25	22	88.0%
Construct, expand, or rehabilitate apron	29	22	75.9%
Construct, extend, or rehabilitate runway	48	30	62.5%
Install perimeter fencing	24	18	75.0%
Install PAPI	10	5	50.0%
Install weather reporting equipment	31	28	90.3%
Remove on-airport obstructions (vegetation)	4		
Vertical Construction Projects			
Construct ARFF facility	42	25	59.5%
Construct SRE building	42	33	78.6%
All Projects			
Total	**183**	**251**	**72.9%**

The updated database was used to support the development of CERs for eight project types (compared to the five project types used for the prototype CER development. Ordinary least squares regression was used. A number of logarithmic and functional forms were investigated, as well as multiple permutations of CIVs and interactions between CIVs. In the final accepted model, all CERs used a linear-linear specification with no interactions. All but two CERs were modeled using a zero intercept. All costs were normalized to fiscal year (FY) 2014 dollars to correct for inflation and to Kansas (KS) construction cost levels to adjust for regional variations. The coefficients for the resulting CERs and results from the associated statistical tests used to evaluate the model’s quality of fit and performance are summarized in Table 4 and Table 5 respectively.

Table 4: Final CERs

Project Type	Intercept (FY2014 KS $)	Coefficient 1		Coefficient 2	
Horizontal Projects					
Construct or rehabilitate taxiway		11.9	Pavement area (SF)	6.1	MTOW (lbs.)
Construct, expand, or rehabilitate apron		1.2	Pavement area (SF)	12.2	MTOW (lbs.)
Construct, extend, or rehabilitate runway		2.9	Pavement area (SF)	35.4	Adj. MTOW (lbs.)
Install perimeter fencing		32.2	Fencing (LF)		
Install PAPI		83.1	No. of Systems		
Install weather reporting equipment	171,700				
Vertical Projects					
Construct ARFF facility		374.5	Floor area (SF)		
Construct SRE building	111,500	116.5	Floor area (SF)		

Table 5: Statistical tests

Project Type	Adj. R2	P-value β_1	P-value β_2	P-value F-statistic
Horizontal Projects				
Construct or rehabilitate taxiway	82.5%	0.0%	0.4%	0.0%
Construct, expand, or rehabilitate apron	87.4%	1.6%	0.0%	0.0%
Construct, extend, or rehabilitate runway	83.7%	0.1%	0.1%	0.0%
Install perimeter fencing	83.5%	0.0%		0.0%
Install PAPI	N/A	N/A	N/A	N/A
Install weather reporting equipment	N/A	N/A	N/A	N/A
Vertical Projects				
Construct ARFF facility	88.2%	0.0%		0.0%
Construct SRE building	88.3%	0.0%		0.0%

As shown in Table 5, adjusted R^2 values are generally close to the target value of 90%. This means that there is a good correlation between construction cost and the cost drivers selected for inclusion in the CERs. The P-value target of <5% is met for all coefficients. “N/A” indicates that the CER did not include any independent variables. In these cases, the CER is simply the average construction cost for the project type in question. This approach was used for project types that consist exclusively of the installation of equipment, such as a Precision Approach Path Indicator (PAPI) or Automated Weather Observing System (AWOS).

Note that in the initial model specification, the project type "Install airport visual aid" was used. However the data collection did not result in enough observations to support CER development for visual aids other than the installation of PAPI systems. Consequently, the project type was changed from "Install airport visual aid" to "Install PAPI." Also, while the project type "Install weather reporting equipment" originally had the type of system as a candidate independent variable, in the final model only AWOS systems were sufficiently represented in the database to support CER development.

Landing gear configuration, a CIV originally proposed for all pavement projects, was eliminated for the taxiway and apron CERs, as it was not found to be a statistically significant predictor of cost. For the runway CER, it was incorporated indirectly by adjusting the MTOW by a factor corresponding to the landing gear configuration. These adjustment factors were computed from data on maximum MTOW for runways in the FAA's Airport Master Record database. The resulting factors are shown in. The factors were used to convert the design aircraft MTOW into a "single-wheel equivalent MTOW", which was then used in the CER. The computation of the single-wheel equivalent MTOW is handled automatically by the cost model and is transparent to the user.

Table 6: Adjustment factors for landing gear configuration

Code	Landing Gear Configuration	Adjustment Factor
SW	Single wheel	1.0000
DW	Dual wheel	1.6429
DTW	Dual tandem	3.0267
DDTW	Double dual tandem	5.7659

Model Validation

In addition to the statistical metrics shown in Table 5, several other methods were used to test the validity of the cost model. One was to retroactively predict construction costs for the data points in the cost database. In the utopian case of a perfect model, the predicted costs should perfectly match the actual costs. When plotted against each other, the values would then fall on a line with a 1:1 slope

Plots of predicted vs. actual costs are shown in Figure 2 through Figure 7. As can be seen, the plotted points generally follow the 1:1 reference line, but there are substantial variations about the line. As an example, of the 24 taxiway-related observations in the cost database, six (or 25%) have differences between predicted and actual costs of 10% or less. At the other extreme, seven data points (or 29%) have differences of 50% of more, while the remaining 11 data points (46%) have differences between 10% and 50%. Results are similar for the remaining project types, with some variation.

