MORS Introduction to Cost Estimation (Part I)

Module Two – Phase 2: Assessment (Initial)

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Learning Objectives of Module Two

1. Understand how to define a program using the various documents and other acquisition and requirements information
2. Understand how to build a complete estimating structure
3. Understand how to identify ground rules and assumptions and how these will be used throughout the estimate

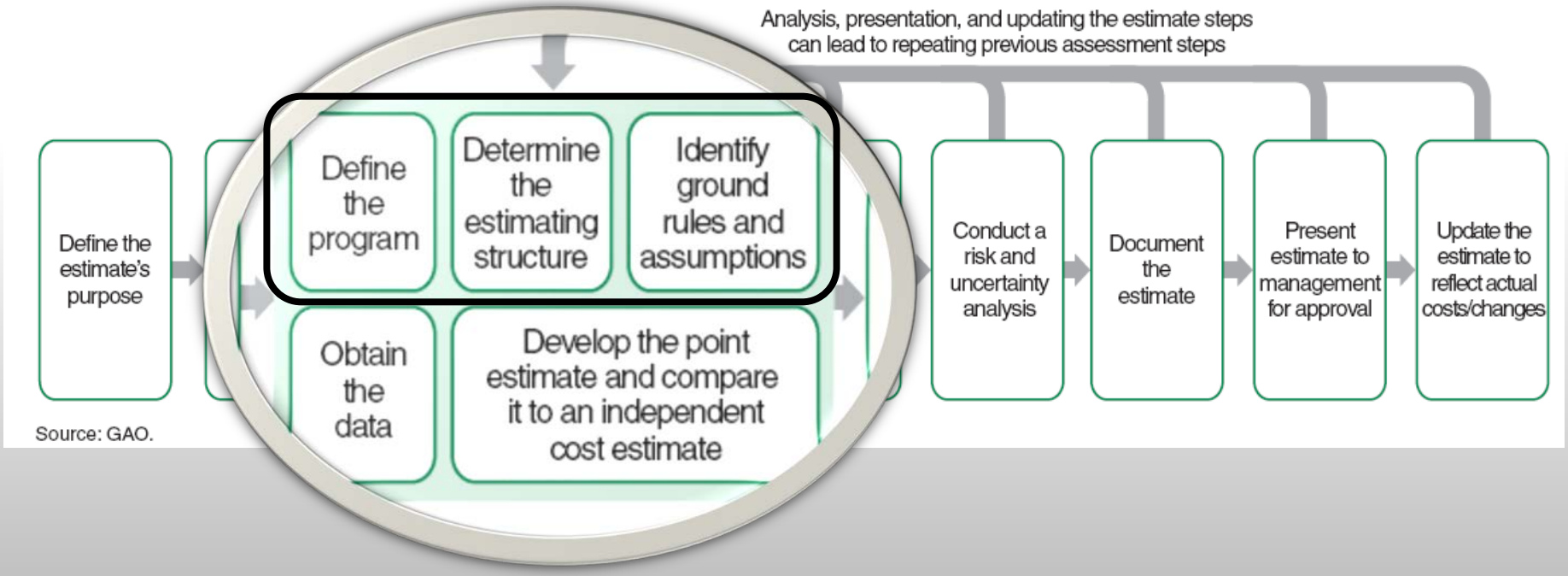
Phase 2: Assessment Steps Three thru Five

Initiation and research
Your audience, what you are estimating, and why you are estimating it are of the utmost importance

Assessment
Cost assessment steps are iterative and can be accomplished in varying order or concurrently

Analysis
The confidence in the point or range of the estimate is crucial to the decision maker

Presentation
Documentation and presentation make or break a cost estimating decision outcome



Source: GAO.

Step 3: Define The Program

Baseline Documents Around the Government

DHS

- Cost Estimating Baseline Document (CEBD)

DOD

- Cost Analysis Requirements Description (CARD)

NASA

- Cost Analysis Data Requirement (CADRE)

Source: GAO

- All of these documents should include (at a minimum):
  - System's purpose
  - Performance characteristics
  - Work breakdown structure
  - Acquisition strategy, quantities, and schedule
  - Test and evaluation plan
  - Deployment and training plans
  - Environmental impacts
  - Operational concept, logistics, and maintenance philosophy
  - The level of risk associated with assumptions

Step 4: Determine the Estimating Structure

Develop Product Work Breakdown Structure (WBS)

