NCMA DINNER MEETING TRAINING

COST ESTIMATING

METHODOLOGY
COST ESTIMATING METHODOLOGY

TABLE OF CONTENT

I. Estimating Overview

II. Functional Estimating Methods

III. Estimating Methods and Practice
I. Estimating Overview

What is Estimating?

• Estimating has a different meaning to each of us. It can be:
  
  ➢ Estimating the size of something in square feet
  ➢ Estimating a weight of popularity - poll
  ➢ Estimating the distance from one place to another in miles

• Estimating can be defined as the act of approximating the worth (or cost), extent, quantity, quality, or character of a future action, event, or product based on data or information available at the time.

• All business activity is estimated (measured) in resources like manpower, materials, facilities, or cost in money.
I. Estimating Overview

Cost Estimating

Cost estimating is defined as the art of predetermining the lowest realistic cost and price of an item or activity which assure a normal profit.
II. Functional Estimating

Methods
II  Functional Estimating Methods

1.0  Engineering Labor Cost Estimating
2.0  Tooling Labor Cost Estimating
3.0  Manufacturing Planning Labor Cost Estimating
4.0  Production Labor Cost Estimating
5.0  Quality Assurance Labor Cost Estimating
6.0  Direct Material Cost Estimating
7.0  Raw Material Cost Estimating
8.0  Equipment Cost Estimating
9.0  Subcontract Cost Estimating
10.0  Indirect Cost
1.0 Engineering Labor Estimating

1. Design Labor is difficult to estimate due to:
   - The complex nature of engineering work
   - Technology changes

2. A master plan efforts might make the problem manageable:
   - Firm and realistic performance specifications
   - Defined interfaces and responsibilities
   - Identification of risk areas
   - Verified technical approaches
   - Manpower requirement identification
   - Firm and realistic schedules
1.0 Engineering Labor Estimating (contd.)

3. An engineering estimated can be quoted several ways:
   o Hours per drawing by each discipline
   o Relative hours by supporting engineering

4. Some engineering work is highly creative, some is routine
   o Creative engineering is required:
     ➢ New techniques, advancement of state-of-the-art can drastically increase engineering manhours
     ➢ Complexity of system drives level of engineering skills required
   o Less creative is:
     ➢ Preparing, updating, and correcting drawings
     ➢ Planning and developing tooling and setting up production lines
     ➢ Planning plant layouts and quality procedures
1.0 Engineering Labor Estimating (contd.)
- Development Phase

1. Staffing or task estimate by task managers

2. Historical design hours/LB times complexity factors:
   - Weight/size
   - Material type
   - Prototype

3. Cost Estimating Relationships (CERs) for
   - Drawing Design Groups
   - Engineering Supporting Groups
   - Project Management
   - Engineering Liaison

4. Correlation to historical programs
   - Ground Test
   - Flight Test
1.0 Engineering Labor Estimating (contd.)
- Production Phase

1. Staffing or task estimate by task managers

2. Historical trend data:
   - Hours per month for fixed staff
   - Hours per a/c for mfg. supporting groups

3. Cost Estimating Relationships (CERs) for
   - Drawing Design Groups
   - Engineering Supporting Groups
   - Project Management
   - Engineering Liaison

4. Correlation to historical programs
   - Ground Test
   - Flight Test
2.0 Tooling Labor Estimating

1. Production rate is a big driver of tooling cost
   - What rate of production is planned and for what period of time?
   - High rate/long time = "HARD" tooling
   - Low rate/short time = "SOFT" tooling
   - Sometimes excess tooling capacity is created in anticipation of future orders

2. Production labor hours vary inversely with the amount of tooling
   - Tooling cost can be traded off against production labor cost

3. Tooling may require both engineering and manufacturing labor

4. Tooling often treated as direct charge to contract; may be amortized against production contract Tooling Hour Estimating Methods
2.0 Tooling Labor Estimating (contd.) - Development Phase

1. Staffing or task estimate by task Managers

2. Historical tool design and fabrication hours per LB times complexity factors:
   - Weight
   - Material type
   - Prototype
   - Technology
   - Tool design as a percent of tool fabrication
2.0 Tooling Labor Cost Estimating (contd.) - Production Phase

1. Staffing or task estimate by task managers

2. Sustaining tooling based on current program trend of man-hours per month

3. Tooling hours as a percent of production hours
3.0 Manufacturing Planning Labor Estimating

Definition of Manufacturing Planning:

• The descriptive information to define the schedules, facilities, tooling, fabrication, assembly, test, personnel, and capital item to conduct a manufacturing operation for a program/project.