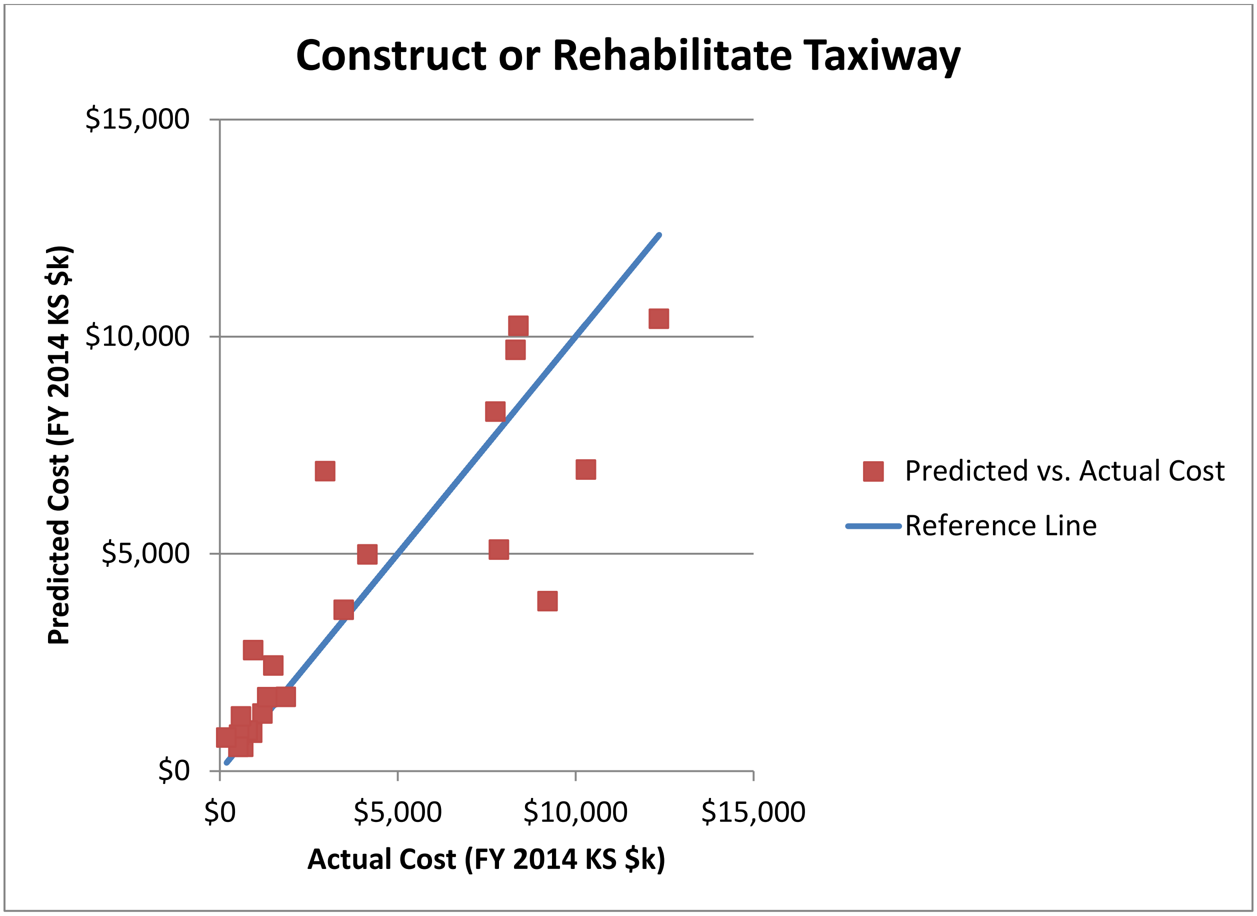

Figure 2: Predicted vs. actual cost – construct or rehabilitate taxiway

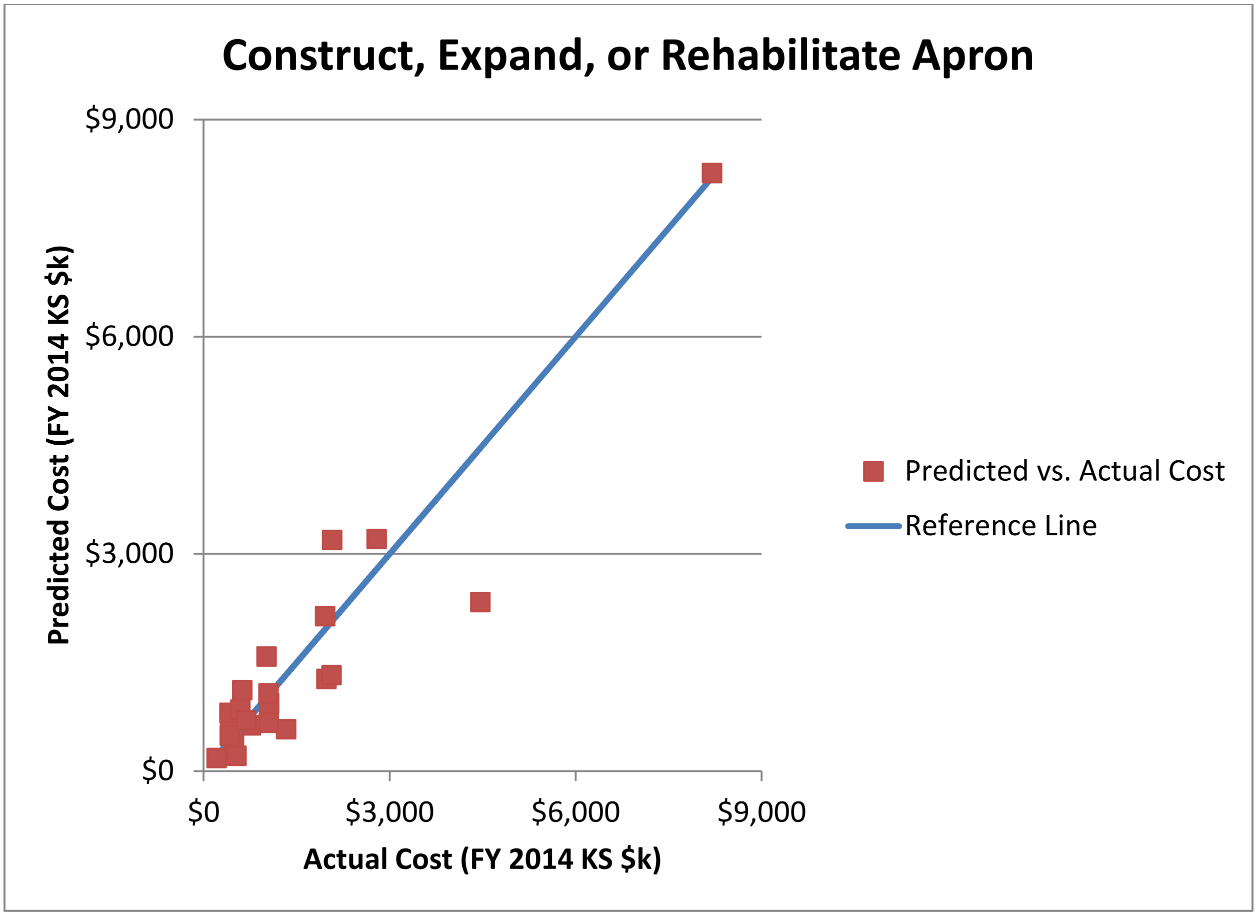

Figure 3: Predicted vs. actual cost – construct, expand, or rehabilitate apron

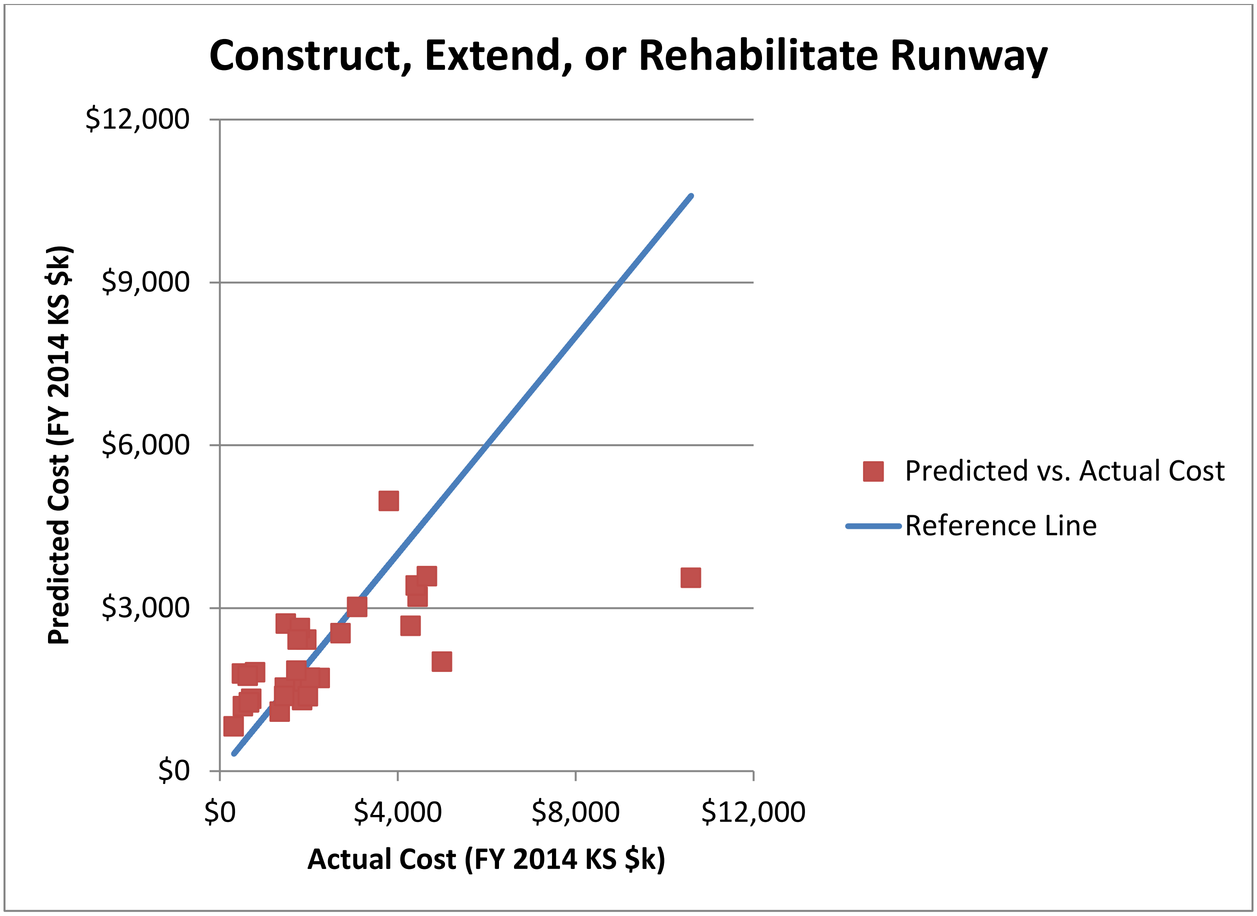

Figure 4: Predicted vs. actual cost – construct, extend, or rehabilitate runway

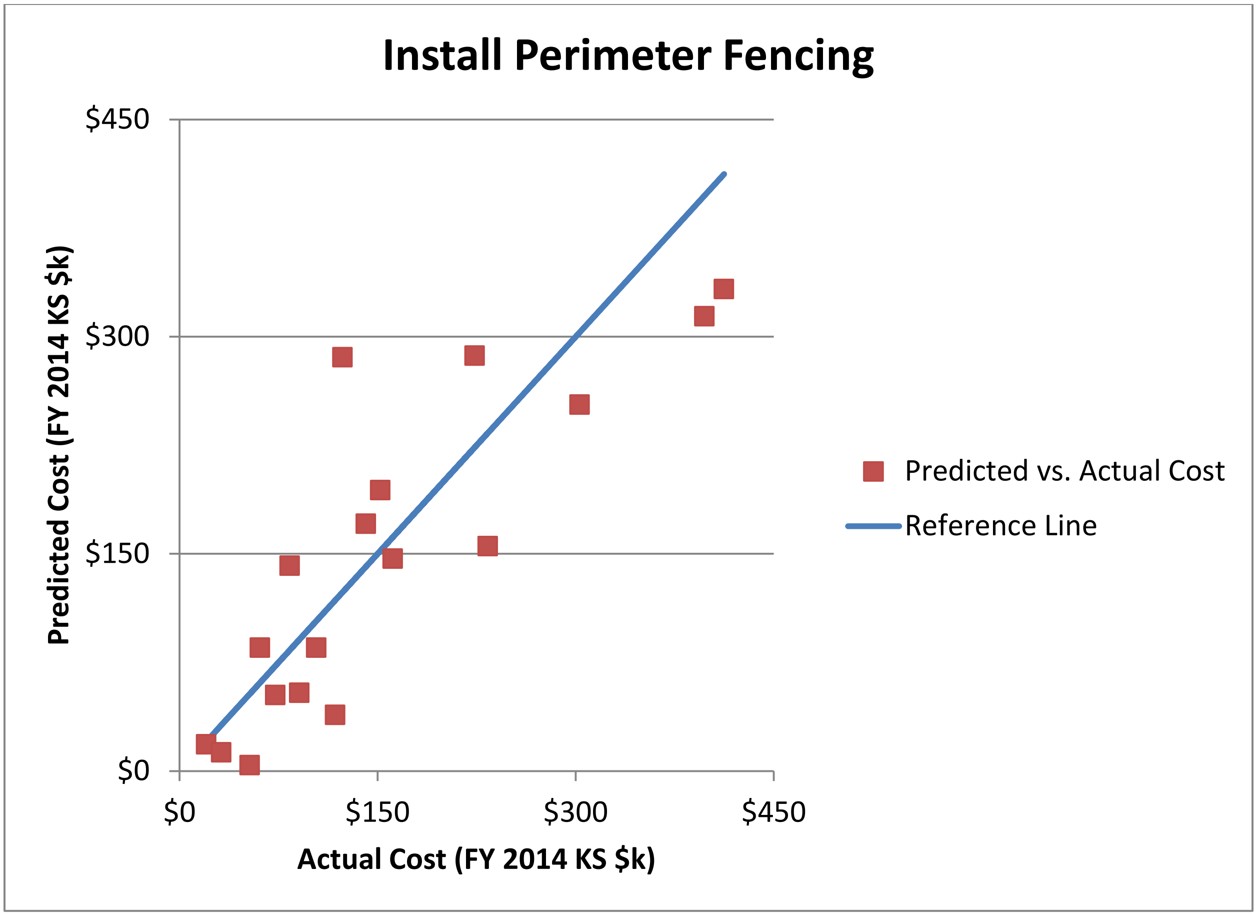

Figure 5: Predicted vs. actual cost – install perimeter fencing

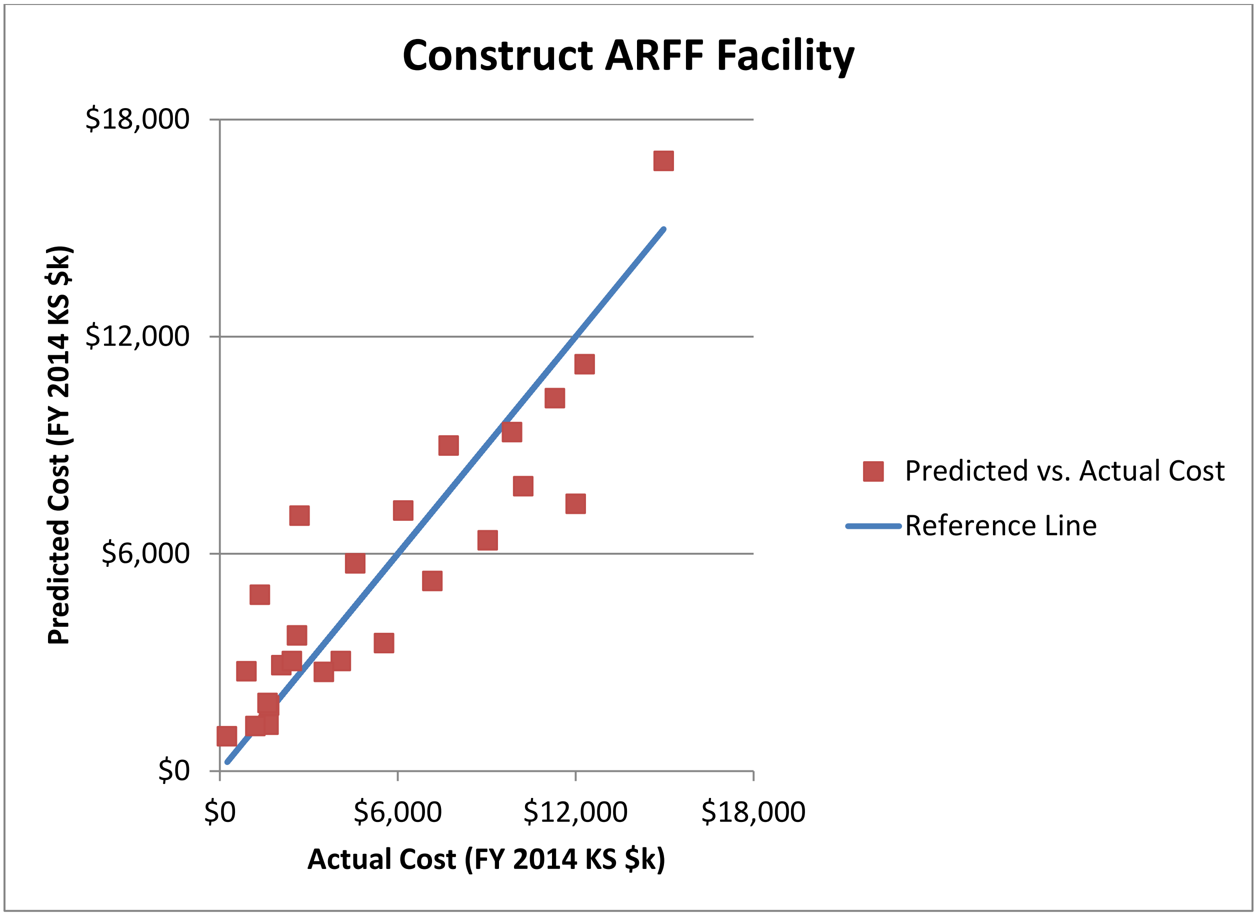

Figure 6: Predicted vs. actual cost – construct ARFF facility

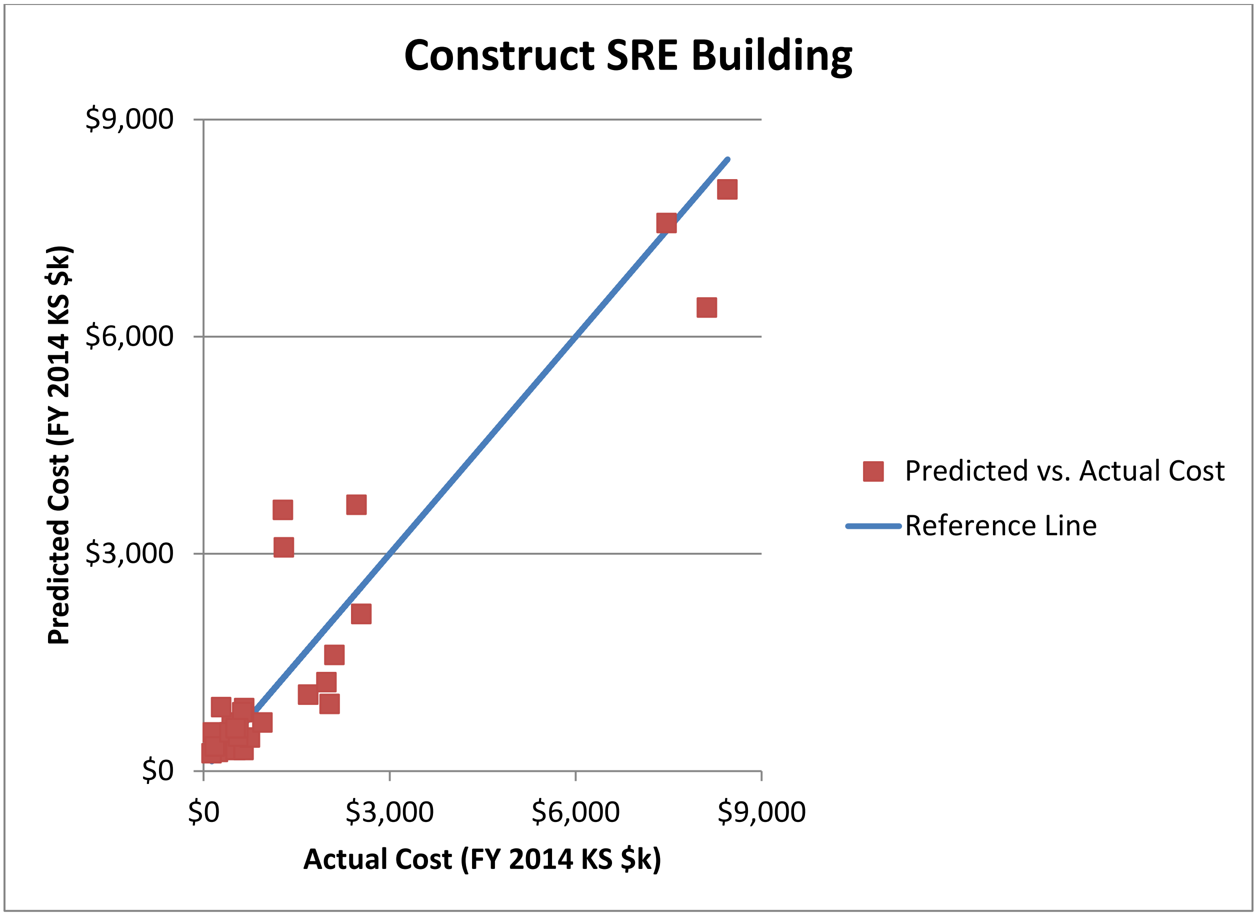

Figure 7: Predicted vs. actual cost – construct SRE building

Another validation method conducted for this study was a case study analysis. Fifteen potential case studies were collected for this purpose. After data verification, nine of the projects were deemed to be sufficiently complete to include in the case study analysis. There was relatively little variation among the case studies: They represent only three states and four project types, all in the horizontal domain. As shown in Figure 8, the case study validation effort showed that the prototype CERs exhibited mixed performance: One-third of the case studies had errors of 10% or less, one-third had errors of approximately 30%, and the remaining one-third had errors of approximately 100% (i.e. the predicted cost was twice the actual cost).

The case study analysis indicates that the cost model appears more likely to overpredict cost than to underpredict cost. This is viewed as a positive characteristic, since an overly conservative cost estimate is generally viewed as a more favorable outcome than a predicted cost that turns out to have been too low.

Figure 8: Case study validation – difference between predicted and actual cost

