AACE International Recommended Practice No. 19R-97

ESTIMATE PREPARATION COSTS – AS APPLIED FOR THE PROCESS INDUSTRIES

TCM Framework: 7.3 – Cost Estimating and Budgeting

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PURPOSE

This Recommended Practice presents benchmark information on the costs to prepare project cost estimates (for engineering, procurement, and construction) in the process industries. It includes qualitative and quantitative lessons that cost engineers and estimators can use to benchmark their cost estimating experiences against. The data on preparation costs was used to develop a parametric cost model that can be used to estimate the cost of preparing estimates.

This information supports AACE International's Recommended Practice 18R-97 entitled *Cost Estimate Classification System — as Applied in Engineering, Procurement, and Construction for the Process Industries*. The effort or cost to prepare a cost estimate is a secondary characteristic of a cost estimate classification.

A primary value of this Recommended Practice is improved understanding of the variables and trends concerning estimate preparation costs. The amount and quality of published reference data is limited, therefore, the value of the quantitative cost model presented here as a benchmark for measuring estimating performance is limited. The cost model is a good starting point for further development.

INTRODUCTION

This Recommended Practice was researched and developed by a sub-team of the AACE International Cost Estimating and Parametric Estimating technical committees. It presents the cost to prepare project cost estimates for the process industries (including chemical, pulp and paper, hydrocarbon processing, utilities, etc.).

Included in this Recommended Practice is an overview of the scope of work included in the estimate preparation process, a summary of literature and data on the subject, an analysis of the variables affecting estimate preparation costs, and finally, a presentation of a parametric estimating cost model for estimating the cost of preparing a cost estimate.

BASIS OF THE DATA

The Scope of Cost Estimate Preparation

As with any estimate, it is necessary to establish the scope of work that is covered. Cost estimate preparation includes estimating functions only (e.g., take-off, costing, risk analysis, benchmarking, etc.) and excludes engineering and design, project cost control, and other functions. Figure 1 illustrates a typical process diagram of the cost estimating process.

The estimating process for a complete project as covered by this study includes the following direct efforts.

- **Establishing estimate requirements** — interface with the project team and client to establish their needs with regard to the estimate.
- **Planning and structuring the estimate** — interface with the project team to establish the work breakdown structure and cost reporting structure and to develop a cost estimating plan (cost, schedule, and resources to prepare the estimate).
- **Develop the estimate** — quantification and costing of the project scope based on input deliverables provided by the project team. Obtain supporting cost information from internal or external reference or vendor sources. Benchmark with other projects and historical information.

- **Risk analysis and contingency** — estimate contingency costs through risk assessment and analysis, range estimating, or similar practices.
- **Document the project basis and prepare reports** — prepare estimate deliverables to the project team in accordance with the established estimate requirements.
- **Estimate review and benchmarking** — review the estimate with the project team, peers, and management, including analysis of costs against relevant benchmarks. Make any changes that result from review comments.
- **Issue the cost estimate** — issue the estimate to the project team for use in establishing budgets and project controls basis. For contractor bids, there is another step of pricing, including determination of profit and other mark-ups and allocations appropriate to the contract situation.

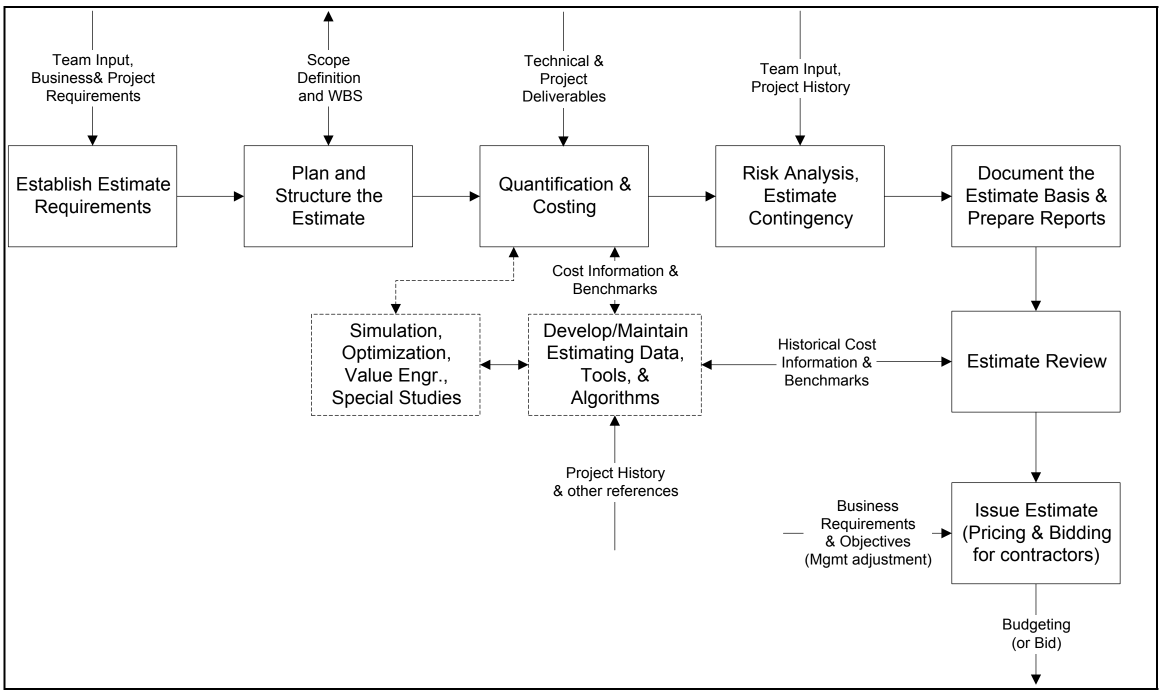


Figure 1 — Typical Process Diagram of the Cost Estimating Process

In support of these efforts, there are overhead or indirect research functions that are normally included as overhead in the estimating billing or charge rate. As such, they are assumed to be included in the cost of preparing an estimate (note: it is often difficult to be sure of the extent of the costs included in charge rates). These include but are not limited to:

- **researching, developing, and maintaining cost estimating and benchmark databases**;
- **creating and maintaining cost estimating procedures, tools, and algorithms**;
- **training of estimators**;
- **marketing of estimating services**;
- **coordination and meetings with the project team and vendors**; and
- **office overhead and expenses (rent, utilities, copying, office supplies, etc.)**.