- A WBS defines in detail the work necessary to meet program objectives
  - WBS should be product-oriented and hierarchical
  - In addition to product-oriented elements, a WBS should also include other common elements like Program office operations, government furnished equipment, and government testing
  - Include WBS definitions
- Each WBS item should be categorized to satisfy customers needs
  - Contract related Contract Line Item Numbers (CLINs) and Sub CLINs
  - Appropriations
  - Internal and External
  - Output to various budget documents (RDocs and PDocs)
- Determine applicable and relevant WBS items for LCCEs and BCAs
- WBS should be tied to Integrated Master Schedule (IMS) and Earned Value Management System (EVMS) reporting
- The WBS is updated as the program changes and becomes better defined

Good WBS ensures estimate is COMPLETE.

Step 4: Determine the Estimating Structure

Sources of Product WBS (881C)

- 1,0 AIRCRAFT SYSTEM
  - 1.1 AIR VEHICLE
    - 1.1.1 AIRFRAME
    - 1.1.2 PROPULSION
    - 1.1.3 VEHICLE SUBSYSTEM
    - 1.1.4 OTHER AIRFRAME, SUBSYSTEM & IATC
    - 1.1.5 RESIDUAL AIRFRAME, SUBSYSTEM & IATC
    - 1.1.6 AVIONICS
    - 1.1.7 ARMAMENT/WEAPONS DELIVERY
    - 1.1.8 AUXILLARY EQUIPMENT
    - 1.1.9 FURNISHINGS AND EQUIPMENT
    - 1.1.10 AIR VEHICLE APPLICATIONS SOFTWARE
    - 1.1.11 AIR VEHICLE SOFTWARE RELEASE
    - 1.1.12 AIR VEHICLE INTEGRATION ASSEMBLY, TEST AND CHECKOUT
  - 1.2 SYSTEM ENGINEERING/PROGRAM MANAGEMENT
    - 1.2.1 SYSTEM ENGINEERING
    - 1.2.2 PROGRAM MANAGEMENT

Step 4: Determine the Estimating Approach

Sources of Operating and Support WBS (CAPE)

- 1.0 Unit-Level Manpower
  - 1.1 Operations Manpower
  - 1.2 Unit-Level Maintenance Manpower
  - 1.3 Other Unit-Level Manpower
- 2.0 Unit Operations
  - 2.1 Operating Materiel
    - 2.1.1 Energy (Fuel, Electricity, etc.)
    - 2.1.2 Training Munitions and Expendable Stores
    - 2.1.3 Other Operational Materiel
  - 2.2 Support Services
  - 2.3 Temporary Duty
  - 2.4 Transportation
- 3.0 Maintenance
  - 3.1 Consumable Materials and Repair Parts
  - 3.2 Depot Level Reparables
  - 3.3 Intermediate Maintenance (External to Unit Level)
  - 3.4 Depot Maintenance
  - 3.5 Other Maintenance