As a final step in the validation effort, the airport construction SMEs on the Research Team were asked to test the CERs against projects that they were currently involved in. The SMEs were also asked to compare the results of the cost model with their professional experience and familiarity with cost estimating for airport construction projects. The horizontal project SME tested the model against four projects:

1. Construction of 10,750 LF security fence at a small regional airport: The model substantially underestimated the cost, by approximately 60%. Follow-up analysis indicated that the presence of tidal wetlands was a substantial cost driver in the project.

2. Construction of 45,000 SF apron at a general aviation airport: The model estimated the cost within 3%.

3. Construction of an 83,000 SF taxiway at a general aviation airport: The model significantly overestimated the cost, by a factor of 225%. No specific explanation was identified in the follow-up analysis, except that the cost database included very few data points with CIV values in the range of the project.

4. Construction of 78,000 SF of taxiway pavement surface at a small regional airport: The model estimated the cost within 18%.

With the exception of the third case, these are all viewed as acceptable outcomes. The third case illustrates that despite the acceptable statistical measures of fit, the model is not as robust as it could be. This is most due to the relatively low number of data points in the database, even after completion of the supplemental data collection. The small size of the database and the resultant lack of variation in projects mean that a number of factors that affect construction cost are not represented in the CERs. For this reason, the final cost model should be viewed primarily as a proof-of-concept tool and a disclaimer to this effect is included with the output of the cost model.

The Research Team's architecture SME reported the following findings after testing the cost model:

1. For snow removal equipment storage buildings, the cost model resulted in unit costs slightly lower than expected. However, the high/low range of cost estimates produced by the model was found to be reasonable.

2. For aircraft rescue and fire fighting facilities, the cost model resulted in unit costs slightly higher than expected. Again, the high/low range of cost estimates produced by the model was found to be reasonable.

User Interface Development

The Research Team implemented the cost database and model in Microsoft Excel, incorporating a graphical user interface to provide inputs and support user interaction with the model. It consists of two key interactive elements:

1. An input window that allows for entry of contact information, airport information, and project-specific information.

2. An output window that displays the reported cost estimate, along with all relevant input data.

The resulting Excel-based tool incorporates airport information for all airports in the FAA's National Plan for Integrated Airport Systems (NPIAS) (FAA 2012). This means that entry of the three-letter airport identifier allows automatic retrieval of airport-specific information for all NPIAS airports. For non-NPIAS airports, the user is prompted to enter the information manually. This information can, as an option, be saved to the database for later retrieval.

The input window is shown in Figure 9 and contains four sections: (1) Contact information for the preparer; (2) airport data; (3) project input; and (4) preliminary cost estimate. The preliminary cost estimate is a running calculation of the cost estimate shown next to the values of the independent variables. In addition to the most likely cost estimate, low and high estimates are also provided. This creates a high/low range of potential construction costs. Costs are shown both in current dollars (i.e. fiscal year 2014) and dollars that have been inflation adjusted to the anticipated year of construction (fiscal year 2018 in this example).