Common estimating functions excluded from the estimate preparation costs covered by this study are the following:

- **Extensive cost data or tools development needed for unique or special situations.**
- **Formal value engineering** — while estimators strive to improve project value in the course of developing an estimate, formal value engineering studies are not included.

- **Simulation, optimization, life-cycle costing or other extensive, unique, or special cost analysis techniques and studies** — as with value engineering, while estimators will normally examine some alternate approaches for various items, extensive special evaluation techniques are not included.
- **Preparation of estimate input deliverables** — estimating excludes engineering, design, project management, and other project functional work to develop estimate input deliverables. This causes some uncertainty as it is common for various team members, vendors, or subcontractors to provide the estimators with various pieces of cost information, but it is assumed here that their effort is charged to engineering or other accounts and is not included here.
- **Ongoing support of project cost control and scheduling.**

Assumed Estimating Skills and Knowledge

The activities in the estimating process are assumed to be performed by professional cost engineers/estimators with clerical and administrative overhead support. Small project or conceptual estimates may be performed by a single individual who must have excellent skills and knowledge of the estimating process and of the process technology being estimated. On large detailed estimates, the estimating team may include a hierarchy of skill and knowledge levels from the overall team leader to the trade specialist technicians doing take-offs from drawings, to clerical support personnel. For some projects, engineers with estimating skills will prepare the estimate. For many small contractors, the estimator is quite often the owner, with profit/loss responsibility.

Literature Reviewed

For this Recommended Practice, the AACE International library was searched for relevant articles, papers, and texts. While not exhaustive, the search covered the major sources that are current and readily available. Some of the sources are secondary references. Some previously unpublished data from private company sources was also obtained.

ANALYSIS OF SOURCES

Summary of Information

In summary, the literature on the topic is not extensive, and the data included is neither current nor consistent. For a given project size and class of estimate, the costs found varied by as much as a factor of 3:1, with a significant standard deviation in all cases. However, a 3:1 accuracy range is not unusual for class 5 estimates in the process industries. While any one data point is suspect, the data is suitable for further analysis as a group.

Table 1 illustrates the range of data included in the references studied (the “shaded” sources included all engineering and design costs that support the estimate — they are not included in later evaluations, but are shown for the benefit of those who may be interested in that kind of data). Because each reference uses a different method to display estimating costs or effort (by equation, table, or graph, and in hours, %, or absolute dollars), the table converts all source data to one display format. The table displays estimate preparation costs as a percentage of total project costs for various project sizes and estimate type classifications. Where applicable, the assumptions used to convert the original source to this table format are shown.

For illustration, figure 2 graphically displays selected data from the table (for class 3 estimates). It is clear that while there is some variation in the cost data, there are some obvious trends as well, which are discussed in the following section.

			AACE International Estimate Classification				
Est. Class Designation			**5**	**4**	**3**	**2**	**1**
% Eng/Design Complete			0-2%	1-5%	10-40%	30-60%	50-100%
Ref.	Basis	Project MM$	**Estimate Preparation as % of Total Project $**				
1	Basis: Process Industry						
		$ 1	0.15%	1.0%	2.5%	4.0%	10.0%
		$ 10	0.060%	0.40%	0.80%	1.6%	5.2%
		$ 100	0.013%	0.06%	0.13%	0.32%	1.0%
2	Basis: Process Industry						
	Assume: 0.1% at class 5 for $1,000,000 project						
		$ 1	0.10%	0.40%	1.0%	1.4%	1.9%
3	Basis: Process Industry						
		$ 1	0.060%	0.20%	0.50%	1.5%	3.0%
4	Basis: Process Industry (approach based on project duration and number of trades involved)						
	Assume: 12 month project, existing tech, 5 disciplines, $80/hr rate, "credible estimate" = class 4						
		$ 1		0.64%			
5	Basis: Process Industry						
	Assume: very large project, Eng = 10% of total project						
		$ 100				0.2%	
6	Basis: Process Industry						
		$ 1	0.15%		0.60%		2.00%
		$ 10	0.040%		0.15%		0.50%
7	Basis: Process Industry (derived from same source as (1))						
		$ 1		2.0%	5.0%	8.5%	
		$ 10		0.40%	0.80%	1.8%	
8	Basis: Process Industry						
		$ 1	0.040%	0.12%		0.9%	
		$ 10	0.014%	0.06%		0.7%	
9	Basis: Government/Aerospace (high complexity)						
		$ 1	2.30%		5.6%		11.0%
		$ 10	0.550%		1.4%		2.7%
		$ 100	0.110%		0.30%		0.6%
10	Basis: Process Industry						
		$ 1	0.20%	0.20%	0.40%	0.60%	0.60%
		$ 10	0.050%	0.050%	0.14%	0.21%	0.21%
		$ 100	0.020%	0.020%	0.07%	0.10%	0.10%
11	Basis: Process Industry						
	Assume: 1 sub-estimate for $1MM project, 3 for $10MM project, 6 for $100MM project, 1 for all Cls 5)						
		$ 1	0.10%		0.30%		
		$ 10	0.017%		0.15%		
		$ 100	0.003%		0.06%		
12	Basis: Process Industry						
	Assume: Engineering 20% for $1MM project, Eng 15% for $10MM project, Eng 10% for $100MM project						
		$ 1				0.50%	
		$ 10				0.26%	
		$ 100				0.10%	
13	Basis: Process Industry						
		$ 1	0.07%	0.12%	0.20%	0.53%	2.60%
		$ 10	0.02%	0.03%	0.07%	0.15%	0.62%
		$ 100					
Median	excludes	$ 1	0.10%	0.20%	0.45%	0.74%	2.00%
	Ref. 1,7,9	$ 10	0.020%	0.05%	0.15%	0.23%	0.50%
		$ 100	0.012%		0.06%	0.10%	
Std.	excludes	$ 1	0.056%	0.20%	0.28%	0.45%	0.91%
Dev.	Ref. 1,7,9	$ 10	0.016%	0.02%	0.04%	0.23%	0.21%
		$ 100	0.012%		0.01%	0.06%	