Step 4: Determine the Estimating Approach

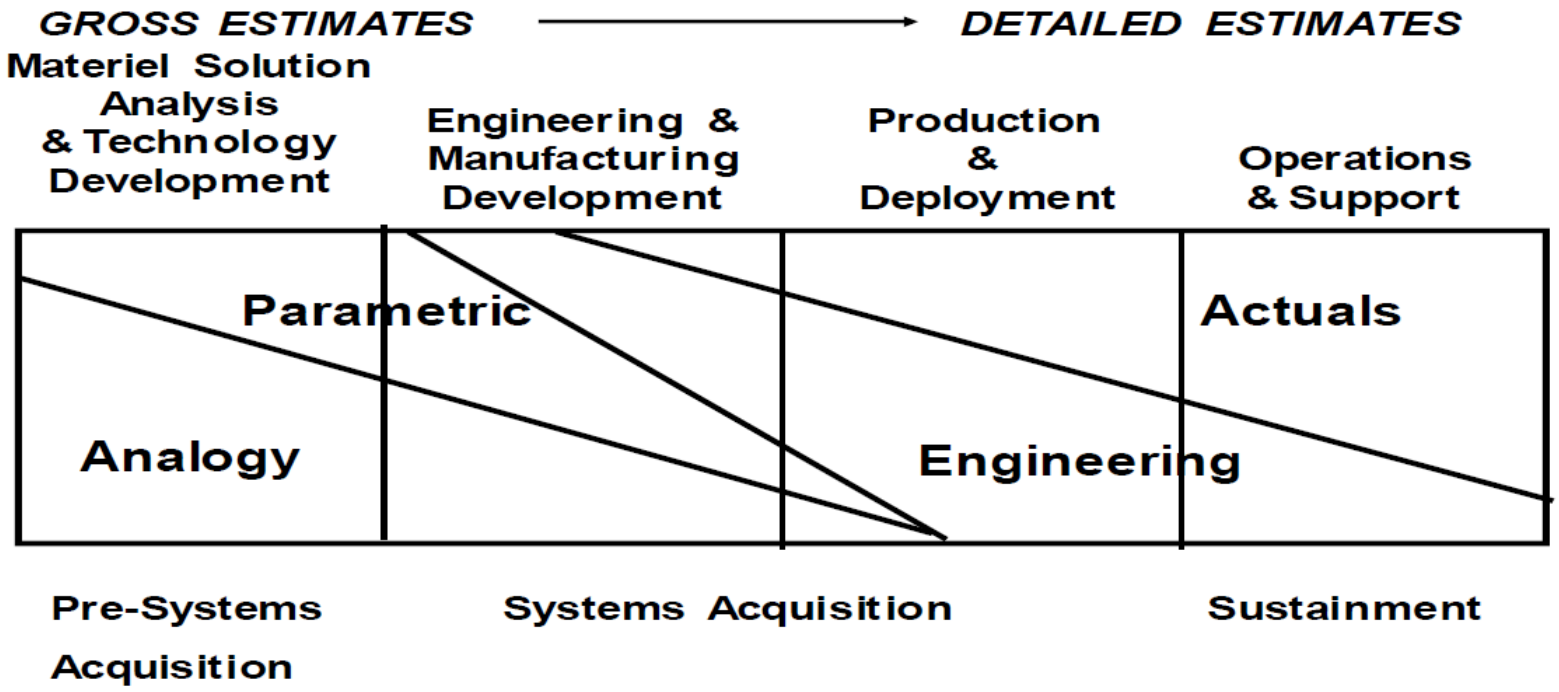
Definitions of Four Major Estimating Methods

Estimating Method	Explanation
Parametric	A mathematical procedure where product or service descriptors (parameters) and cost algorithms directly yield consistent cost information.
Analogy	Under this method, costs for a new item are estimated using comparisons with the cost of completing similar tasks under past or current contracts. Any differences are isolated and cost elements applicable to the differences are deleted from or added to experienced costs. Comparisons may be made at the cost element level or total price level. Adjustments may also be made for possible upward or downward cost trends. Most commonly used when specifications for the item being estimated are similar to other items already produced or currently in production and for which actual cost experience is available.
Engineering Buildup	This method is characterized by a thorough review of all components, processes, and assemblies. It requires detailed information to arrive at estimated costs and typically uses cost data derived from the accounting system, adjunct statistical records, and other sources. Most commonly used when the required information is available and future production potential warrants the cost of the detailed analysis required. It is the most accurate of the three methods for estimating direct cost. It is also the most time consuming and expensive.
Extrapolation of Actuals	Extrapolation method requires prototype or preproduction actual cost data on the system considered. Primarily used in estimating the production cost of system hardware, and assumes a relationship (technical, performance) between cost of prototypes and production units.

Step 4: Determine the Estimating Approach

Choose "Best" Estimating Methodology (When to Use)

Cost Estimating Methods Appropriate to Acquisition Phases



DAU Teaching Note of February 2011

Step 4: Determine the Estimating Approach

Choose "Best" Estimating Methodology (Types, Pros/Cons)

TD Phase . . . . . Production Phase

	Estimating Method			
	Parametric	**Analogy**	**Engineering Buildup**	**Extrapolation from Actuals**
Relative Accuracy	**Low** -- because limited data are used	**Moderate/High** --depending on data, technique, and estimator	**High** -- based on engineering principles	**High -** based on actuals
Relative Estimator Consistency	**Low** -- different experts make different judgments	**Moderate/High** --depending on data, technique, and estimator	**High** -- based on uniform principle application	**High -** based on actuals
Relative Development Speed	**Fast** -- little detailed analysis required	**Moderately Fast** -- especially with repetitive use	**Slow** -- requires detailed design and analysis	**Moderately Fast** -- especially with repetitive use
Relative Estimate Development Cost	**Low** -- fast development and limited data requirements allow low development cost	**Moderate** -- depending on the need for data collection and analysis	**High** -- detailed work design and analysis require time and increase cost	**Moderate** -- depending on the need for data collection and analysis
Relative Data Requirements	**Low** -- based on expert judgment	**Moderate** -- only requires historical data	**High** -- requires detailed work design and analysis	**Moderate** -- only requires historical data

No method is more or less correct, depends on data available and WBS element.