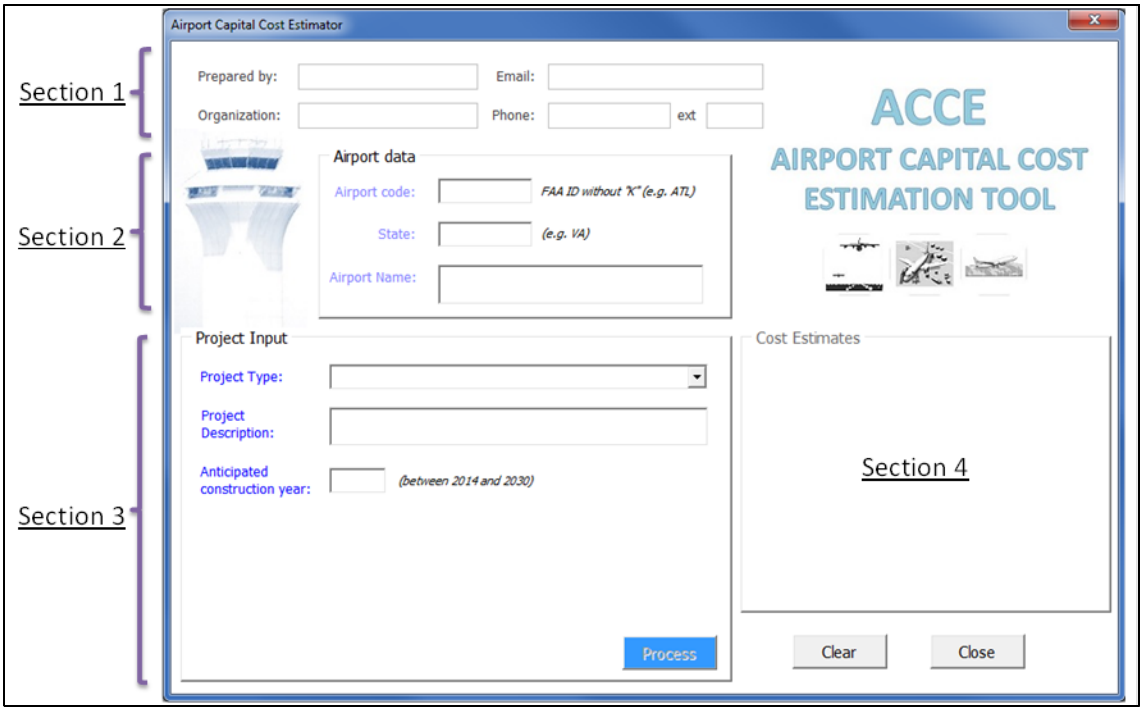

Figure 9: ACCE input window

Figure 10 shows a sample cost estimate report generated in the output window. While not shown, the output window also features support for the following features:

- Exporting the cost estimate to another Microsoft Excel file
- Sending the report to a printer
- Saving the file as a PDF file
- Returning to the input window in order to modify the input values

The last feature allows for the preparation of what-if analyses, in which the input values that define the project can be modified. The report includes all of the data provided in the input fields, the calculation of the cost estimate (including the high/low range), a disclaimer that highlights that the actual cost may differ substantially from the estimate, and any other warning messages generated.

Airport Capital Cost Estimation Tool: Report

Report Name	BED FY18 Fence
Report Description	Construct Security Fence (FY 2018)
Name of Preparer	Joakim Karlsson
Contact Information	jkarlsson@mcri.com
Date Created	1/15/14 9:30 AM
FAA Airport ID	BED
State	MA
Airport Name	Laurence G Hanscom Field
Project Type	Perimeter Fencing
Project Description	Construct Security Fence
Planned Year of Construction	2018
Length	8,000 Linear Ft.

Output			
	Cost Estimate	Low Estimate	High Estimate
FY2014$	$325,000	$214,000	$436,000
FY2018$	$349,000	$230,000	$468,000

Inflation factor [2018/2014]: 107.3%

Disclaimer: *This cost model is a proof-of-concept tool developed as a research project under the Airport Cooperative Research Program. Actual costs may differ significantly from the estimates provided here. These cost estimates are intended for initial planning purposes only and should not be used as the sole means to evaluate a proposed project.*

Figure 10: ACCE cost estimate report

CHAPTER 4: CONCLUSIONS AND SUGGESTED RESEARCH

After an iterative process consisting of several rounds of data collection, the Research Team created a cost database consisting of 251 observations of historical airport construction projects. The parametric cost estimating methodology was used to develop CERs for eight construction types. The CERs were developed using linear regression analysis, using ordinary least squares estimation. A user interface developed in Microsoft Excel was employed to provide a simple but effective mechanism for members of the airport community to interact with the cost model.

The cost model was tested and validated through a series of statistical test, by visual inspection of plots of predicted versus actual cost, and through subjective evaluation by the Research Team's airport construction SMEs. The statistical measures used to test the quality of the model were satisfactory, both at the individual CIV level and when considering the CER as a whole. The plots of predicted versus actual cost show general adherence to the expected reference line, but scatter about the line indicate that the performance of the CERs is variable. The case study validation also confirms that the model can be highly variable. For this reason, the accompanying Guidebook includes considerable guidance on how the results should be interpreted. The Guidebook identifies the limitations of the model, including checklists to identify specific sources of uncertainty.

The variable performance of the model is a result of the limited size of the database, which in turn is a function of limited data availability. While the stakeholder outreach effort indicates that a large number of airports and agencies store historical cost data, there are a number of challenges that limit the value of the available information. These challenges include:

- When historical cost data is available it is often stored in a format that prevents from easily being incorporated into an electronic spreadsheet or database. For example, data is often stored in PDF format, which is an electronic format, but which cannot readily be imported into a database.

- Airport projects often bundle several construction activities that represent different project types. This can make it difficult or impossible to attribute construction cost to a specific project type, which is necessary in order to support CER development.

- Historical project data often does not include information on the CIV values required to develop CERs. For example, information on a pavement project may include the amount of pavement materials required, but not specify the pavement surface area or the design aircraft MTOW.

- When airport projects are funded with AIP or PFC funding, the available cost data may only specify the federal share. This can make it difficult to identify the total project cost, especially if the project includes a large share of ineligible items.

Overall, however, the Research Team concludes that the objective of producing a cost database and model based on parametric cost estimating has been met. Recommendations for future work focus on establishing guidelines for expanding the cost database. Expanding the database would allow for additional project types to be supported in the cost model. It would also allow for a larger number of CIVs to be included in the CERs. This should improve the explanatory power of the CERs, leading to increased robustness and substantially less variability in the model's performance. The Guidebook prepared by the Research Team contains specific recommendations for data collection practices, including guidance on defining total project cost and data requirements that would support an increase in the number of cost drivers that can be included in the model.

REFERENCES

Federal Aviation Administration. 2012. *National Plan of Integrated Airport Systems (NPIAS): 2013-2017*.

Merkel, J. and A. Cho. 2003. For Airport Designers and Architects, the Future Is at the Gate. *ENR: Engineering New-Record*, Vol. 251, No. 24, pp. 36-40.

APPENDIX A: BIBLIOGRAPHY

Cost Estimating Practices

American Association of State Highway and Transportation Officials, *A Practical Guide to Estimating*, Washington, D.C., 2009

The AASHTO Technical Committee on Cost Estimating documents practical guidance on preparing final estimates, including recommended procedures and guidance on reviewing bids prior to award. The guide drew on the expertise of AASHTO members and the agencies they represent, to document the best practices in use by State Departments of Transportation. This guide provides practical guidance on preparing final estimates. Of particular interest to this project is the discussion on the differences between cost estimation utilizing historical bid pricing and cost-based estimating. The guide contains an analysis and discussion of the importance of proper bid tabulation methods, as well as critical factors that affect cost estimating.

