GAO Cost Assessment Guide:
Best Practices for Estimating and Managing Program Costs

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Outline

- Why is the GAO Cost Assessment Guide important?
- How the Guide was developed
- An overview of the Guide
- Recent GAO Reports Highlighting Cost Estimating Issues
- Invitation to participate in future expert meetings at GAO to discuss follow-on development of the Guide

Why is the GAO Cost Assessment Guide important?

- GAO assists Congress in its oversight of the federal government including agencies' stewardship of public funds
  - Legislators, government officials, and the public want to know
    - Whether government programs are achieving their goals
    - What these programs are expected to cost
  - Developing reliable program cost estimates is critical to
    - Effectively using public funds
    - Meeting OMB's capital programming process
    - Avoiding cost overruns, missed deadlines, and performance shortfalls
      - Many of our program assessments find that unreliable estimates are the cause
- We developed this Guide to
  - Establish a consistent methodology based on best practices to be used across federal government for the development and management of its program cost estimates

Why is the GAO Cost Assessment Guide important? (continued)

- Original intent was to provide auditors with a standardized approach for analyzing program costs
  - Our research, however, found federal guidelines to be limited on the processes, procedures, and practices for ensuring credible cost estimates
  - We decided to fill the gap and shifted the intent of the Guide from an auditor's manual to a best-practice manual
- Purpose of the Guide is to
  - Address best practices for ensuring credible program cost estimates for both government and industry
  - Provide a detailed link between cost estimating and Earned Value Management (EVM)
    - OMB has endorsed EVM for measuring cost, schedule, and technical performance
    - Guide demonstrates how realistic cost and schedule estimates are necessary for setting achievable program baselines and managing risk

Why is the GAO Cost Assessment Guide important? (continued)

- Managers and auditors alike should find this Guide to be a useful manual as they assess:
  - The credibility of a program's cost estimate for budget and decision-making purposes
  - Program status using EVM

- To help GAO auditors fully utilize this Guide, we are including a number of "auditor checklists" for use on program assessments
  - These checklists will assist auditors in
    - Identifying whether a program meets best practices
    - Looking for common pitfalls that may undermine the reliability of cost estimates and program baselines

How the Guide Was Developed

- We developed this Guide in consultation with a “community of experts” from the federal government and industry.
  - Formal kick-off began at the Society of Cost Estimating and Analysis conference in June 2005
  - Since then, the community of experts helping to review and comment on the Guide has grown
    - Their contributions have been invaluable both in
      - Providing historical information and experience
      - Keeping the guide current with industry trends
- Together with these experts, we have developed a Guide which
  - Clearly outlines GAO’s criteria for assessing cost estimates and EVM during audits
  - Has been endorsed by OMB and cited as a key reference document for use by federal agencies in its June 2006 Capital Programming Guide

GAO Cost Assessment Guide:
Best Practices for Estimating and Managing Program Costs

An Overview of the Guide

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GAO's Cost Assessment Guide Layout

- The Guide consists of 20 chapters with supporting appendices
  - Chapters 1-17 address the importance of developing credible cost estimates and discuss in detail a 12 step cost estimating process for developing high quality cost estimates
  - Chapters 18-20 address managing program costs once a contract has been awarded and discuss
    - EVM
    - Risk management
    - Other program management best practices