(shaded) shaded data indicates that reference also includes engineering and design (shaded refs: 1, 7, 9)

Table 1 – Typical Percent Estimate Preparation Costs

Table 1 References:

1 Peters, M., and Timmerhaus, K., Plant Design and Economics for Chemical Engineers, 4th ed., McGraw-Hill Inc., 1991, p102.
2 Heisler, S., Project Engineer's Desk Reference, John Wiley & Sons, 1994, Table 6.4.
3 Park, W. and Jackson, D., Cost Engineering Analysis, John Wiley & Sons, 1984, p128.
4 Stewart, R., Wyskida, and Johannes, Cost Estimator's Reference Manual, John Wiley & Sons, 1995, p196.
5 Clark, F., and Lorenzoni, Applied Cost Engineering, 3rd Ed., Marcel Dekker, Inc., 1996, p85.
6 Humphreys, K., and English, L., Project and Cost Engineer's Handbook, 3rd Ed., Marcel Dekker, Inc., 1993, p63.
7 Humphreys, K., Jelen's Cost and Optimization Engineering, 3rd Ed., McGraw-Hill, Inc., 1991, p370.
8 Hackney, J., and Humphreys, K., Control and Management of Capital Projects, 2nd ed., McGraw-Hill, Inc., 1992, p27.
9 Remer, D., and Buchanan, H., "The Cost of Doing a Cost Estimate", Cost Engineering, March 1993, p7.
10 Short, D.L. Tempest Company Services Price Guide, 1997 (with permission).
11 Confidential - Owner Company.
12 Confidential - A/E Firm.
13 Ritz, George, Total Engineering Project Management, McGraw-Hill, Inc., 1990, p133.