Step 4: Determine the Estimating Approach

Identify potential cross- checks and schedule drivers

1. Look at high cost and/or high risk WBS items
2. Provide alternative methodology to include uncertainty
3. Is original methodology within “reasonable” range of alternative methodology?
4. Look at Integrated Master Schedule (IMS) to determine schedule drivers. Use uncertainty around setter events. (testing, reviews, etc.)

Step 5: Identify Ground Rules and Assumptions
Definitions

- Cost Estimates are based on limited information
- Ground Rules and Assumptions help establish the estimate's boundaries
  - Ground Rules: a common set of agreed upon estimating standards. Ground rules provide guidance and minimize definition conflicts
  - Assumptions: Made in the absence of ground rules, they are judgments about past, present, or future conditions
  - Recommend separate in briefs and documentation
- Both Ground Rules and particularly Assumptions should be tested and adjusted for risk (see steps 8 & 9)

Step 5: Identify Ground Rules and Assumptions
Ground Rules vs. Assumptions

Ground Rules	Assumptions
• Low Rate Initial Production (LRIP) will begin in 2018 • The Operating and Support period will be 30 years • Costs are in Base Year 2014 Dollars	• Labor rate for a carpenter is $31/Hr • Empty aircraft weight is 42,000 lbs. • Non-recurring costs are 2.54 times the amount of recurring costs

Best Practices Checklist #3

Define the Program

- There is a technical baseline description that:
  - Has been developed by qualified personnel
  - Has been updated with technical, program, and schedule changes
  - Contains sufficient detail of the best available information
  - Contains information that drives the cost estimate and the cost estimating methodology
  - Has been approved by management
  - The technical baseline answers the following questions
  - What the program is supposed to do (requirements)
  - How the program will fulfill its mission (purpose)
  - What it will look like (technical characteristics)
  - Where and how the program will be built (development plan)
  - How the program will be acquired (acquisition strategy)
  - How the program will operate (operational plan)
  - Which characteristics affect cost the most (risk)

Best Practices Checklist #4a

Determine the Estimating Structure

- A product-oriented WBS represents the best practice
  - The WBS contains at least 3 levels of indenture
  - **It is flexible and tailored for each unique program**
  - The 100 percent rule applies—i.e., the sum of the children equals the parent
  - **The WBS defines all cost elements and includes all relevant costs**
  - In addition to hardware and software elements, the WBS contains common elements to capture all the effort
  - **Each system has one program WBS but it may have several contract WBSs that are extended from the program WBS, depending on the number of subcontractors**
  - **The WBS is standardized so that cost data can be used for estimating future programs**
  - It changes as changes occur and the program becomes better defined
  - **It provides for a common language between the government program management office, technical specialists, prime contractors, and subcontractors**
  - A schedule with a written study plan has been developed
  - The team has access to the necessary subject matter experts

Source: GAO

Best Practices Checklist #4b

Determine the Estimating Structure

- The WBS has a dictionary that
  - Defines each element and how it relates to others in the hierarchy
  - Clearly describes what is and is not included in each element
  - Describes resources and processes necessary to produce the element
  - Links each element to other relevant technical documents

Source: GAO

Best Practices Checklist #5A

Identify Ground Rules and Assumptions

- All ground rules and assumptions have been:
  - Developed by estimators with input from the technical community
  - Based on information in the technical baseline and WBS dictionary
  - Vetted and approved by upper management
  - Documented to include the rationale behind the assumptions and historical data to back up any claims
  - Accompanied by a level of risk of the assumption's failing and its effect on the estimate

Source: GAO

Best Practices Checklist #5B

Identify Ground Rules and Assumptions

- ❑ Risk and sensitivity analysis can be performed quickly and efficiently on all GR&As
- ❑ A schedule assessment has been performed to determine its realism
- ❑ Budget constraints have been clearly defined and the effect of delaying program content has been identified
- ❑ Peaks and valleys in time-phased budgets have been explained
- ❑ Inflation index, source, and approval authority are identified
- ❑ Dependence on participating agencies and the availability of government-furnished equipment have been identified, as have the effects if these assumptions do not hold
- ❑ Items excluded from the estimate have been documented and explained
- ❑ If technology maturity was assumed, the estimate addresses the effect of the assumption's failure on cost and schedule
- ❑ Cost estimators and auditors met with technical staff to determine risk distributions for all assumptions
- ❑ Management has been briefed, and the results have been documented

Source: GAO

Review of Learning Objectives of Module Two

1. Understand how to define a program using the various documents and other acquisition and requirements information.
2. Understand how to build a complete estimating structure.
3. Understand how to identify ground rules and assumptions and how these will be used throughout the estimate.

