11.0 ENGINEERING ESTIMATING

11.1 Introduction

This is the last of three chapters providing extensive discussions on one of the three main estimating methodologies. The reader was first introduced to engineering (also know as detailed engineering estimating) in Chapter 3, Section 3.3 in the context of the estimating process. Engineering estimating methods are important because they result in the most detailed estimates. Specifically, engineering estimating methods generally involve a more detailed examination of the new system and program. A full and detailed treatise on engineering estimating is provided within this chapter.

When talking about an engineering estimate, it is prudent to clarify whether this is a detailed estimate prepared by bidders or a cost estimate prepared by government personnel (hereafter referred to as an in-house engineering cost estimate). The two tend to be quite different estimates, even on the same program. Section 11.2 will address bidder- or contractor-prepared engineering estimates to help cost estimators understand how contractors prepare estimates, so they will be better prepared to use and evaluate such estimates. Section 11.3 will address in-house estimates and differences between detailed in-house prepared engineering estimates and those prepared by contractors.

The process of developing engineering estimates often calls for techniques described in other chapters of the handbook. This chapter will show how methods (including those described elsewhere in the handbook) are integrated into engineering estimates. All available system descriptions and applicable historical cost data must be considered in a logical manner when arriving at an estimate. In the case of engineering estimates there generally are more data available upon which to base an estimate than there are available for a parametric or analogy estimate. For instance, a firmer, more complete description of the new program for acquiring the end item usually is available. Often the converse is true for parametric and analogy cost estimates.

Nothing in the definition of engineering estimates limits the scope of the estimate with respect to cost element contents. However, engineering estimates prepared by contractors usually do not include such elements as other government costs and engineering change costs that must be included in most government budget estimate submissions.

Most significant estimating efforts are a combination of several methods. The best combination of methods is the one which makes the best possible use of the most recent and applicable historical data and system description information and which follows sound logic to extrapolate from historical cost data to estimated costs for future activities. The smaller the extrapolation gap in terms of technology, time, and activity scope the better.

11.2 Engineering Estimates Prepared by Contractors

11.2.1 Brief Description

As discussed in Section 11.1, engineering estimates prepared by contractors differ substantially from engineering estimates performed by government personnel in at least two important ways. First, the contractor-prepared estimate is based on input from work units that will do the work and that have performed similar work in the past. Second, contractors are able to bring more detailed program description data such as tooling plans, make or buy plans, etc., to the cost estimating process. It is not unusual to see contractor engineering cost estimates documented in at least two volumes. One volume most likely would be called the Cost Estimate or Financial Plan with the other volume being called something like the Engineering Estimate or Substantiating Data. The second volume is primarily time (direct labor hours) and material estimates prepared by the organizations that would do the work.

The activities described in Section 11.2.2 are consistent with the brief descriptions provided in this section. However, not only do different contractors do things in different ways, procedures will vary by individual contractor depending on the availability of cost data on similar programs, vendor proposals, and the degree of design and program description uncertainty. Therefore, the activities described in Section 11.2.2 must be viewed only as representative - not the only type, combination, or sequence of activities that can be encountered with respect to contractor-prepared engineering estimates.

11.2.2 Key Activity Descriptions

Most contractor-prepared engineering cost estimates that are seen by government cost estimators were prepared for cost proposals. Such estimates are described here.

<u>Activity A. Understand Program Requirements</u>

An initial and critical activity is to understand the program requirements clearly and completely. This understanding is gained by a complete review of several documents describing what is to be done, how it is to be done, and the contractors' responsibilities with respect to getting it done. These documents include:

- Proposal instructions
- Statement of Work (SOW)
- Lists of deliverables
- Data lists
- Specifications
- MIL Standards
- Federal Acquisition Regulation (FAR) clauses
- Contract requirements

For most programs, especially major programs, contractors will be in direct contact with government personnel at bidders' briefings or through the buyer to get further clarification on the program requirements.