• The general activities include:
  1. Develop/release plan manufacturing
  2. Create assembly sequence and as planned Bill of Materials
  3. Define fabrication requirements
  4. Define manufacturing scheduling and resource requirement
     ➢ Develop and Implement
     ➢ Measure and status
  5. Develop manufacturing work measurement standards
4.0 Production Labor Estimating

Definition of Production Labor:

• Production Labor (Touch Labor): Associated directly with product
  ➢ Produces a change in the raw material
  ➢ Generally consists of "Fabrication" and "Assembly"

1. Fabrication is fashioning parts from raw material, including:
   - Sawing
   - Perforating
   - Punching
   - Cutting
   - Forming
   - Layout

2. Assembly is integration of parts or subassemblies into larger assemblies
4.0 Production Labor Estimating (contd.) - Development Phase

1. Staffing or task estimate by project/task managers in Production

2. Similar program history “Hours/LB” adjusted complexity factors
   - Weight
   - Technology improvement

3. Cost Estimating Relationships (CERs)
4.0 Production Labor Estimating (contd.) - Production Phase

1. Staffing or task estimate by project/task managers

2. Current program history using “learning curve” projections for
   - Metal fabrication hours
   - Composite fabrication hours
   - Major assembly hours
   - Final assembly & checkout hours

3. Manufacturing Planning as a ratio tooling & production hours based on similar program

4. Labor Standards and Realization factors
4.0 Production Labor Estimating (contd.) - Production Phase

Labor Standards and Realization

• A labor standard is a "Standard Time" for performing a particular factory operation.

• Some standards are based on a "A skilled worker working under ideal conditions."

• Others are based on a "An average worker working under normal conditions." The difference can be important.

• Sometimes it includes time for personal needs, fatigue, and delays; at other times, it does not.

• Depending on how it is defined, it may be achieved at the beginning of new production, in the middle, or never.
4.0 Production Labor Estimating (contd.) - Production Phase

Labor Standards and Realization:

- "Time Study" is an Industrial Engineering (IE) technique for developing labor standards.

Realization (percent) = \frac{\text{Actual Hours}}{\text{Standard Hours}}

Example:
- Actual Hours: 25
- Standard Hours: 10
- Then the realization factor is 2.5
- This means that the realized performance is 2.5 times standard hours.
5.0 Quality Assurance Labor Estimating - Development Phase

Definition:
• Quality control is setting up for and conduction of mechanical or electrical tests to verify conformance to specifications.

1. Staffing or task estimate by project/task managers in Quality Assurance (QA)

2. Similar program history for (Factor Method)
   - QA hours related to Engineering hours
   - QA hours related to Production hours
   - QA hours related to Tooling hours
5.0 Quality Assurance Labor Estimating - Production Phase

1. Staffing or task estimate by project/task managers

2. Current program history for (Factor Method)
   - QA hours related to Engineering hours
   - QA hours related to Production hours
   - QA hours related to Tooling hours
6.0 Direct Material Estimating

• Direct materials includes:
  ➢ Raw Materials
  ➢ Purchased Parts
  ➢ Subcontracted items

• Definition of direct material cost
  1. Direct materials become a part of the product
  2. Quantity and price are significant
  3. Measurement of quantity and price should be easy and inexpensive

• If the above 3 conditions are not met, classify as Indirect materials (see 10.0 Indirect Cost).
6.0 Direct Material Estimating (contd.)

Three Estimating Methods
- Method used depends on the state of knowledge, desired accuracy of the estimate, and time, and cost limitation of the estimate.