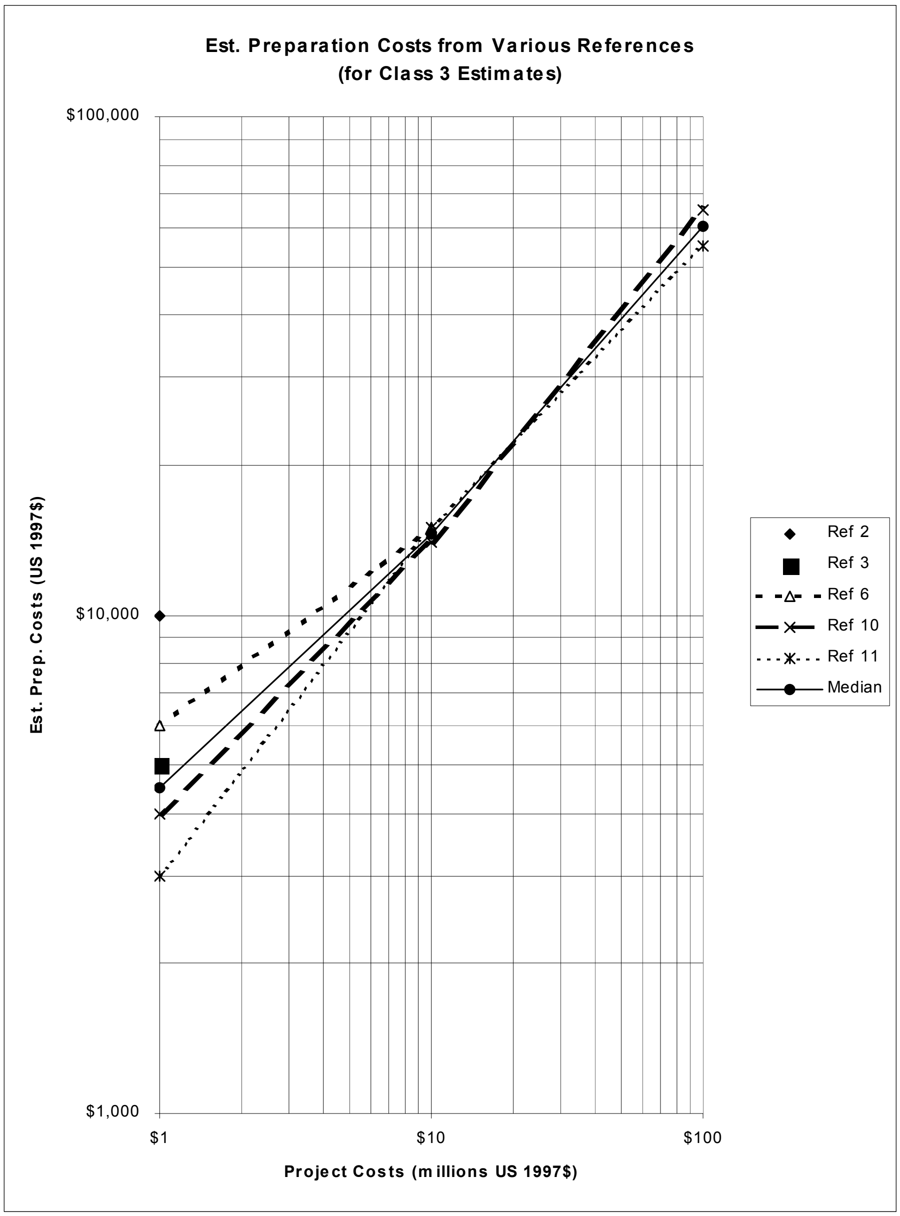


Figure 2 — Typical Estimate Preparation Costs From Various References
(illustrates the variation in published data, but similar trend or slope)

Sources of Data Variation

The sources of inconsistency were considered. The following list describes some of the possible sources of variation in published data.

- **Estimating function scope** — most sources do not describe what the scope of "estimate preparation" work includes. It was clear that at least three sources included engineering and design effort to produce inputs used in the cost estimate. Some sources show estimating hours required (rather than costs) — we assume that these hours exclude indirect research and support efforts.
- **Out of date** — most of the publications are based on original source information from the 1960s or 1970s that have been normalized to a current basis. In one case, two sources, using the same root data, show widely different normalized results. Some would assume estimating productivity should have improved due to the use of personal computers, electronic spreadsheets and databases, and affordable commercial estimating software in the 1980s and 90s. Others feel that the average skill level and productivity of estimators may be declining as companies increasingly rely on estimating programs rather than estimator's knowledge.
- **Project scope being estimated** — sources do not always indicate if the cost being estimated include total project costs, or some limited portion such as field direct construction costs, excluding home office, owner, indirect, or other project elements.
- **Estimate purpose and roles** — most sources do not indicate if the costs described cover work performed by owner firms or their contractor partners in support of internal funding and control, or whether it covered contractors developing bids. Contractors often rely on subcontractors for parts of their estimates — it is unclear how much of this subcontracted effort is included. Owners do not always have to deal with "pricing" issues.
- **Project/process complexity and technology** — sources generally assume some "typical" level of process technology and work breakdown; however, there was little or no elaboration of what the "typical" technology is or how costs may vary with different levels of complexity.
- **Skills and knowledge/quality** — sources generally do not indicate the level of estimating or project team skill and knowledge and level of estimate quality assumed in the data.
- **Estimate classification** — most sources show costs for estimates of various "types" of estimate or level of detail, but the means of categorizing those types is inconsistent.

There are some consistencies noted in the data. These include:

- **estimating costs increase in a nonlinear relationship with total project cost** — estimating costs as a % of project cost decreases as project size increases;
- **estimating costs increase with complexity of the project/process technology**; and
- **estimating costs increase with the level of project definition or stage of the project**.

ANALYSIS OF VARIATIONS

The sources of variation in published data were further examined to determine if any conclusions could be drawn that would help estimators better evaluate and quantify estimating costs depending on specific parameter values. For each variable clear trends occur, but, the magnitude or slope of the trend varies widely, as represented in the large standard deviations.

Estimating Costs vs. Level of Project Definition (Estimate Classification)

Table 2 illustrates the variation of estimating costs with the level of project definition as represented by the standard estimate types. The costs are represented as a relative index, with a value of 1.0 being equal to the cost to prepare a Class 5 estimate. Although each source varies, the estimate preparation costs increase more-or-less proportionally with the level of project definition (e.g., percent engineering/design complete).

Estimating Costs vs. Project Size

Table 3 illustrates the variation of estimating costs with the level of project size in millions of US dollars normalized to 1997. The costs are represented as a relative index, with a value of 1.0 being equal to the cost to prepare a Class 4 estimate of a $1 million dollar project. Although each source varies, the estimate preparation costs increase in a nonlinear fashion with project size. There is a "fixed cost" aspect of estimate preparation that yields an economy of scale. Also, large jobs generally have either very large equipment items or multiple, repetitive process units or trains that reduce estimating effort relative to project costs.

Estimating Costs vs. Process Complexity

Table 4 illustrates the variation of estimating costs with the level of project complexity. The value shown is the ratio of the cost to prepare a project of "high" complexity vs. "normal or low" complexity. Where data sources illustrated "ranges," it was assumed that this was mostly due to complexity. The data displays a 2:1 or 3:1 variation for a given project size and estimate class.

Estimating Costs vs. Estimating Organization

Table 5 illustrates the variation of estimating costs with the way the estimating process was administered in terms of breaking the work into subparts. The costs are represented as a relative index with a value of 1.0 being equal to the cost to prepare a Class 3 estimate of a $10 million dollar project using only 1 estimating subgroup.

This variable is related both to project complexity and project size. Large and complex jobs generally require a larger, more complex estimating organization, with its attendant inefficiencies. The estimating work may be organized by trade specialty and/or by project work breakdown or systems. This trend works counter to the economy of scale of large projects (i.e., administratively, it breaks large estimates into smaller pieces). The possible variations in project size, complexity, and estimating processes certainly are a source of the inconsistency in published data.