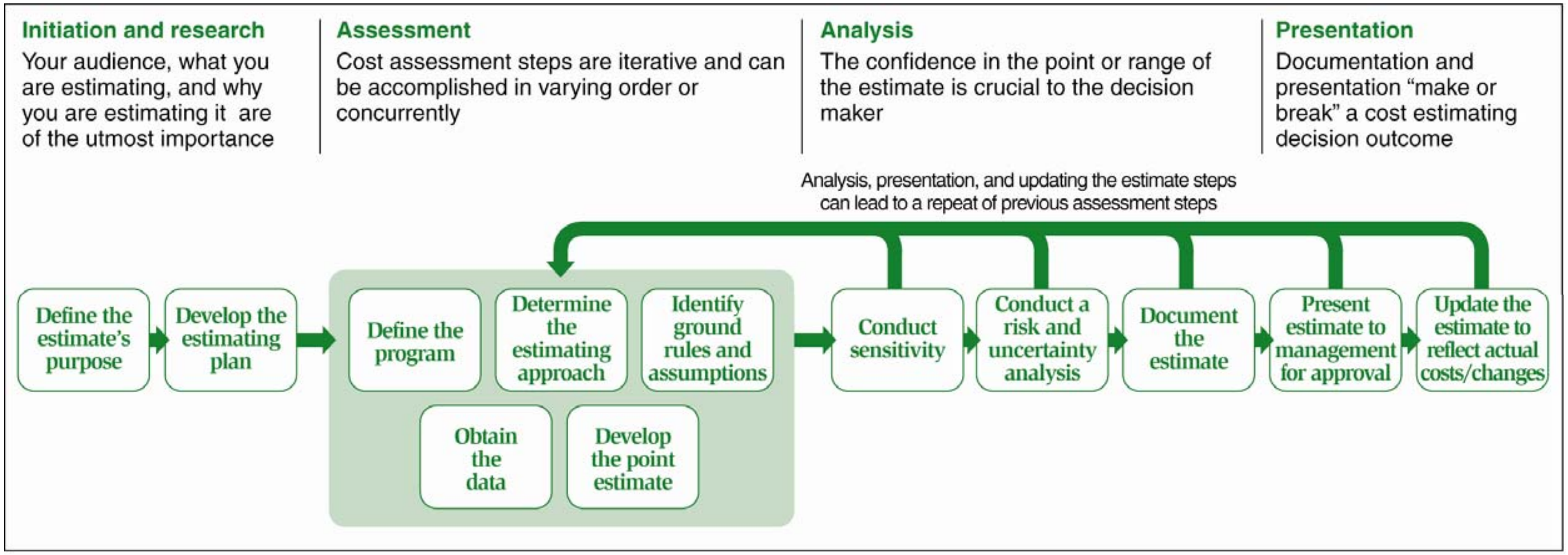
- The Guide also provides case studies of prior GAO audits to showcase typical pitfalls that can occur in the cost estimating process

GAO CAG : Table of Contents

GAO CAG: Table of Contents (cont)

Chapter 1: Characteristics of credible cost estimates and a reliable process for creating them

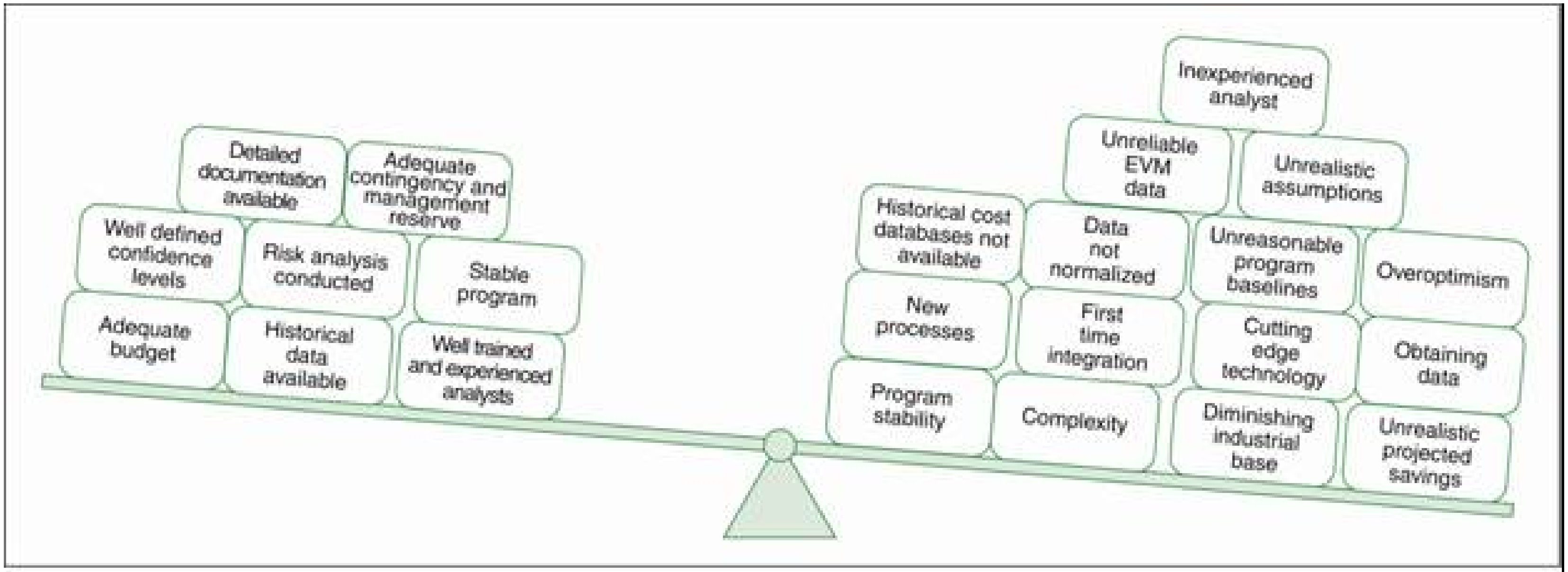
- This chapter discusses a 1972 GAO report on cost estimating
  - We reported that cost estimates were understated and causing unexpected cost growth
  - Many of the factors causing this problem are still relevant today
- We also discuss a 12 step process for producing high quality cost estimates



Source: GAO.