Module Two

Module #(s)	Items covered	Presenter	Start	Stop
One & Two	(1) Overview and Background (1) Define Estimate's Purpose (1) Develop Estimate Plan --- (2) Define Program (2) Determine Estimate Structure (2) Identify Ground Rules and Assumptions	Huu	13:00	14:30
Break	**N/A**		**14:30**	**14:45**
Three	Obtain data	Huu	14:45	15:45
Break	N/A		15:45	16:00
Four	Develop point estimate	Huu	16:00	17:00

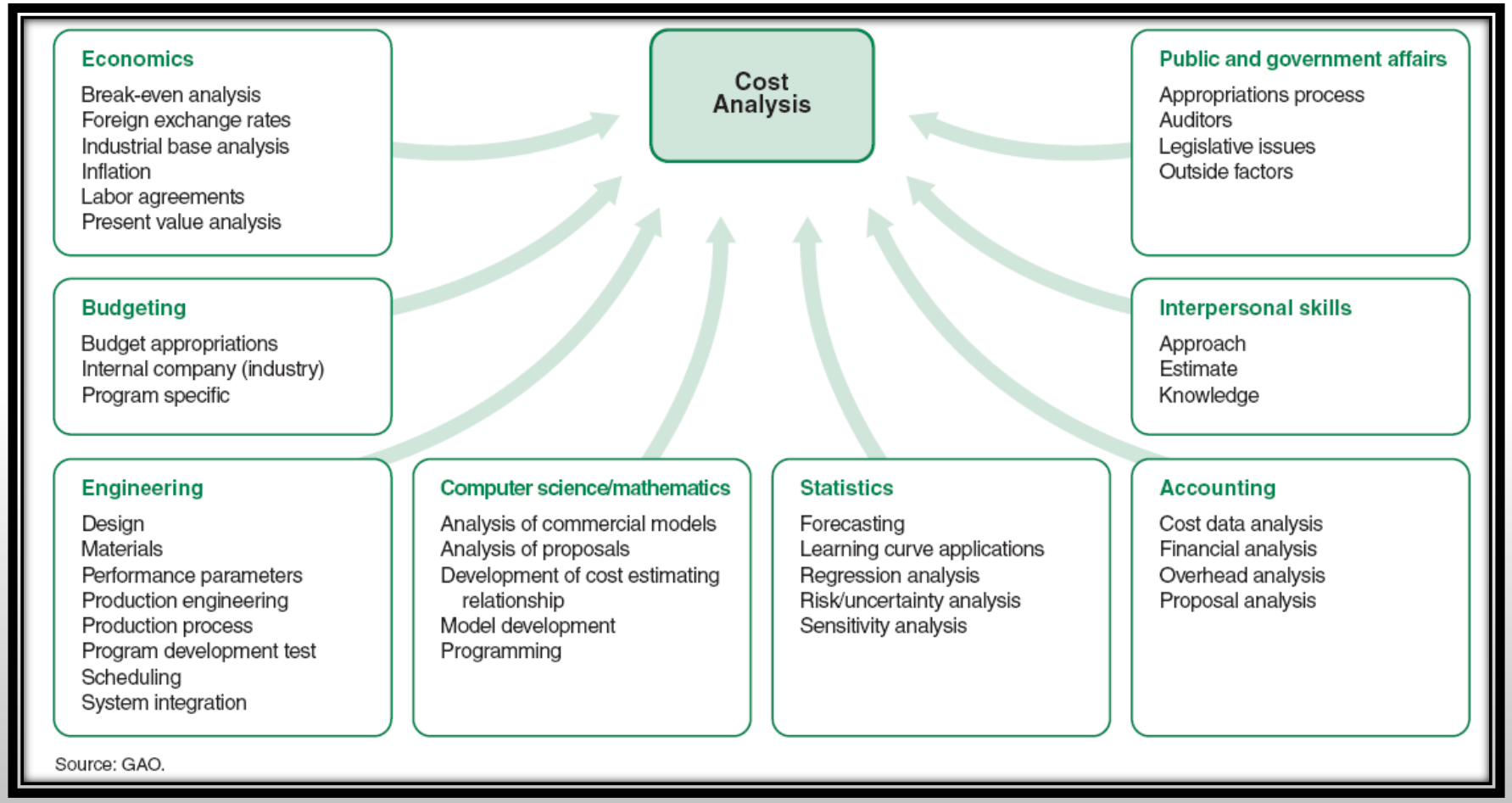
Backup

…In the Cost Guide

Step	Description	Cost Guide Chapter	Phase in Process
1	Define estimate's purpose	5	Initiation & Research
2	Define estimate's plan	5, 6	Initiation & Research
3	Define program characteristics	7	Assessment
4	Determine estimating structure	8	Assessment
5	Identify GR&As	9	Assessment
6	Obtain data	10	Assessment
7	Develop point estimate and compare	11, 12, 15	Assessment
8	Conduct sensitivity analysis	13	Analysis
9	Conduct risk & uncertainty analysis	14	Analysis
10	Document the estimate	16	Analysis
11	Present estimate to management	17	Presentation
12	Update the estimate	16, 18, 19, 20	Presentation

Source: GAO

Cost Estimating Team Structure



Sample Study Plan

1. Background
2. Mission Needs
3. Program Status
4. Overarching Principles of the Study
   - 4.1 Study Objective
   - 4.2 Scope of Analysis
   - 4.3 Overarching Assumptions
   - 4.4 Study Oversight
   - 4.5 Governing Guidance and References
5. Analysis Elements
   - 5.1 Introduction
   - 5.2 Alternatives
     - 5.2.1 Baseline
     - 5.2.2 Baseline Plus
     - 5.2.3 Other Existing Capabilities or New Technology
   - 5.3 Exploratory Analysis
     - 5.3.1 Methodology
     - 5.3.2 Screening Criteria
   - 5.4 Evaluation Analysis
     - 5.4.1 Mission Tasks, Measures of Effectiveness, Measures of Performance
     - 5.4.2 Mission Effectiveness
     - 5.4.3 Cost/Affordability
6. Cost – Effectiveness Synthesis
   - 6.1 Introduction
   - 6.2 Synthesis Process
7. Final Report Format
8. Schedule and Deliverables
9. List of References
10. List of Acronyms

Example WBS Definition

- 1110 AIRFRAME INTEGRATION, ASSEMBLY, TEST AND CHECKOUT (1.1.1.1)