1. Priced Bill of Materials, current items

2. Priced Bill of Materials, modifications of preceding item

3. Projection of average per unit based on preceding lot or contract

4. Consider Other Considerations
6.0 Direct Material Estimating (contd.)

1. Priced Bill of Materials, Current Items:

- Should properly reflect quantity requirements
- Should reflect most efficient use of materials (scrap, yield)
- Scrap and yield factors should have a reasonable basis
- Should reflect latest available price information

  ➢ Was the quote for the correct quantity?
  ➢ Is cost trend reasonably accounted for?
  ➢ Are prices negotiable downward?
6.0 Direct Material Estimating (contd.)

2. Priced Bill of Materials, Modifications of Preceding Items:
   • Same as for current items, plus:
     - Review additions and deletions
     - Review changes in manufacturing methods
     - Review changes in tooling
     - Review changes in Make or Buy program
     - Review inflation adjustments
6.0 Direct Material Estimating (contd.)

3. Projection of Average per Unit based on Preceding Lot or Contract:
   • Application of learning curve may be appropriate
     ➢ Develop curve for "Make" items
     ➢ Develop separate curves for each major subcontract
   • Consider conditions which may have changes relative to previous item
     ➢ Scrap, spoilage,
     ➢ Tooling
     ➢ Make or Buy
6.0 Direct Material Estimating (contd.)

4. Other Considerations:

• Inventory pricing methods
  - First-in-First-Out (FIFO)
  - Last-in-First-Out (LIFO)
  - Weighted average

• Material Overhead
  - Material handling
  - Subcontract administration
  - Receiving inspection
  - Storage
  - In-transit insurance
  - Freight (may be direct)
7.0 Raw Material Estimating - Development Phase

1. Dollars per LB by material type from similar program history adjusted for economics and improvement curve:

Class 0: Pan stock
Class 1: Raw material
Class 2 & 3: Purchased parts
Class 7: High value raw material
7.0 Raw Material Estimating - Production Phase

1. Bill of material including allowance for usage and economics

2. Current program history using improvement curve

3. Class 0 as percent of total class 1 & 7 material
8.0 Equipment Cost Estimating - Development Phase

Class 6 – High Value Equipment

1. Models (Price)

2. Similar equipment adjusted for
   • Weight
   • Test requirement
   • Technology
   • Schedule requirements

3. Supplier quotes
8.0 Equipment Cost Estimating - Production Phase

1. Firm purchase orders

2. Cost analysis of supplier quotes

3. Estimates based on current program history

4. Historical bills of material for current program plotted on improvement curve
9.0 Subcontract Cost Estimating (Class 8 & 9)

Development

Major Subcontract Bill of Material (Class 8)
• Supplier quote
• Estimate based on in-plant build
• Similar equipment cost adjusted program history

Overload Subcontract (Class 9)
• Estimate on in-plant basis using history from current program
9.0 Subcontract Cost Estimating (Class 8 & 9)

Basic Production

Major Subcontract Bill of Material (Class 8)
• Firm purchase orders
• Cost analysis of supplier quote
• Estimate based on current or peculiarities program

Overload Subcontract (Class 9)
• Based on prior production manhour processes adjusted for:
  ➢ Increase/decrease based on in-plant capacity
  ➢ Improvement curve
10.0 Indirect Cost

- Definition of Indirect Cost
  - An indirect cost is a cost NOT directly identified with a single final cost objective
  - Indirect = Overhead = Burden
  - Generally, indirect costs are grouped into "Pool" which are allocated against the most appropriate direct costs.

- Analysis of Overhead Cost should consider:
  - Recent overhead cost experience, reasonableness, and necessity to continue at this level, or increase, or decrease
  - The base to which the overhead has been applied
  - The expected future trends in this base
10.0 Indirect Cost (contd.)

- Commonly seen overhead categories:
  - Engineering
  - Manufacturing
  - Material
  - General & Administration (G&A)
III. Estimating Methods and Practice
III. Estimating Methods & Practice

1.0 Introduction

2.0 Descriptive Estimating Method

3.0 Comparison Estimating Method

4.0 Standard Estimating Method

5.0 Historical Estimating Method

6.0 Parametric Estimating General Overview

7.0 Cost Model

8.0 Man-Loading
1.0 Introduction

• The quality of the cost estimates begins with the estimator's awareness and ability to select the right set of tools for the job while understanding the limitations and capability of each.