	Estimate Classification Designation				
	5	**4**	**3**	**2**	**1**
Ref.	Relative Index, $1M Project, Class 5 = 1.0				
2	1.0	4.0	10.0	14.0	19.0
3	1.0	3.3	8.3	25.0	50.0
6	1.0		4.0		13.3
8	1.0	3.0		22.0	
10	1.0	1.0	2.0	3.0	3.0
11	1.0		3.0		
13	1.0	1.7	2.9	7.6	37.1
Median	**1.0**	**3.0**	**3.5**	**14**	**19**
Mean	1.0	2.6	5.0	14	24
Std Dev.	0.0	1.2	3.3	9.3	19

Table 2 — Variation of Estimate Preparation Costs with Estimate Classification
Relative Index of Effort to estimate a $1M project with Class 5 effort = 1.0

	Project Size (millions 1997$)		
	$ 1	$ 10	$ 100
Ref.	Relative Index, Class 4, $1M = 1.0		
7	1.0	0.21	
8	1.0	0.74	
10	1.0	0.35	0.17
12	1.0	0.51	0.20
13	1.0	0.28	
Median	**1.0**	**0.35**	**0.18**
Mean	1.0	0.42	0.18
Std Dev.	0.0	0.21	0.02

Table 3 — Variation of Estimate Preparation Costs With Project Size
Relative Index of Effort to estimate $1 million worth of project value

Ref.	Description of Complexity Range	High/Low Effort Ratio
4	Ratio of "existing" to "high technology"	2.3
9	Ratio of this high tech. source to avg. of other sources (for Class 3, $1M projects - for this source, the cost to prepare includes "preliminary engineering report")	3.8
11	Typical complexity adjustment for this firm	2.0
Median		**2.25**
Mean		2.69
Std Dev.		0.98

Table 4 — Variation of Estimate Preparation Costs With Process Complexity
Relative Index of Effort to estimate a project with low complexity = 1.0

	Estimate "Sub-Groups"*		
	1	3	6
Ref.	Rel. Index, Class 3, $10M, 1 group = 1.0		
4	1.0	3.0	6.0
12	1.0	1.9	2.9
Median	**1.0**	**2.5**	**4.4**
Mean	1.0	2.5	4.4
Std Dev.	0.0	0.7	2.2

Table 5 — Variation of Estimate Preparation Costs With Estimating Organization
Relative Index of Effort to estimate with 1 estimate team subgroup or person = 1.0
* Estimate “Subgroups” is a count of the number of subdivisions of the project assigned to and estimated by separate lead estimators/subgroups (may be by trade/discipline, system, area, key skill, location, etc.)
Note: Estimate team tends to increase with “process complexity”

A PARAMETRIC MODEL FOR ESTIMATE PREPARATION COSTS

With the many variables noted and the wide variations observed in the reference data, it is clear there can be no “standard” values for estimating preparation costs. However, a parametric estimating model could be developed that addresses the key variables or parameters noted in the study — such a model could be used as a “benchmark” or comparison guide against which estimators could evaluate their experiences. The goal of the model was to produce a Class 5 estimating tool that produces results within the range of reference data.

The Parametric Algorithm

A complex algorithm was developed by trial and error based on the observed data variations, with back-checking to verify that the results corresponded to observed data. Regression analysis with so many variables and so little data was inconclusive. The basic form of the algorithm is:

$$E = \left[c + K * \left(T / S\right)^{e} * S\right] * C * P$$

where:

E = cost to prepare an estimate in 1997 US$
c = a constant adder (each estimate classification has a unique constant)
K = a constant multiplier (each estimate classification has a unique constant)
T = total project costs in 1997 US$
S = number of estimate subparts or groups
e = exponent (slope) for each estimate classification
C = a factor to adjust for project/process complexity
P = a composite factor to adjust for estimating function productivity

Table 6 provides the values of the constants c, K, and e. Table 7 provides typical values for the complexity factor (C) for various project/process types.

The productivity factor (P) is a subjective variable that typically is in the range of 0.5 to 1.5. It assumes that estimating productivity is determined by three major quality factors: team, tools, and process. The factors include:

- team — quality of project team skill, cooperation and coordination, and quality of input deliverables;
- tools — use of specialized tools to automate or otherwise augment normal estimating practice (no credit is given for typical spreadsheet or database type line item estimating systems); and
- process — experience, skill, and quality of the estimating function and the availability of quality resources (primarily data).

Table 8 illustrates typical values that, multiplied together, yields the P factor.

	Estimate Classification Designation				
Constant	5	4	3	2	1
c	80	160	240	320	640
K	35.0	15.0	3.0	0.8	1.6
e	0.25	0.35	0.50	0.60	0.60

Table 6 — Parametric Algorithm Constant Values

Typical Project / Process Type	Complex Factor	Notes
Building - Commercial	**0.8**	
Industrial/Chem - Repeat or Bldg - Complex	**0.9**	
Industrial/Chem - Typical	**1.0**	
Industrial/Chem - Advanced	**1.7**	
Industrial/Chem - Pilot Plant	**2.5**	
Aerospace/Nuclear - Typical	**3.5**	(caution - based on Ref. 9 only)
Aerospace/Nuclear - Advanced	**4.6**	(caution - based on Ref. 9 only)

Table 7 — Parametric Algorithm Complexity Factors

Team and Input	Rating	1 best	2	3	4 avg-good	5	6	7 very poor
	Factor	**0.76**	**0.87**	**0.94**	**1.00**	**1.05**	**1.08**	**1.12**
Special Tools & Methods	Rating	10%	25%	40%	45%	60%	75%	90%
	percent of the project cost estimated using a specialty tool or system (mostly class 5 or 4)							
	Factor	**0.93**	**0.83**	**0.72**	**0.69**	**0.58**	**0.48**	**0.37**
Est. Process & Data	Rating	1 best	2	3	4 avg-good	5	6	7 very poor
	Factor	**0.50**	**0.71**	**0.87**	**1.00**	**1.12**	**1.22**	**1.32**
Productivity Factor = Team Factor x Tools Factor x Process Factor								

Table 8 — Parametric Algorithm Estimating Productivity Factors

Results of the Parametric Model

The parametric model was tested with various sets of input parameters. The estimate preparation costs that result from the model fall well within the standard deviations of the published data. For illustration, figure 3 shows typical model results in comparison to some of the observed data (for Class 3 estimates).