- The integration, assembly, test and checkout element includes all efforts as identified in Appendix L: Common Elements, Work Breakdown Structure and Definitions, to provide a complete airframe, less other Level 3 elements.

- Included in this element are the efforts required to provide the integration, assembly, test and checkout of the major airframe structures (fuselage, wing, empennage, nacelle, and other airframe). Included in this effort is all administrative and technical engineering labor to perform integration of Level 4 airframe elements.

- Includes, for example:

a. Overall airframe design and producability engineering
b. Detailed production design; acoustic and noise analysis
c. Loads analysis; stress analysis on interfacing airframe elements and all subsystems
d. Design maintenance effort and development of functional test procedures
e. Coordination of engineering master drawings and consultation with test and manufacturing groups
f. Tooling planning, design, and fabrication of basic and rate tools and functional test equipment, as well as the maintenance of such equipment
g. Production scheduling and expediting
h. Joining or installation of structures such as racks, mounts, etc.
i. Installation of wiring ducting, engines, and miscellaneous equipment and painting
j. Set up, conduct, and review of testing assembled components or subsystems prior to installation

Excludes, for example:

a. All Integration, Assembly, test and Checkout activities associated with non-airframe Level 3 elements

Step 4: Determine the Estimating Approach

Develop a best practice cost estimating checklist

1. Estimate Purpose and Scope
2. Develop the Estimating Plan
3. Define the Program
4. Determine the Estimating Structure
5. Identify Ground Rules and Assumptions
6. Obtain Data
7. Develop the Point Estimate and Compare it to an Independent Cost Estimate
8. Conduct Sensitivity Analysis
9. Conduct Risk and Uncertainty Analysis
10. Document the Estimate
11. Present the Estimate to Management for Approval

Provided at end of each respective module and in Word handout.