American Association of State Highway and Transportation Officials, *Guidance for Major Project Cost Estimate Reviews*, Washington, D.C., 2008

The major topics covered by this guide are the scope of the costs that must be included in the estimated cost of the project, and the role of the State Transportation Agency in FHWA independent cost estimate reviews. The focus areas are the steps titled:

- Prior to the cost estimate review
- Conducting the review
- Closeout presentation
- Cost review report

American Society of Professional Estimators, *Standard Estimating Practice*, 8th Edition, Nashville, Tenn., 2011

The American Society for Professional Estimators (ASPE) is one of two industry organizations identified by the U.S. Bureau of Labor Statistics as providing industry certification for professional cost estimating. ASPE publishes and regularly updates this standard “how-to” manual for use as a guide for all professional estimators in the construction industry.

Anderson, S., K. Molenaar, and C. Schexnayder, *NCHRP Report 574: Guidance for Cost Estimation and Management for Highway Projects During Planning, Programming, and Preconstruction*, Transportation Research Board of the National Academies, Washington, D.C., 2007

This NCHRP report examines highway cost estimation practice and cost estimation management with the goal of helping achieve greater consistency and accuracy between planning, programming and preliminary design, and final design. The Guidebook explores strategies, methods, and tools to develop, track, and document realistic cost estimates during each phase of the process. This is pertinent to this project as highway cost estimating is very similar to horizontal airport cost estimating.

Cullen, L., A. D'Amato, N. LaFarge, and H. Park, *ACRP Report 49: Collaborative Airport Capital Planning Handbook*, Transportation Research Board of the National Academies, Washington, D.C., 2011

This ACRP report provides guidance to those in the airport community who have responsibility for, and a stake in, developing, financing, managing, and overseeing an airport capital plan and the individual projects included in it. This will be pertinent to this study as it will help to establish what projects are deemed important in an airport capital plan and, more importantly perhaps, what project types should be modeled in this project.

Executive Order 12893, *Principles for Federal Infrastructure Investments*, 1994

This Executive Order applies to the entire Federal Government and requires that each executive department and agency with infrastructure responsibilities develops and implements plans for investment management consistent with the following principles:

1. Systematic analysis of expected benefits and costs.

    (a) Benefits and cost should be quantified and monetized to the maximum extent practicable.
    (b) Benefits and costs should be measured and appropriately discounted over the full life-cycle of each project.
    (c) When the amount and timing of important benefits and costs are uncertain, analyses shall recognize the uncertainty.
    (d) Analyses shall compare a comprehensive set of options.
    (e) Analyses should consider not only quantifiable measures of benefits and costs, but also qualitative measures.

2. Efficient management. Infrastructure shall be managed efficiently in accordance with the following:

    (a) Agencies should conduct periodic reviews of the operation and maintenance of existing facilities.
    (b) Agencies should use these reviews to consider a variety of management practices.

(c) Agencies also should use these reviews to identify the demand for different levels of infrastructure services.

3. Private sector participation.

4. Encouragement of more effective State and Local programs.

As such, this Executive Order defines the underlying national policy on employing the BCA method for transportation infrastructure investments.

Federal Aviation Administration, *Airport Benefit-Cost Analysis Guidance*, 1999

The purpose of this document is to provide clear and thorough guidance to airport sponsors on the conduct of project-level BCAs for capacity-related airport projects. It is intended to facilitate the production of consistent, thorough, and comparable analyses that can be used by the FAA in its consideration of airport projects for discretionary AIP funding. Airport sponsors are required to conform to the general requirements of this guidance for all BCAs submitted to FAA. However, airport sponsors are encouraged to make use of innovative methods for quantifying benefits and costs where these methods can be shown to yield superior measures of project merit.

Federal Aviation Administration, *Airport Improvement Program Handbook*, FAA Order R5100.38C, 2005

This FAA Order provides guidance and sets forth policy and procedures to be used in the administration of AIP funding. Several subordinate FAA Orders and ACs are referred to in this directive and included by reference.

Federal Aviation Administration, *Planning Information Needed for FAA Headquarters Review of Benefit-Cost Analyses*, 2006

This guidance identifies airport planning information required by FAA Headquarters for its review of BCA prepared for AIP discretionary grant and LOI purposes. Review offices include the FAA Office of Aviation Policy and Plans (APO-200 and APO-110) and the FAA Office of Planning and Programming (APP-500 and APP-400).

General Accounting Office, *Airport Development Needs: Estimating Future Costs*, GAO/RCED-97-99, 1997

This report provides a range of aggregate cost estimates for capital improvement projects for U.S. airports. Estimates are obtained from the airport and airline industries are reported and are compared with the GAO's own range of estimates. The report includes a regression analysis for associating aviation activity with capacity-related projects that will be reviewed when developing the framework for the cost estimating model.

Government Accountability Office, *GAO Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Capital Program Costs*, GAO-09-3SP, 2009

The U.S. Government Accountability Office (GAO) has released a guide designed to help federal, state, and local government agencies develop more reliable cost estimates for government projects of all sizes. The focus of the report is on federal acquisition projects. The guide is intended to help agencies produce well-documented, comprehensive, accurate, and credible estimates. The report constitutes an exhaustive primer on the art and science of cost estimating, identifying the processes, key stakeholders, and best practices. The report includes a large number of case studies. One of the case studies is from the field of aviation, but it is related to an FAA air traffic management system, not airport construction. The report includes a thorough discussion of the identification and application of data sources, but does not identify any specific data sources applicable to airport construction projects. The report generally does not identify specific cost estimating models or software packages.

Hatch Mott MacDonald Group, Inc., *Managing and Controlling Complex Airport Construction Projects*, Millburn, N.J., n.d.

The purpose of this publication is to share experience and insight in the hope that players in the industry may take advantage of some of the unique characteristics of airport work and utilize these for their construction project. The remarks are structured, not so much on the tools, new technology, or on project management ways, but rather on the techniques that are used in the execution of airport projects; strategies and principles used to effectively manage the assignment and to deliver satisfying results to the airport owner. This presentation refers to past airport projects undertaken by the author and, more specifically, to the new terminal project at L. B. Pearson International Airport. This terminal project was, at the time of writing, the largest building project ongoing in North America, with estimated costs of approximately $1.7 billion.

Kim, K. J. and K. Kim, Preliminary Cost Estimation Model Using Case-Based Reasoning and Genetic Algorithms. In *Journal of Computing in Civil Engineering*, Vol. 24, No. 6, American Society of Civil Engineers, Reston, Va., November/December 2010

This study proposes a preliminary cost estimation model using case-based reasoning (CBR) and genetic algorithm. In measuring similarity and retrieving similar cases from a case base for minimum prediction error, CBR is a key process in determining the factors with the greatest weight among the attributes of cases in the case base. Previous approaches using experience, gradient search, fuzzy numbers, and analytic hierarchy process are limited in their provision of optimal solutions. This study therefore investigates a genetic algorithm for weight generation and applies it to real project data. When compared to a conventional construction cost estimation model, the accuracy of the CBR- and genetic algorithm-based construction cost estimation model was verified. It is expected that a more reliable construction cost estimation model could be designed in the early stages by using a weight estimation technique in the development of a construction cost estimation model.

Landau, S. and G. Weisbrod, *ACRP Synthesis 13: Effective Practices for Preparing Airport Improvement Program Benefit-Cost Analysis*, Transportation Research Board of the National Academies, Washington, D.C., 2009

This document describes successful assessment techniques that can be used by airports in performing BCAs to quantify benefits for projects needing more than $5 million in AIP discretionary funding. The synthesis includes a literature review, a review of BCAs submitted to the FAA for AIP funding, and evaluation and summary of successful practices.

Landau, S., G. Weisbrod, and B. Alstadt, *Applying Benefit-Cost Analysis for Airport Improvements: Challenges in a Multi-Modal World*, Economic Development Research Group, Inc., Boston, Mass., 2009

This document addresses BCAs in light of the fact that aviation travel also requires ground access travel, making it intrinsically multi-modal. The report states that when benefit-cost analysis is applied for airport project proposals, it can raise issues of how to handle competing modes, inter-modal interactions, and definitions of who are the real users and beneficiaries of airport improvements. The authors compared benefit-cost guidance for airports with counterpart guidance for other travel modes, and also include a review of the current state-of-practice of benefit-cost studies for airport improvements. The findings point to challenges for improving future analysis methods of airport benefit-cost analysis.