As with any model, caution must be exercised by the user in selecting extreme values of parameters. For instance, there is no published data for projects over about $500 million US dollars in size, and very little data for complex process technologies.

A limitation on the accuracy of the model is that it requires the user to estimate the project size as an input parameter — in most cases that estimate will likely be of Class 5 level of project definition. The model is appropriate for performing Class 5 or 4 estimates of estimating preparation costs. Class 3 or lower estimates should be activity based — i.e., include more detail for the kinds of estimating tasks illustrated in figure 1.

Illustrative Charts

A series of charts was developed to illustrate how the parametric model results vary with different input parameter values. These charts are for illustration only — they are not recommended values or standards and are only applicable for the stated assumptions.

CONCLUSION

Published and private sources of data on estimate preparation costs were found. As individual, absolute measures, the data exhibits wide variation and a lack of basis documentation and is thus of limited utility. Taken together, the data does exhibit some consistencies in trends that could be drawn out with further analysis.

Variables that affect estimate preparation costs were identified and analyzed. From this study, a Class 5 parametric algorithm was developed to model estimate preparation costs. This model will allow cost engineers and estimators to benchmark their experiences with a cross-section of published data and industry sources. The results of the parametric model should fall into the typical accuracy range for Class 5 estimates in the process industries. Users should adapt the model to fit their situations.

This study found an area of cost engineering knowledge that calls out for additional study and data. AACE International encourages its members to research and publish papers on the subject. Potential papers could address the effects of the various parameters noted here, and could extend the data to a broader range of industry and project types. More current cost data is needed.

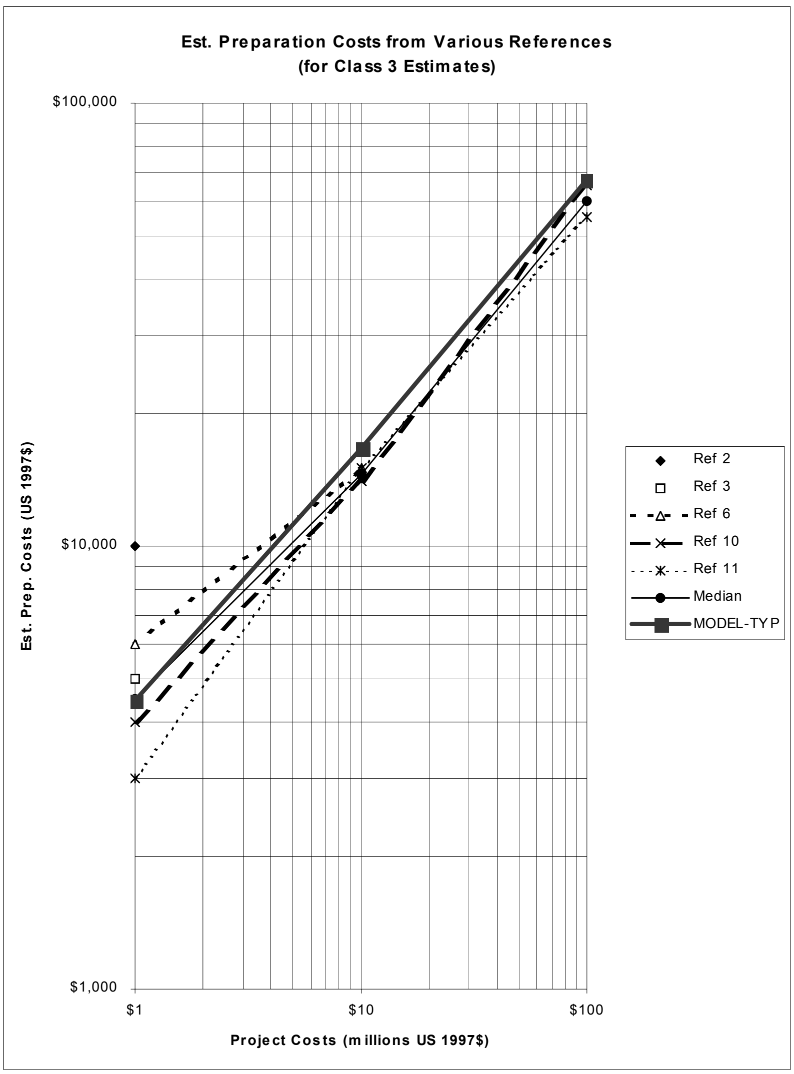
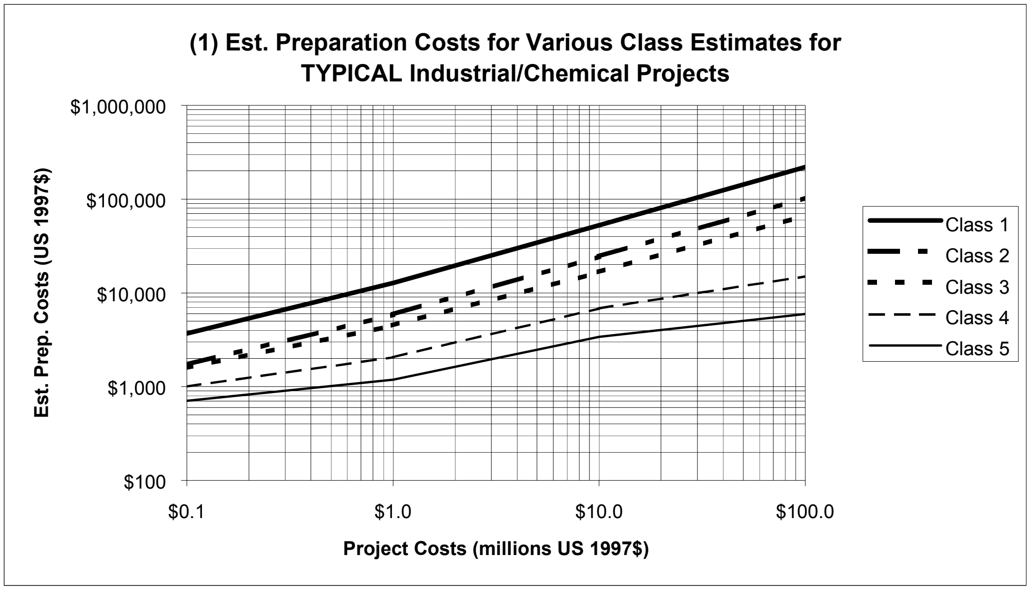
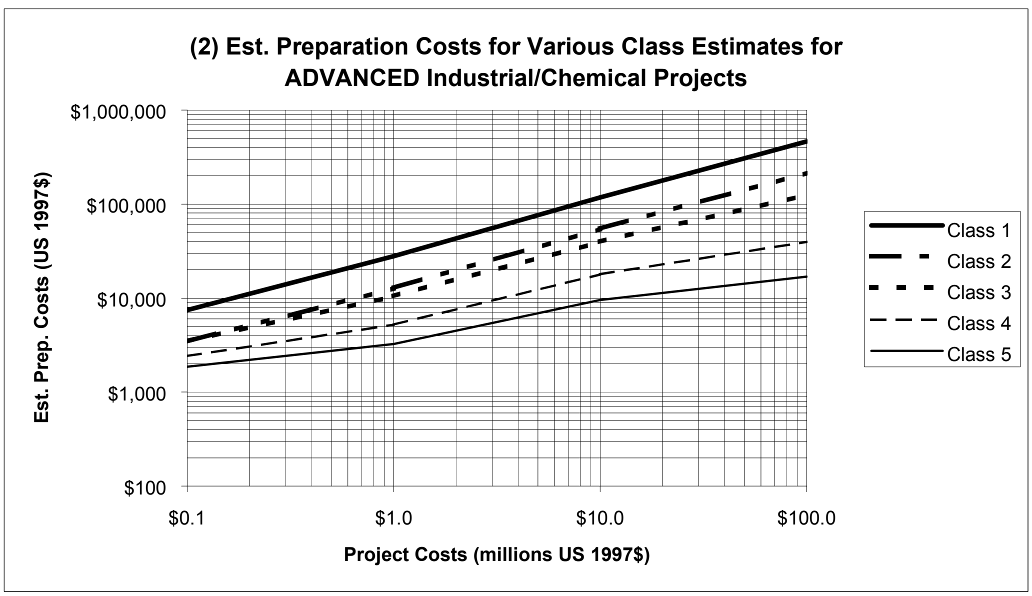