Activity B. Prepare Program Baseline Definition

This critical activity includes company preparation of detailed plans and documents describing how they plan to complete required work. These preliminary plans and documents can include:

Technical descriptions	Production illustrations
Manufacturing, tooling, and facility plans	Government Furnished Property (GFP) lists
Quality assurance plans	Master equipment lists
Test plans	Support equipment lists
Logistics plans	Tool lists
Training plans	Special test equipment lists
Management plans	Schedules
Contractor support plans	Facility layouts
Associate contractor agreements	Model contract
Make or buy plans	
Hardware drawings and descriptions	

Activity C. Prepare Ground Rules and Estimating Instructions

The early publication of cost estimate ground rules and instructions is important to assure that the many people involved in the preparation of the cost estimate clearly understand and correctly carry out their roles. Subjects addressed include, but are not limited to:

- Quantity and schedule information
- Estimate formats to be used
- Escalation rate assumptions
- GFP availability assumptions
- Man-month to man-hour conversion factor

The estimating instructions usually define major cost groups and list their components. Table 11.1 is an example of such instructions.

Table 11.0 Cost Element Group Definitions

Term	Definition
Direct Material	Includes raw materials like lumber and oil, as well as processed materials (sheet metal), purchased parts (nuts and bolts), and purchased equipment (tools). This category also includes subcontracted items or items produced outside of the company, which could be major sub-components of an end item.
Direct Labor	The effort of hourly or salaried employees, usually expressed in labor hours or labor years. Direct labor typically is broken out by functional category, such as engineering, quality assurance, and manufacturing.
Overhead (Indirect)	A cost which, because of its incurrence for common or joint

	objectives, is not readily subject to treatment as a direct cost to one contract or product. Such indirect cost is incurred to benefit the total direct cost or business base of a contractor. The character of overhead thus requires estimating, budgeting, and control techniques that take into account the total business base of a contractor. This term is synonymous with indirect costs. It could include such costs as the Engineering Department head office expenses.
Direct Travel	Includes all travel by direct personnel in support of contract tasks.
Other Cost Elements	Fringe benefits, direct charges, state taxes, cost of facilities capital, and inter-divisional support.
General and Administrative (G&A) costs	These are indirect costs necessary for maintaining an ongoing business entity. They typically include a company's general and executive offices, the cost of staff services such as legal, accounting, and similar expenses related to the overall business.

Activity D. Develop Required Matrices and Checklists

Control matrices relate WBS tasks to contract line items. Matrices and checklists are prepared to assure that all required work is considered during preparation of the estimate. Also, matrices are used to show organizational responsibilities with respect to WBS tasks.

Activity E. Develop Functional Organization Task/End-item Estimates

This is the most important activity in the company-prepared engineering cost estimating process. Most of what was done in Activities A through D was done to assure that this activity is complete and valid. Many people in several functional organizations must estimate the time in hours, days, or months to carry out their responsibilities with respect to each of many WBS tasks and end items. These estimates are primarily direct labor values but may also include some material and subcontract cost estimates. Elements of costs estimated in this manner include:

- Engineering direct labor
- Tooling fabrication labor
- Basic factory labor
- Manufacturing engineering labor
- Quality assurance labor
- Facilities engineering

How this activity is done differs substantially from how the equivalent activity is done in the in-house engineering estimate. This is because the in-house team is not supported with man-hour estimates made by people who will do the work and who have done similar work before.

Activity F. Use Other Program History

The availability and use of other program historical cost and description data are essential for developing and substantiating sound estimates of direct labor, appropriate factor, and future costs. Most companies will have a computerized system for bringing such data quickly to bear on the preparation of estimates for future work. These computer programs often include

procedures for entering descriptive data on the new system and for generating an estimate automatically based on this input and the historical data in the system.

Activity G. Compile Estimate Data

This activity consists of aggregating all the time and material cost data provided by the functional organizations in accordance with the proper contract line item number (CLIN), SOW, and WBS breakouts needed both to show the estimate detail required and to properly apply rates and factors. To an extent, this activity is the dividing line where primary estimating activities pass from the functional organizations to the pricing or financial specialists. Often these time and material estimates and the rationale supporting them are documented in a separate volume or volumes from the information prepared by company pricing or financial specialists.