• Each estimating method or tool has advantages and disadvantages for solving the problem at hand based on:

  ➢ Customer's requirements
  ➢ Time constraints (Turnaround time)
  ➢ Limited Data Availability
  ➢ Quality of Data
  ➢ Limited Resources - Cost Analysts & Computers
2.0 Descriptive Estimating Method

2.1 Conference Estimating Method

2.2 Level of Effort Estimating Method

2.3 Discrete Estimating Method
2.1 Conference Estimating Method

Definition:
Is also called round-table estimating.

- **Advantages**
  1. Used when no other experience, history or support exists or is unavailable.
  2. Used on new designs, new configurations, or when the work scope has not been done before.

- **Disadvantages**
  1. Difficult to justify, support and prove credibility with the customer.
  2. Lowest credibility with the customer.
  3. Difficult to achieve full value in negotiations.
2.2 Level of Effort Estimating

Definition:
- An estimate to perform work or tasks which are based on the headcount level in nature such as field service reps and Program Office.
- It sells support by the headcount over time.

- Advantages
  1. Easy to generate and estimate.
  2. Easy for customer to understand and comprehend.

- Disadvantage
  1. Difficult to justify without previous experience or history.
2.3 Discrete Estimating

Definition:

• Is characterized by a thorough, in-depth analysis of the Statement of Work (SOW) and identification/documentation of all tasks required to support the SOW effort.

• "Grass roots" or "bottom up" estimating is a method which develops costs by defining and calculating costs from the lowest element of work or task and identifying the hours it will take to accomplish those tasks.

• The estimator starts at the lowest level of engineering work such as engineering drawings, specifications, detailed tasks required to accomplish the SOW or project.

• The hours for all detail tasks are then summarized, to come up with the total hours of cost to perform the effort.
2.3 Discrete Estimating (contd.)

- **Advantages**
  1. Used when no other experience, empirical or supporting data exists or is unavailable.
  2. Provides better credibility than plain judgment estimate and level of effort without history.
  3. Estimate is task by task; a lower level estimate.

- **Disadvantages**
  1. Limited by the experience level of the person developing the estimate.
  2. Difficult to justify, support and prove credibility.
  3. Difficult to achieve full value in negotiations.
  4. Limited by the time-consuming nature of the tasks.
3.0 Comparative Estimating

Definition:

• Uses actual costs of a similar (analogous) existing or past program or project, and adjusts for complexity on technical or physical differences in order to drive the new system or task estimate.

• In comparative estimating, complexity factors or ratios may be used and applied to the known costs or cost elements (cost factor) to create the estimates.

• Factors must be fully explained.

• This method could be used in any stage of a program where there is insufficient actual cost data to use as a basis for a detailed approach.
3.0 Comparative Estimating (contd.)

• If enough technical and cost information are available on the completed program, it can help validate comparison of the new program with the old program.

• The most common types of data used in preparing comparative cost estimates are:
  
  ➢ Actuals for the same or similar item or activity.
  
  ➢ Technical engineering actual data.
  
  ➢ Labor actuals or standards with adjusted historical efficiency factors.
  
  ➢ Similar projects or programs.
3.0 Comparative Estimating (contd.)

- **Advantages**
  1. Easy to generate and estimate, provided historical data is available.
  2. Provides better credibility than plain detailed estimating.
  3. Quick and reasonable accuracy for similar systems, or end items.
  4. Good accuracy for similar systems.

- **Disadvantages**
  1. Requires analogous product and program data.
  2. Difficult to apply for differences in scope of work, design, configuration and number of aircraft or aircraft programs.
  3. Requires a detailed program and technical definition of the analogous system as well, as the system being estimated.
  4. Once the technical assessment has identified the analogous system, actual cost data on that system must be obtained.
  5. Uncertainty due to subjective evaluations made by estimator.
4.0 Standards Estimating

Definition:
- Estimate based on standard hours generated by work measurement techniques.
  - Time and motion study
  - Industrial Engineering standards
  - Theoretical standards
- Typically used for manufactured parts and hardware.
- Standard hours generated for each work sequence on shop order.