Figure 3 — Estimate Preparation Costs Predicted by Model vs. Reference Data

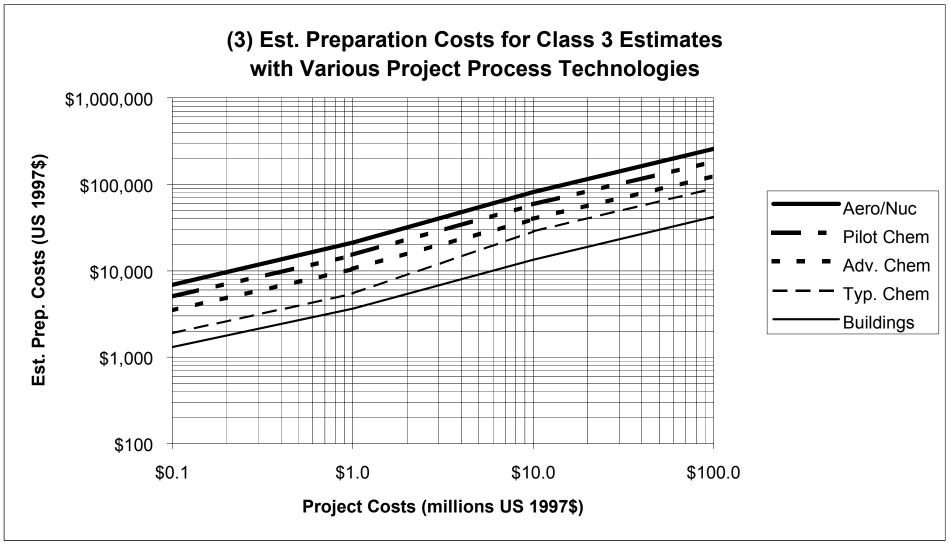


This Chart Illustrates Estimate Preparation Costs given these parameters:
Typical Industrial/Chemical Type Project
Average Project Complexity
Average Estimating Productivity
No. Est. Sub-Parts/Groups: for <= $1M: Class 5 = 1, Class 4 = 1, Class 3 = 2, Class 2 = 4, Class 1 = 5
No. Est. Sub-Parts/Groups: for $10M: Class 5 = 2, Class 4 = 2, Class 3 = 3, Class 2 = 5, Class 1 = 6
No. Est. Sub-Parts/Groups: for $100M: Class 5 = 2, Class 4 = 2, Class 3 = 5, Class 2 = 6, Class 1 = 7



This Chart Illustrates Estimate Preparation Costs given these parameters:
Advanced Industrial/Chemical Type Project
Average Project Complexity
Average Estimating Productivity
No. Est. Sub-Parts/Groups: for <= $1M: Class 5 = 2, Class 4 = 2, Class 3 = 4, Class 2 = 8, Class 1 = 10
No. Est. Sub-Parts/Groups: for >$1M: Class 5 = 4, Class 4 = 4, Class 3 = 6, Class 2 = 10, Class 1 = 12

Charts 1 and 2 – These charts illustrate the variation in estimate preparation costs for projects using typical vs. advanced technology, assuming average complexity and productivity.