Activity H. Develop Rates and Factors

Many rates and factors are used to develop a contractor-prepared engineering estimate. For major programs these rates are different and must be provided by year over the entire life of the program. The development of these rates is subject to strict rules enforced by various audit agencies. Ideally, contractor estimates are based on rates and factors already approved by a government audit agency. If not, the usual process of reviewing a contractor's estimate is to have the rates and factors used audited by one of the organizations. The primary criteria for acceptable rates and factors is that they were developed using accepted accounting procedures, appropriate recent historical data, and reasonable assumptions about the future with respect to inflation, plant loading, wage contract settlements, etc. Many rates and factors are used which differ from contractor to contractor depending on individual accounting systems. Some of the rates and factors that could be used and that are defined in the example in the appendix to this chapter include:

- Direct labor pay rates for all categories of direct labor
- Overhead rates covering all categories of direct labor
- Facilities Capital Cost of Money (FCCOM)
- Overtime premium factors
- Tooling material cost per tooling fabrication hour
- Engineering operations cost per hour of engineering direct labor
- Sustaining engineering cost per factory labor hour
- Tooling and production planning cost per factory labor hour
- Quality assurance cost or hours per factory labor hour
- Program financial control cost per hour
- Fringe benefit cost factor of direct labor costs
- Other direct charge factors (e.g., freight) of material costs
- General and administrative factor of labor and overhead

A detailed discussion concerning the construction of Wrap Rates, used by government personnel in estimating, is included as an appendix to this chapter (Appendix 11A: Wrap Rate Construction).

Activity I. Incorporate Supplier Proposal Prices

Most major prime contracts for government equipment result in many subcontracts for goods and services. For common items, costs can be obtained from catalogs. For one of a kind items or services, the prime contractor usually asks for quotes from one or more suppliers. Since such subcontracts will not be negotiated and signed until after the award of the contract to the prime, the contractor-prepared engineering estimates generally use the vendor quoted price, less an assumed negotiation decrement (based on past experience).

Activity J. Compute the Estimate

Because of the large volume of data involved, the need to present the cost estimate in several ways, and the need to incorporate last minute changes, all prime contractors use computers to compute, organize, format, and print their engineering cost estimates. The computations are consistent with the ground rules, instructions, matrices, and checklists discussed in Activities C and D. They reflect all the data generated in Activities E, F, G, H, and I.

Activity K. Summarize the Cost Estimate

The results of the cost estimate computations must be summarized in several ways, according to decision maker needs.

Activity L. Review the Estimate

Several levels of review usually are required for all contractor-prepared major program engineering estimates. Special scrub teams look at details, while a higher-level corporate team may perform the last review. Unfortunately, these review teams have been known to raise or lower estimates in the past, especially in response to a Best and Final Offer (BAFO) request, without having to supply all the desired supporting rationale for the new estimate. As a result, some of the input data described in Activities E, H, and I may need to be changed without sound rationale to arrive at the desired estimate.

11.2.3 Additional Guidance

Since the role of a government cost estimator is to use or evaluate a contractor-prepared engineering estimate, the additional guidance that follows will be directed to that end. The following guidelines have proven useful in the past with respect to evaluating contractor prepared engineering estimates:

- Quickly find out what the high cost areas or items are, and focus attention on them.

- If the evaluation is part of a source selection, compare WBS element and CLIN costs among contractors to spot unusually high or low costs quickly for further investigation.

- Probe to see whether major and poorly substantiated changes were made to the cost estimate during the contractor's review or BAFO preparation process.

- If the contract has been awarded and the purpose of the Government review is to update the estimate, check the final negotiated subcontract price against those proposed.

- Use audit reports to check the validity of the rates and factors used by the contractor.

- In high cost areas, make sure the contractor has provided all cost estimate substantiating information requested.

Perhaps the most important guidance that can be given to improve government review of contractor-prepared engineering cost estimates is to require the submission of cost data and substantiating information in a format that is clear, complete, and ready for evaluation. This is not always easy, but several requirements are common to most review needs. They include:

- Requirements that data be totaled in each table, both down and across, if appropriate.

- Requirements that the contractor make it easy to track totals from low-level breakout sheets to higher levels of aggregation.

- Requirements for CLIN/WBS and other information matrix summary sheets to help convey how the estimate aggregates to a total cost.