- **Advantages**
  1. Detail labor standards established for make parts or hardware.
  2. Consistency in "Touch Labor" estimating.

- **Disadvantages**
  1. Time consuming (time and motion study for hundred, thousand parts).
5.0 Historical Estimating Method

Definition:
- An estimate based on actual cost history for the same work in the various area
  - Labor hours
  - Material dollars

  o **Advantages**
  1. Strong correlation and support for estimate.
  2. Plotting of learning curve or trend analysis based on history
  3. High credibility level

  o **Disadvantages**
  1. Required detailed program and product definition
  2. difficult to apply for differences in scope of work, design, configuration and aircraft programs.
6.0 Parametric Estimating Method

Definition:
- Parametric estimating is the method of estimating costs by using mathematical equations that relate cost to one or more physical or performance variables associated with the item being estimated.

o Advantages
- Fast execution and most cost effective estimating method.
- Easy to justify (consistent), support and prove credibility with a good data bank.
  - Statistical data base can provide expected values and prediction intervals
  - By making broader use of these techniques they anticipated realizing some of the following benefits:
    - Improvement in the quality of estimates due to focusing more heavily on the use of historical data, and establishing greater consistency in the estimating process
    - Streamlined data submission requirements decreasing the cost associated with preparing supporting rationale for proposals
    - Reduced proposal evaluation cost and cycle time
    - Decreasing negotiation cost and cycle time through quicker proposal updates
6.0 Parametric Estimating Method (cont’d)

- **Disadvantages**
  - Often too simple to forecast costs.
  - Estimate is aggregate not detailed estimate.
  - No way of knowing if past and present methods are the same - Difficult to apply when difference in scope of work, design, configuration and numbers of aircraft exist.
  - Data collection, evaluation, and adjustment are a very critical and time consuming step in the parametric estimating process.

*Never use a model without reviewing the source documentation and hypothesis.*
7.0 Cost Model

Definition:
- Commercial models are based on more universal data and almost always need some form of calibration to be useful, whereas the corporation’s internal cost model data has already gone through calibration via the data collection, analysis, and adjustment process.

- After calibration, the cost model must be tested for validity, and ultimately accepted by the customer. The validation process includes the following steps:
  - Calibrate the model to historical cost data
  - Parametrically estimate the cost of past completed projects using the parametric cost model developed
  - Compare the estimates with actual costs to demonstrate acceptable accuracy

- A computer model is used to generate cost estimates based on mathematical relationship built in the software.
- Examples are Price and SEER model.
7.0 Cost Model (cont’d)

- **Advantages**
  - Can be used with design concepts & configurations which are too vague and sketchy to estimate accurately.
  - May be used to develop ROM's and for new programs or new version of existing aircraft.

- **Disadvantages**
  - Difficult to use for Firm proposal pricing and estimating.
  - Often too simple to forecast costs.
  - Estimate is aggregate not detailed estimate.
8.0 Man-Loading Method

- To establish a standard unit for measuring direct charge hours by man-month or equivalent man-month.

1. Headcount Basis (153 Hours)

   a. Hours in average year (40 hrs/wk x 52 wks) = 2,080.0

   b. Days per year not charged direct (less):
      (1) Holidays (13 Days/yr x 8 hrs) = 104.0 hours
      (2) Vacations (13 Days/yr x 8 hrs) = 104.0 hours
      (3) Sick Days (5 Days/yr x 8 hrs) = 40.0 hours

   c. Total work hours per year = 1,832.0

   d. Man-month: (1,832 Hours / 12 Months) = 152.67(round 153) Hours/Mo
8.0 Man-Loading Method (contd.)

2. Program Requirement (165 Hours)

a. Hours in average year (40 hrs/wk x 52 wks) = 2,080.0

b. Days per year not charged direct (less):
   (1) Holidays (13 Days/yr x 8 hrs)= 104.0 hours

c. Total work hours per year = 1,976.0

d. Man-month: (1,976 hours / 12 Months)=164.67 (round 165) hours/Mo
QUESTIONS ?