Martín, J. C. and A. Voltes-Dorta, The Econometric Estimation of Airports' Cost Function. In *Transportation Research Part B: Methodological*, Vol. 45, No. 1, Transportation Research Board of the National Academies, Washington, D.C., January 2011

This article documents the efforts made to analyze the econometric estimation of cost functions that has been proposed in the literature as a suitable approach in order to obtain estimations of marginal costs, efficiency levels, and scale elasticities for transport industries. However, for airport construction projects, no significant attention has been paid in developing an airport-specific estimation methodology as opposed to adapting the procedures applied to other industries. The lack of comparable airport data is one of the causes which could explain the scarcity of this literature in the past, as well as the use of very limited approaches to explain airport technology. This paper tries to overcome these limitations by developing an airport-specific methodology to estimate a multi-output long-run cost function using an unbalanced pooled database on 161 airports worldwide. The specification of hedonically-adjusted aircraft operations, domestic and international passengers, cargo and commercial revenues in the output vector, as well as the calculation of input prices are discussed. Both technical and allocative inefficiencies are specified in the model using a Stochastic Frontier method that has been estimated through Bayesian Inference and Markov Chain Monte Carlo methods.

Massachusetts Certified Public Purchasing Official Program, *Public Contracting Overview*, Seminar Publication No. 17878-200-2C-1/97-IGO, Boston, Mass., 2001

This publication provides practical guidance and training on public purchasing procedures in the State of Massachusetts. Of particular interest is the definition and discussion on terms such as horizontal construction, vertical construction, Design-Bid-Build (DBB), Design-Build (DB), and Construction Manager at Risk (CRM).

Molenaar, K., S. Anderson, and C. Schexnayder, ***NCHRP Report 658: Guidebook on Risk Analysis Tools and Management Practices to Control Transportation Project Costs*****, Transportation Research Board of the National Academies, Washington, D.C., 2010**

This guidebook provides guidance to State DOTs for using specific, practical, and risk-related management practices and analysis tools for managing and controlling transportation project costs. Containing a toolbox for agencies to use in selecting the appropriate strategies, methods and tools to apply in meeting their cost estimation and cost-control objectives, this guidebook provides guidance to practitioners that are accountable for the accuracy and reliability of cost estimates during planning, priority programming and preconstruction.

Niedzwecki, K. E. and L. Bell, ***Best Practices for Developing the Engineer's Estimate*****, Department of Civil Engineering Research Project 661, Clemson University, Clemson, S.C., 2007**

The primary objective of this research project was to investigate the strengths and weaknesses of two types of estimating methods being utilized today by State DOTs nationwide. These two types of estimating methods are the unit cost line item approach, which the South Carolina State DOT utilizes, and the cost-based approach. The unit cost line item approach uses a formulated line item estimate price, based on historical data, multiplied by the anticipated quantity to reach a final unit price. The cost-based estimating approach takes into account production rates, crew compositions, fuel cost adjustments, haul distances, and other factors before applying a cost value to a line item estimate. The project is published in two volumes.

Reed Construction Cost, Inc., ***RSMeans Square Foot Costs 2011 Book*****, Norwell, Mass., 2011**

This manual provides descriptions of residential, commercial, industrial, and institutional buildings. It is updated each year and serves as a primary reference source for cost data categorized in accordance with the CSI format. Costs are categorized according to material and system type as a unit cost, and include associated unit labor costs for installation of each item. Also included are equipment rates required for special installation, as well as crew costs. Factors are provided to address regional differences in prices throughout the United States.

Touran, A., D. D. Gransberg, K. R. Molenaar, P. Bakhshi, and K. Ghavamifar, ***ACRP Report 21: A Guidebook for Selecting Airport Capital Project Delivery Methods*****, Transportation Research Board of the National Academies, Washington, D.C., 2009**

This ACRP report provides guidance on three different types of project delivery methods for airport projects: DBB, DB, and CRM. The report provides a two-tiered approach to decision process on when to use what method. The report describes the advantages and disadvantages, as well as the cost efficiencies of each of the three methods. The guidebook offers a two-tiered project delivery selection framework that may be used by owners of airport projects to evaluate the pros and cons of each delivery method and select the most appropriate method for their project. Tier 1 is an analytical delivery decision approach that is designed to help the user understand the attributes of each project delivery method and whether the delivery method is appropriate for their specific circumstance. Tier 2 uses a weighted-matrix delivery decision approach that allows users to prioritize their objectives and, based on the prioritized objectives, select the delivery method that is best suited for their project.

Washington State Department of Transportation, *Cost Estimating Manual for WSDOT Projects*, Olympia, Wash., 2009

This document provides cost estimating policies and procedures for estimate quantification, estimating pricing, estimate review, estimate documentation, estimate communication, and management of estimate data. It also provides guidance on treating a number of recurring challenges encountered in the estimating process. It does not include airport-specific guidance, however.

Databases and Web Sites

Economics, ENR: Engineering News-Record

Full access requires a membership fee. Data is provided on various construction and labor cost indices, which aggregate cost trends across a basket of products, as well as historical prices for 75 different materials. The data is updated with each issue of *ENR: Engineering News-Record*. Source information for which ENR retrieves data includes organizations such as the Department of Justice, Department of Labor, and the Bureau of Labor Statistics.

Estimating Information, Washington State Department of Transportation

This Washington State DOT site provides a comprehensive cost estimating manual (Washington State DOT, 2009), forms, templates, and software tools. These resources are not specific to aviation projects, however.

MasterFormat, The Construction Specifications Institute

MasterFormat is a master list of numbers and titles classified by work results or construction practices, used throughout the North American construction industry to organize project manuals, detailed cost information, and relate drawing notations to specifications. This format forms the basis for allocation of work items and associated costs for labor and materials. This is a cost item classification system: It does not include cost data.

National Highway Construction Cost Index (NHCCI), Federal Highway Administration

This web site provides a price index that can be used both to track price changes associated with highway construction costs and to convert current highway construction costs to real or constant dollars. The NHCCI is intended to replace the FHWA Bid-Price Index (BPI) in the future, but also to be compared with BPI for historical purposes. This information appears to be public information, non-proprietary, and will be a good source for the project to refer to for normalizing unit cost data to a constant dollar basis.

RSMeans Reed Construction Cost Data, Reed Construction Cost, Inc.

Reed Construction Cost Data is offered under the name “RSMeans” and is typically referred to by this term. However, the term refers to a number of different printed and electronic sources, targeted for different industries and project types, such as building construction or site work. The cost information is available through purchases of single, printed volumes or through subscription pricing that provides online access to electronic data for one year.

***Technical Committee on Cost Estimating*, AASHTO**

The AASHTO Technical Committee on Cost Estimating web site provides current information on the progress of creating new guidelines for recommended industry practices. In addition to information on the committee and its progress, the site provides links to related documents and research, most of which are from the FHWA and NCHRP.

***Transportation Costs Report: Airport Costs*, Florida Department of Transportation**

This report provides basic unit costs as of April 2011 for the most common types of airport construction projects. Most costs are provided in the FAA categories of general aviation, reliever, or commercial service airport facilities. Note that the Research Team plans to contact the Florida DOT to discuss how these "rules of thumb" were established. This is anticipated to occur during Task 3, *Define and develop a framework for the model*.

Transportation Estimators Association

The web site for this organization contains a free, downloadable "Bid Comparison Graph" spreadsheet which provides a tool to analyze bid tab data. It is dated 2000 and is therefore at risk of containing outdated information. However, this represents an approach to normalizing historical bid tab data which will be evaluated for incorporation into the model. This is anticipated to occur during Task 3, *Define and develop a framework for the model*.