- Requirements for summary sheets containing the rates and factors used to prepare the estimate.

- Requirements for man-hour summary sheets by WBS for direct and subcontracted work by labor type, if appropriate, to assess the level of effort proposed.

- Requirements that the contractor track cost estimate changes and justify the basis for the change fully.

- Requirements for fiscal phasing of costs, but only at the highest level of aggregation that will meet anticipated analysis needs.

11.3 In-House Engineering Estimates

11.3.1 Brief Description

To many, engineering is synonymous with detailed with respect to cost estimating. Generally, the most common level of detail always contained in an engineering estimate is a breakout of functional labor categories such as engineering, manufacturing, quality control, and tooling. In most engineering estimates one also can expect to find a breakout of major subcontracts and material items.

By definition, an in-house engineering estimate almost always is prepared by government personnel or by cost analysis support contractors and not by the contractor who can or will do the work. The other type of engineering estimate (where contractors prepare the estimate) was described in the previous section. Many, but not all, in-house engineering estimates are prepared to forecast out year costs for systems in production or for which prototype production cost data are available. It is less common, but possible, to do a detailed estimate for a future system by using cost estimating relationships (CERs) or analogy estimating techniques to develop detailed labor and material estimates that can be summed into an engineering-like estimate containing a minimum of detail.

It generally is more time consuming to develop detailed engineering estimates than to develop other types of estimates. However, where detailed and pertinent historical data are available, this approach more completely takes such data into consideration. It is more appropriate when the design is stable.

11.3.2 Major Differences Between Contractor and In-House Engineering Estimates

In-house engineering estimating processes differ from the contractor-prepared engineering estimating process described in Section 11.2 in several important ways. For an in-house estimate:

- Typically fewer people are available to help prepare the estimate
- Fewer product and program description details are developed and used in the process of developing the estimate
- Specialists responsible for doing the work do not estimate functional labor requirements; therefore, labor requirements usually are estimated at or near the total functional level (i.e., in far less detail)
- Supplier proposals are not available, unless the work is on contract, so material costs most likely will be based on historical costs and not broken out at as low a level

These differences can cause in-house and contractor estimates to vary from each other significantly, especially prior to production when not as much actual data is available. When the program is in production, the differences between the estimates should not be so significant. In such circumstances, actual man-hour, material, and subcontract cost data for prior production provides an excellent basis for projecting the costs associated with future production. Government cost estimators usually obtain the necessary data through visits to the prime contractor and one or more of the major subcontractors.

11.4 Summary

To apply the engineering methodology, the program to be estimated must be well defined and capable of being broken down to a fairly low indenture level. As a result, engineering estimates

generally are more detailed than either parametric or analogous estimates. The key disadvantage and limitation of this approach is that a great deal of time may be required to define all of the discrete activities, tasks, and/or operations at a low enough indenture level to estimate labor and material.

11A. Wrap Rate Construction

This appendix contains a discussion of the mechanics of wrap (wrap-around) rate construction. The majority of this handbook has been concerned with methods of predicting those comprehensive quantifiable elements (e.g., labor hours, material dollars, other direct costs, etc.) that produce the total costs of the particular effort being estimated. These quantified elements must be converted to program dollars through the use of various multipliers (e.g., labor rates, overhead rates, G&A rates, etc.). The conversion of quantifiable elements to program dollars can be accomplished by first calculating each individual element of cost (e.g., labor dollars, overhead dollars, G&A dollars, profit dollars, etc.) and then adding the individual results to arrive at a total bottom line program cost. This approach dictates a tremendously laborious computational effort and is very susceptible to mathematical errors. Substantial reduction in computational time is achieved through use of wrap rates.

A wrap rate is a rate that encompasses all direct labor, overhead, general and administrative expenses, profit, Facilities Capital Cost of Money (FCCOM), and other costs as appropriate. When applied to estimated hours, the wrap rate will yield total program dollars for each representative functional area. Each specific element of the wrap rate will be discussed below and a computational example is presented. The addendum will conclude by addressing precautions the cost estimator should exercise when dealing with wrap rates.