This Chart Illustrates Estimate Preparation Costs given these parameters:

Class 3 Estimates

Average Project Complexity

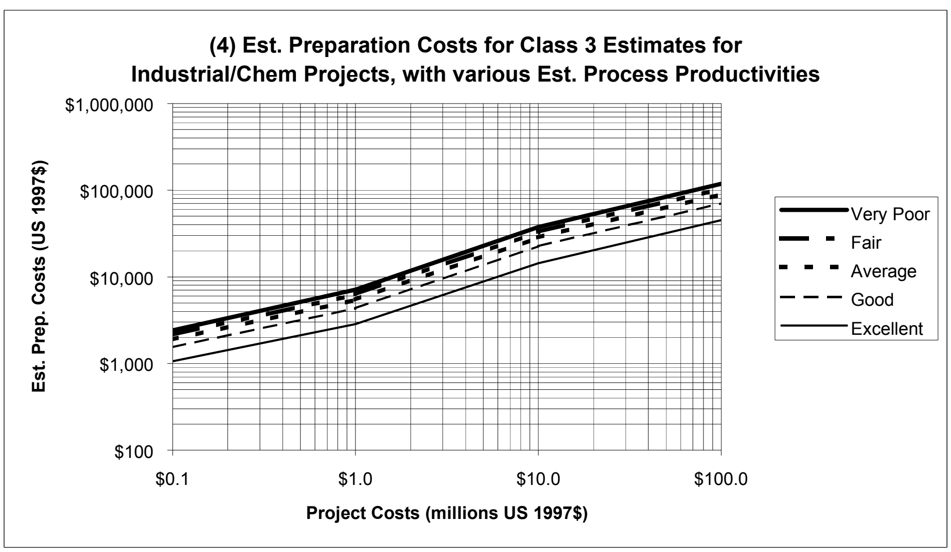
Average Estimating Productivity

No. Est. Sub-Parts/Groups: for Advanced Technologies; <=$1M = 4, >$1M = 6

No. Est. Sub-Parts/Groups: for Typical Chem; <=$1M = 3, >$1M = 5

No. Est. Sub-Parts/Groups: for Simple Buildings; <=$1M = 2, >$1M = 4

Chart 3 – This chart illustrates the variation in estimate preparation costs for projects using various process technologies (other parameters held constant)



This Chart Illustrates Estimate Preparation Costs given these parameters:

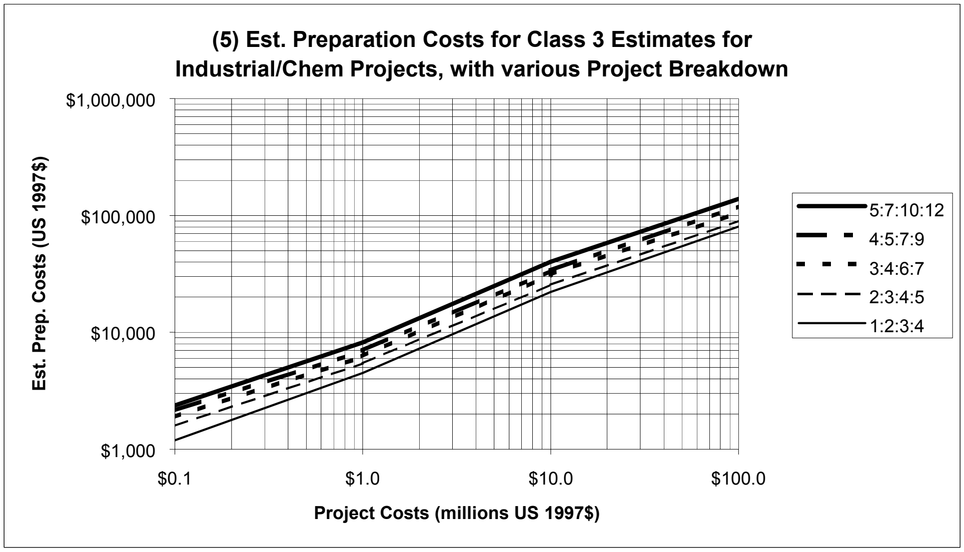
Class 3 Estimates

Typical Industrial/Chemical Projects

Average Project Complexity

No. Est. Sub-Parts/Groups: for Typical Chem; <=$1M = 3, >$1M = 5

Chart 4 – This chart illustrates the variation in estimate preparation costs for various estimating process productivities (other parameters held constant)



This Chart Illustrates Estimate Preparation Costs given these parameters:
w:x:y:z indicates the No. of Est. Sub-Parts/Groups for Project Sizes of $0.1M:$1M:$10M:$100M
Class 3 Estimates
Typical Industrial/Chemical Projects
Average Project Complexity
Average Estimating Productivity

Chart 5 – This chart illustrates the variation in estimate preparation costs for various project breakdown or estimating subparts/groups (other parameters held constant – relates to complexity)

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