Chapter 2: Why cost estimates are required for government programs and challenges associated with developing credible results

- Introduces why cost estimates are required for government programs
  - Developing annual budgets, supporting management decisions about which program to fund, and evaluating resource requirements at key decision points
- Discusses various challenges associated with developing credible results



Chapter 3: Criteria related to cost estimating/EVM and data reliability

- We address how auditors rely on criteria to provide a benchmark for measuring how well a program is performing
  - Criteria provide a context for what is required, what the desired state should be, and what the program was expected to accomplish
  - Criteria are the laws, regulations, policies, procedures, standards and expectations that define what should exist
- We discuss how we researched legislation, regulation, policy and guidance for those most related to cost estimating and EVM
  - DOD, by far, had the most guidance on these subjects
  - Based on our research, we provide tables outlining various criteria that pertain to cost estimating and EVM such as:
    - GPRA, Clinger-Cohen Act, FAR EVMS Changes (7/5/06), Selected Acquisition Reports, 10 USC ICE, 10 USC Nunn-McCurdy, OMB Circulars (A-11, A-94, A-109, etc.), OMB Capital Programming Guide, DOD 5000.1,5000.2, 5000.4, and the NDIA Guides (EVM Intent, Implementation, Surveillance, Application, System Acceptance, and Integrating EVM and Risk Management)
- We also address the importance of data reliability for cost estimating and EVM

Chapter 4: Cost Analysis Overview

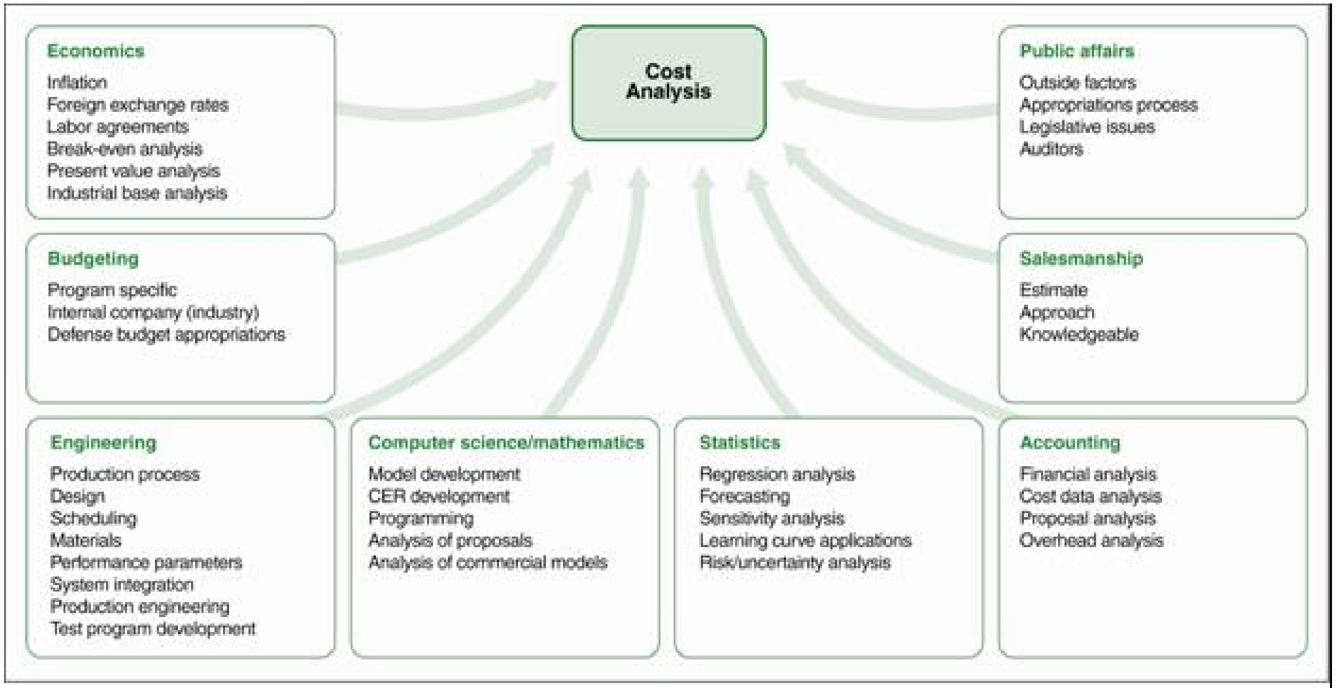
- We review the two main categories of cost estimates
  - Life Cycle Cost Estimates (LCCE) including independent cost estimates (ICE) and total ownership costs (TOC)
  - Business Case Analysis including Analysis of Alternatives (AOA), Cost Effectiveness Analysis (CEA), Economic Analysis (EA), and Cost Benefit Analysis (CBA)
- We also talk about other types of estimates like Rough Order Magnitude (ROM), Independent Cost Assessment (ICA), Independent Government Cost Estimate (IGCE), and Estimates at Completion (EAC)
- We discuss cost estimates in acquisition including
  - The cone of uncertainty and how it is important to update the estimate with actual costs often
  - The importance of cost estimates in establishing budgets
  - Affordability assessments and how LCCE are a best practice
  - Evolutionary acquisition as a best practice for
    - Reducing risk and making cost predictable
    - Incorporating lessons learned