The major elements that compose a wrap rate are presented below:

- Direct Labor Rate. Typically, the direct labor rate is that composite rate charged by each functional area (e.g., engineering, tooling, quality assurance, manufacturing), on a per hour basis, to accomplish their respective tasks. The importance and significance of the direct labor rate being a composite will be addressed when the precautions of wrap rate usage are discussed.

- Overhead Rate. Overhead is a cost which, because it is incurred for common or joint objectives, is not readily subject to treatment as a direct cost. Such indirect cost is incurred to benefit the total direct cost or business base of a contractor. The distribution of indirect costs applicable to any one project is accomplished through the use of a rate per hour or percentage (i.e., overhead rate) applied to direct hours or costs. The kind and quantity of indirect cost elements are functions of how each individual contractor's accounting system is structured.

- Other Costs. Other costs can consist of myriad items such as allocated material, factored labor, travel, computer time, overtime premium, fringe benefits, and support services. The kind and quantity of other cost items included in a wrap rate is a function of how each individual contractor's accounting system is structured to provide the kinds of cost information needed for its cost estimating system to be effective.

- General and Administrative (G&A) Expenses. General and Administrative expenses are indirect expenses, including corporate office costs, staff services such as legal, accounting, marketing, public relations, financial, and similar expenses related to the overall business. These costs are allocated through the application of factors/percentages to the combination of direct labor, overhead, and other costs.

- Facilities Capital Cost of Money (FCCOM). Facilities Capital Cost of Money factors are typically applied to various labor and/or overhead accounts (engineering, manufacturing, G&A, etc.) and allow the contractor to recoup the cost of money (interest) incurred as a result of his investment in capital facilities. As such, FCCOM factors function in the same manner as ordinary engineering or manufacturing overhead rates. The purpose of FCCOM factors is to reward contractors for facility investments, motivate increased productivity, and reduce costs through the use of modern manufacturing technology.

- Profit. Profit is the excess of revenues from the sale of goods over the related costs thereof.

A wrap rate computational example for a production estimate follows. For simplicity of presentation, the following assumptions are made:

- A Forward Pricing Rate Agreement (FPRA) is in existence such that there are no disputes between the contractor and governmental agencies with regard to projected labor, overhead, FCCOM rates, or factors. If an FPRA is not in existence, it falls to the estimator to evaluate the relative merits of the contractor and government positions with respect to projected rates and factors. One area frequently requiring analysis is the projected future business volume of the contractor. The evaluation can, of course, result in acceptance of either position or development of an independent third position.

- Wrap rates will be calculated at the labor functional level, and composite direct labor rates reflecting the same have already been calculated.

- Other costs consist of overtime premium and computer time. Both are factored from direct labor dollars.

General and Administrative rates are listed in Table 11A.1. The composite direct labor rates, by function, are given in Table 11A.2. Overhead rates and other cost factors are given in Table 11A.3 and Table 11A.4, respectively.

Table 11.0A.1 General and Administrative Rates

	G&A Rates
CY84	7.7%
CY85	8.9%
CY86	9.5%
CY87	9.0%

CY=Current Year

Table 11A.2 Composite Direct Labor Rates (CY$)

Function	CY84	CY85	CY86	CY87
Engineering	14.44	15.25	15.56	15.64
Tooling	10.81	11.34	11.57	11.64
Quality Assurance	10.47	10.99	11.20	11.27
Manufacturing	10.07	10.56	10.76	10.83

Table 11A.3 Overhead Rates (CY$)

Function	CY84	CY85	CY86	CY87
Engineering	14.15	13.88	14.16	14.23
Tooling	20.76	23.25	23.72	23.86
Quality Assurance	20.10	22.53	22.96	23.10
Manufacturing	19.33	21.65	22.06	22.20

Table 11A.4 Other Cost Factors

Function/Items	CY84	CY85	CY86	CY87
Engineering:				
Overtime Premium	5.0%	7.0%	6.5%	6.1%
Computer Time	1.0%	2.0%	1.5%	1.9%
Tooling:				
Overtime Premium	8.0%	9.0%	9.0%	9.0%
Computer Time	N/A	N/A	N/A	N/A
Quality Assurance:				
Overtime Premium	N/A	N/A	N/A	N/A
Computer Time	N/A	N/A	N/A	N/A
Manufacturing:				
Overtime Premium	8.0%	9.0%	9.0%	9.0%
Computer Time	0.5%	0.6%	0.6%	0.8%

Facilities Capital Cost of Money (FCCOM) factors are given in Table 11A.5. A profit rate of 12.0 percent, exclusive of FCCOM, is assumed.