Cost Modeling Software

***AASHTO Client/Server Trns•port*, AASHTO:** This system consists of the following 14 modules designed to meet most transportation agency preconstruction and construction management needs. The modules pertinent to this ACRP study include:

CES: Cost Estimation System

Trns•port Estimator: Cost Estimation Workstation

Trns•port FieldNet: Electronic Data Transfer System for FieldManager

Trns•port TRACER: TRAnsportation Cost EstimatoR

Trns•port Preconstruction: Proposal, Estimates, Letting and Award System

***AASHTO Software Cost Estimation System*, AASHTO**: This system pulls information from a State DOT's project cost database, which typically consists of construction bid tab data from the last three years of public construction projects in the state. Every three months, the database is updated and refreshed with the construction item cost from the projects. This ensures the planning level estimates remain reliable and reflect any significant changes in construction cost.

***AEsti*, Duke Associates:** This Microsoft Excel-based cost model provides the user to define cost items, unit costs, and cost per unit. The model can also apply profit to the direct cost subtotal. The tool includes links to the RSMeans and Craftsman cost libraries, if the user has purchased the right to access those libraries. There is no pre-defined Work Breakdown Structure (WBS) and is simply an Excel tool to multiply cost items and to sum them up.

***AspenONE for Engineering & Construction*, aspentech**: This system uses a comprehensive cost database and rules based software to scope projects, predict expenses, and generate detailed cost breakdowns.

***Automated Cost Estimating Integrated Tools (ACEIT)*, Tecolote Research, Inc.**: This is a family of applications that support program managers and cost/financial analysts during all phases of a program's life-cycle. ACEIT allows for analyzing, developing, sharing, and reporting cost estimates, and provides a framework for automating key tasks in the cost estimating process.

Bid2win: This is a Windows-based client/server application designed to standardize the entire estimating and bidding process.

***Bid4Build*, Bid4Build Enterprises**: Bid4Build construction estimating software is designed for all types of residential construction, insurance estimating, home remodeling projects and many areas of commercial construction. Bid4Build's comprehensive database covers basic construction categories and materials and allows users to generate accurate estimates for a broad range of projects. It also includes an Estimate Advisor Wizard which presents a five-step process for building an estimate. The program comes with a cost database that can be customized by adding, deleting or changing line item entries as well as line item costs.

CostX Estimating Software: This hierarchical spreadsheet based cost estimating program provides automatic quantities generation from 3D models and a simple interface for the extraction of dimensions and geometry from 2D CAD files. It can be tied to a cost database to provide instant cost information and recalculation when changes are made.

D4Cost: This system comes loaded with a database of 1,100 construction projects broken down using CSI MasterFormat. All data in D4COST is based on real cost data from projects. The software also includes integral cost escalators and local/regional adjustment factors

***FAA Pavement Design Model*, FAA Advisory Circular 150/5320-6E, FAA**: This model utilizes engineering inputs such as the number of sublayers and generates a summary of the resulting engineering design requirements for flexible and rigid pavements. It does not provide cost outputs.

***GeneralCOST*, CPR, Inc**.: This is a low-cost Excel-based cost model. GeneralCOST Estimator for Excel is a spreadsheet based, easy-to-use construction cost estimating system. It contains built-in functionality including one-click reporting. GeneralCOST Estimator also contains several cost data worksheets, identified by tabs at the bottom of the Excel screen. The model includes 16 tabs containing extensive unit cost data. Examples of tab names are “Concrete”, “Metals”, and “Sitework”. The model provides the user with the ability to generate the cost for an item based only on the number of units needed, such as the number of paving stones required. The model also includes locality rate adjustments for 210 cities. There is no pre-established

WBS, the user needs to define each type of task and then use the tabs to estimate the direct cost for each task.

***Price H*, Price Systems, LLC**: Price H is a stand-alone desktop application which uses parametric modeling to estimate costs, resources, and schedules for hardware projects. The model is available via annual licensing with the type of license such as a site license or a general license for a specific number of users. The model is primarily aimed at the development of items such as a custom process control facility and is not directly intended for use on construction projects.

***Project Risk Management Plan Spreadsheet (RMP) Cost Model*, Washington State Department of Transportation**: This Excel model was developed to track project risks. The Washington DOT developed this spreadsheet and an associated template for the Montana DOT's Risk Management Guidelines. Montana DOT has adopted this process for managing its projects related roads and bridges in the state. The model includes a description on how risk management is structured and performed.

***SEER for Hardware, Electronics & Systems (SEER-H)*, Galorath Associates**. This stand-alone model is available via annual licensing with the type of license such as a site license or a general license for a specific number of users. The model is primarily aimed at the development of items such as a custom process control facility and is not directly intended for use on construction projects. Standard WBSs are pre-programmed for a variety of project types. The model is comprised of four major functions:

> Interface: An intuitive interface for defining and describing projects. Users can generate a new project from an existing project "template" or by adding and defining individual work elements. A series of pop-up windows and annotations guides users through the process of defining project scope, complexity, and technologies.
>
> Simulation/Modeling Engine: Sophisticated sector-specific mathematical models derived from extensive project histories, behavioral models, and metrics.
>
> Knowledge Bases: SEER Knowledge Bases provide default project definitions, values, ranges, and calibrations based on comparable project histories. They enable users to develop first-look estimates when very little information is known, and to refine those estimates as details become available.
>
> Outputs: A variety of charts, graphs, and reports for quickly summarizing and presenting project outcomes and alternatives as well as work-in-progress.

SwiftEstimator Commercial Estimator: This system contains costs for more than 200 commercial, retail, institutional, industrial, and agricultural building types, including a number of building classes, sizes, shapes and quality levels.

US Cost Success Estimator: This is a desktop estimating software application based on parametric cost models and detailed bottom-up estimates. It can use a combination of data sources, including RSMeans, Richardson, and historical cost data.

APPENDIX B: SURVEY INSTRUMENT

1) Responder
    a) Name of Responder
    b) Phone number of Responder
    c) Email of Responder:
    d) Agency/Firm:
2) What types of construction cost estimating issues do you find most difficult to deal with and what would you like to see this model do to help solve those issues (e.g. estimating mobilization costs)?
3) What are the most common types of construction project that you estimate (e.g. Runway improvements, new/modified aprons, airfield lighting, terminal improvements, new/modified equipment storage facilities)?
4) Is construction cost estimation at your facility performed in-house?

    Yes **No**

    If yes:

    a) If you use proprietary software:
        (a) What software are you using?
        (b) Advantages of software?
        (c) Disadvantages of software?
    b) If you use non-proprietary software (such as an Excel model):
        (a) What software are you using?
        (b) Advantages of software?
        (c) Disadvantages of software?
5) Do you use outside consultants to perform construction cost estimating services?

    Yes **No**

    a) If not, what staff do you have in-house to prepare estimates?
6) Do you access online cost data for generating construction cost estimations?

    Yes **No**

    a) If yes, what sources do you use to obtain unit cost info?

7) Do you store historical construction cost estimations?

   Yes **No**

   If yes:

   a) Is that data considered proprietary or can you share it with for this study? **Please note that this information will be aggregated and kept confidential.**

   b) What format is the data in (e.g. Microsoft Access)?

8) Do you store construction project bid tabs?

   Yes **No**

   If yes:

   a) For how long is the data stored?

   b) In what format?

   c) In what type of database?

9) Do the quantities in your construction cost estimates include a round up or contingency?

   Yes **No**

   If yes:

   a) What contingency value(s) are used

   b) What is the rationale for the specific values?

10) Do you use an overall contingency factor at the end of a construction estimate?

   Yes **No**

   a) If yes, what percentage values(s) and with what rationale?

11) Please provide any rules of thumb for applying construction cost adjustments for your local region, for example adding 20% for construction on islands (please describe the procedure or provide percentage value(s) used).

12) Do you use standard construction cost estimating factors such as dollars per square feet of runway?

   Yes **No**

   a) If yes, would you be willing to provide those factors and, if documented, the rationale for those values?