Chapter 5: The Cost estimate's Purpose, Scope, and Schedule

- Purpose – Cost estimates
  - Help managers evaluate and select alternative systems and solutions
  - Support the budget process by providing estimates of the funding required to efficiently execute a program
  - Provide valuable data for use in trade studies, independent reviews, and evaluating baseline changes
- Scope of the cost estimate
  - Determined by customer's needs (e.g., by law, policy, request, etc.)
  - Driven by the availability of data and program phase
- Schedule
  - Ensure timeframe to complete estimate is reasonable
    - Not enough time will result in a lesser quality estimate

Chapter 6: The Cost Assessment Team

- The estimating team must manage a great deal of risk, including making assumptions and interpreting what historical data represents
  - Many times, these decisions are subjective and require the estimator to possess many skills
  - Cost estimators must have good organization skills in order to pull together disparate data and package it in a meaningful way



Chapter 6: The Cost Assessment Team (continued)

- The size of the team is driven by the estimate type
  - A ROM estimate requires less skill and time than a LCCE
- Enough time should be allotted for
  - Collecting and understanding historical data
  - Clarifying technical program aspects with experts
- A best practice is centralizing the cost estimating team and process
  - Facilitates the use of standard processes
  - Results in a strong organizational structure and leadership support
  - Allows for the identification of resident experts
  - Enables better sharing of resources
  - Encourages commonality of tools and training for cost estimating
  - Provides for more independence and less bias
  - Presents opportunities for advancement within the cost estimating field
- Certifications, training, and practical experience are necessary for cost estimators and EVM analysts to effectively perform their job

Chapter 7: Technical Baseline Description

- Adequate information must be available to identify the technical and programmatic parameters with which to bind the estimate including
  - The system's purpose, detailed technical and system performance characteristics, work breakdown structure, and legacy systems, if any
  - Acquisition strategy, quantities, and program schedule
  - Test and evaluation plan, deployment details, and training plans
  - Environmental impacts, operational concept, and manpower needs
  - Logistics support and changes to the prior technical baseline, if applicable
- The technical baseline description should answer the following:
  - What is the program supposed to do? (requirements)
  - How will the program fulfill its mission? (purpose)
  - What will the program look like? (technical characteristics)
  - Where and how the program will be built? (development plan)
  - How will the program be acquired? (acquisition strategy)
  - How will the program operate? (operational plan)
  - Which characteristics most affect the cost? (risk)

Chapter 7: Technical Baseline Description (continued)

- The accuracy of the cost estimate depends on the how well the program is defined
- A best practice is for this information to be included in a single document
- The technical baseline should be developed by qualified personnel, preferably system engineers, and approved by the Program Manager
- The technical baseline should be kept updated with technical, programmatic, and schedule changes
  - It should be treated as a living document and updated as changes occur
  - It should also identify the level of risk associated with assumptions so the credibility of the estimate can be determined

Chapter 8: Work Breakdown Structure (WBS)

- A WBS defines in detail the work necessary to meet program objectives
  - It communicates what needs to be done and how the activities relate to one another
  - It creates a framework for the EVM system to
    - Plan and assign work
    - Track technical accomplishments in relation to the plan
    - Enable continuous improvement and improved communication
- A product-oriented WBS represents the best practice
  - It should contain at least 3 levels of indenture
  - Be flexible and tailored to each unique program
  - The 100% rule always applies
    - The sum of the children must always equal the parent
  - The WBS should have all cost elements defined and include all relevant costs
  - In addition to hardware and software elements (product-oriented), there should also be common elements to capture all the effort
    - Such as, program management, systems engineering, integration, training, data, testing, support equipment, site activation, facilities, initial spares and repair parts
  - A given system should have one program WBS, but might have several contract WBS's depending on the number of subcontractors involved