Table 11.0A.5 FCCOM Factors

Function	CY84	CY85	CY86	CY87
Engineering	.04304	.04014	.05111	.05210
Manufacturing	.18000	.18010	.21680	.20987
G&A	.00985	.01121	.01486	.01652

Based on the information given, wrap rates for engineering would be calculated for each year as follows in Worksheet 11A.1.

Worksheet 11A.1 Calculating Wrap Rates

Wrap Rate Elements			CY84
Direct Labor Rate.....			$14.44
Overtime Premium ($14.44 × 0.05).....	+	0.72	
Computer Time ($14.44 × 0.01).....	+	0.14	
Overhead Rate[1].....	+	14.15	
Subtotal	=		$29.45
G&A ($29.45 × 0.077).....	+	2.27	
Subtotal	=		$31.72
Profit ($31.72 × 0.12).....	+	3.81	
FCCOM[2]			
(ENGR: $14.44 × 0.04304).....	+	.62	
(G&A: $2.27 × 0.00985)[3].....	+	.02	
TOTAL PRICE WRAP RATE	=		$36.17

TABLE FOOTNOTES:

1.) Overhead rates are expressed frequently as a percentage of direct labor. If expressed as a percentage, overhead is applied in the same manner as overtime premium and computer time in the example ($14.44 × 0.98 = $14.15).
2.) FARs and Cost Accounting Standard 414 prohibit application of contractor overheads, G&A, and profit to FCCOM costs. Therefore, FCCOM is the last element calculated in a wrap rate.
3.) Note that G&A cannot be applied to the FCCOM cost element but the G&A cost element can serve as the base from which the FCCOM cost element is factored.

Repeating the above calculations (as applicable) for each functional category and each calendar year generates the wrap rates presented in Table 11A.6.

Table 11A.6 Calendar Year Wrap Rates (Current Year$)

Function	CY84	CY85	CY86	CY87
Engineering	36.17	37.86	38.81	38.85
Tooling	39.15	43.47	44.60	44.67
Quality Assurance	36.89	40.91	41.95	42.01
Manufacturing	38.33	42.45	43.90	43.94

The rates contained in Table 11A.6 reflect calendar year values. To use these rates for production cost estimating purposes, the calendar year rates must be composited to establish fiscal year buy rates. This conversion is accomplished through the use of an effort distribution profile. The effort distribution profile indicates how much effort will fall in each year of the period of performance. Table 11A.7 displays assumed effort distribution profiles for each of the functional labor categories.

Using the expenditure profile in Table 11A.7 and the calendar wrap rates in Table 11A.6, the fiscal year-buy wrap rates for FY84 and FY85 were calculated. Table 11A.8 depicts these rates. These current year buy wrap rates also could be expressed as current year-wrap rates by applying applicable inflation indices directly.

Table 11.0A.7 Effort Distribution Profiles

Function	YEAR 1	YEAR 2	YEAR 3	TOTAL
Engineering	45%	40%	15%	100%
Tooling	30%	60%	10%	100%
Quality Assurance	40%	33%	27%	100%
Manufacturing	31%	39%	30%	100%

Table 11A.8 Fiscal Year Buy Wrap Rates (TY$)

Function	FY84	FY85
Engineering	37.24*	38.39
Tooling	42.49	44.27
Quality Assurance	39.58	41.55
Manufacturing	41.61	43.46
* Sample calculation for FY84 Engineering		

Worksheet 11A.2 Constructing Wrap Rate

CY	CY RATE		DISTRIBUTION %		FY RATE	
84	36.17	×	0.45	=	16.277	
85	37.86	×	0.40	=	15.144	
86	38.81	×	0.15	=	5.022	
					37.243	≈ $37.24

The wrap rate example (Worksheet 11A.2) demonstrates the process for construction of wrap rates. As with any process, the steps or procedures used to arrive at the end result (e.g., a wrap rate) can be modified, rearranged, or otherwise manipulated and still achieve the same final result. When developing a wrap rate, the cost estimator should strive to mirror the structure of the contractor's accounting system. By doing so, the cost estimator ensures that the goal of a wrap rate is achieved - to capture total program costs associated with each functional hour of labor.

There are three major variables that impact wrap rate formulation:

- The structure of the contractor’s cost accounting system
- The estimating approach or methodology employed by the cost estimating team
- The selection of an appropriate composite direct labor rate

Each of these variables has been touched on previously, but further elaboration is required, along with cautions to the estimator.

The first variable to impact wrap rate formulation is the contractor's cost accounting system. Many contractors, in an effort to reduce the size of their overhead accounts, have incorporated numerous rates and factors into their estimating systems. An example is development of machine maintenance hours as a factor of fabrication labor. The kind and quantity of rates and factors are potentially endless, with some contractor's estimating systems so intricate that computer programs are required to generate their wrap rates. The cost estimator should recognize also that at a gross level all accounting systems function in the same manner basically, but at lower (i.e., more specific) levels, however, each contractor's accounting or estimating system is uniquely his own. Because each contractor's accounting system is unique and wrap rate formulation is a mirror of that system, the cost estimator is cautioned to be thoroughly familiar with the mechanics of the accounting system before attempting the development of wrap rates.

The second variable to be considered in wrap rate formulation is the estimating approach or methodology being employed by the cost estimating team. A contractor could estimate quality assurance man-hours as a factor of fabrication hours within the manufacturing function. The cost estimating team also could choose to use a factor or instead to do a detailed man-loading estimate. Should the estimating team select the man-loading approach, the manufacturing wrap rate formulation must exclude the quality assurance factor to ensure that no double counting of effort occurs. In this case, the team must construct a separate wrap rate for quality assurance so that the detailed man-loading estimate could be converted to dollars. Again, the cost estimator must be thoroughly familiar with the estimating approaches being used before attempting the development of wrap rates.

The third variable is the selection of the appropriate composite direct labor rate to be used in the wrap rate. This is critical because all wrap rates start with a composite direct labor rate. Four different types of composite labor rates are possible. Composite labor rates can be developed by:

- Functional cost category (engineering, manufacturing, etc.)
- Labor type within each function (fabrication, assembly, test)
- Cost centers, departments, or organizational units
- Job classification

Composite labor rates also can be developed on a plant wide basis, a commercial versus government business basis, a program basis, or on a particular procurement (i.e., contract) basis. The basis of selection of the most appropriate composite direct labor rate is primarily a function of the scope of the estimate. For example, if the estimate were very narrow in scope (e.g., involving only engineering tasks) then composite labor rates by labor type would be appropriate. In the vast majority of cases, composite labor rates by functional cost category are most appropriate.

Finally, a couple of major points must be made based on the above discussion. First, in those situations where a cost estimator is either given a wrap rate or uses a wrap rate developed by

someone else, extreme caution is recommended. The concern is the proper application of the correct wrap rate. This concern has its origins in the fact that there can be multiple wrap rates, each being referred to by the same generic name. For example, an engineering wrap rate for XYZ Corporation could be based on either plant wide data or just one specific contract. The wrap rate could be at the functional level or for one job classification within the engineering function. The wrap rate also could be for either a calendar year or a fiscal year. Because so many types of wrap rates are possible, an estimator should never use a wrap rate without specifically knowing how it was developed to ensure that its application is proper. The second major point to be made is that comparison of different contractor wrap rates is hazardous at best. Meaningful comparison of contractor wrap rates is nearly impossible due to the unique intricacies of each contractor's accounting system, compounded by the multitude of wrap rates that can be generated based on the selection of a composite direct labor rate.

In closing, to avoid potential pitfalls resulting from incorrect wrap rate formulation, it is recommended that the cost estimator develop wrap rates with input from the staff cost/price analyst personnel. These personnel have cognizance over the contractor for which the wrap rates are being developed. They are particularly knowledgeable of the contractor's cost accounting system structure, due to their daily monitoring of contractor activities.