Chapter 8: Work Breakdown Structure (continued)

- WBS best practices
  - The WBS should be standardized so that cost data can be used for estimating future programs
  - It should be updated as changes occur and the program becomes better defined
  - It should provide for a common language between the government program management office, technical specialists, prime contractors, and subcontractors
  - Like the Technical Baseline Description, the WBS should be a living document and mature with the program
- Work Breakdown Structures and EVM
  - A WBS can be used to integrate scheduled activities and costs
  - It enables the development of a resource loaded schedule which forms the EVM Performance Measurement Baseline (PMB)
  - It provides a consistent framework from which to measure actual progress, update the estimate, and analyze where and why variances occur
  - A WBS helps keep program status current and visible so that risks can be better managed
  - It provides a common thread between EVM and the Integrated Master Schedule used to assess technical performance
- The WBS should also come with a dictionary that:
  - Defines each element and how it relates to others in the hierarchy
  - Clearly describes what is and is not included in an element
  - Resources and processes necessary to produce the element
  - Links each element to other relevant technical documents

Chapter 9: Ground Rules and Assumptions

- Since cost estimates are based on limited information, they need to be bound by various constraints or assumptions
  - These assumptions bind the estimate's scope by establishing baseline conditions and serve to flush out any misunderstandings
  - Ground rules represent a common set of agreed upon estimating standards that provide guidance and minimize conflicts in definitions
    - Technical baseline requirements discussed in Chapter 7 represent ground rules
    - Each program will have its own unique ground rules
  - Assumptions are made in the absence of firm ground rules
    - They represent judgments about past, present or future conditions
    - To avoid optimistic assumptions, judgments should be sought from experienced technical staff
    - All assumptions should be documented including rationale and backed by historical data
- Each cost estimate, at a minimum should define the following global ground rules and assumptions:
  - Program schedule, time phasing, base year, labor rates, and inflation indices
  - Participating agency support, cost limitations, and government furnished equipment
    - The schedule should be realistic and level of confidence about its achievability should be presented
    - Budget constraints should be clearly explained along with how the limitation affects the estimate

Chapter 9: Ground Rules and Assumptions (continued)

- Assumptions must clearly identify any factors that impact a program's cost, schedule, or technical status
  - Well supported assumptions include documentation on sources, weaknesses, and/or risks
  - Solid assumptions are measurable, specific, and validated by historical data
- To mitigate risk:
  - All ground rules and assumptions should be placed in a single spreadsheet tab
    - Allows for risk and sensitivity analysis to be performed quickly and efficiently
  - A schedule assessment should be performed to determine the realism of the schedule
  - Budget constraints should be clearly defined and the impacts of delaying program content identified
  - Peaks and valleys in time phased budgets should be explained
  - Inflation index, source, and approval authority should be identified
  - Dependencies on other participating agencies and GFE availability should be identified
    - The impacts of these assumptions not holding should also be identified
  - Items excluded from the cost elements should be documented and explained
  - Technology should be mature before being included in a program
    - If the assumption is that the technology will be mature, the estimate should address the cost and schedule impact of that assumption failing
  - Cost estimators and auditors should meet with technical staff to determine risk for all assumptions

Chapter 10: Data

- The quality of the data affects the overall credibility of the cost estimate
- Estimators usually rely on data from existing programs to estimate the cost of new programs
  - Adjustments are made to account for differences between the old and new program
- Collecting valid historical data takes time and access to large amounts of data
- As the foundation of an estimate, data should be:
  - Gathered from historical actual cost, schedule / programmatic, and technical sources
  - Applicable to the program being estimated
  - Analyzed for cost drivers
  - Collected from primary sources (e.g., accounting records), if possible
    - Secondary sources (e.g., cost studies) are next best option, especially for cross-checks
  - Adequately documented including
    - The source, content, timeframe, units, assessment of accuracy and reliability, and a description of any circumstances affecting the data
  - Continually collected, protected, and stored in a database for future use
  - Assembled as early as possible, so there is enough time to participate in site visits to better understand the program and question data providers

GAO CAG: Chapter 10

- Before using in a cost estimate, data should be:
  - Fully reviewed to understand what limitations exist
  - Segregated into nonrecurring and recurring costs
  - Validated using historical data as a benchmark for reasonableness
  - Current and determined applicable to the program being estimated
  - Analyzed using a scatter plot to determine trends and outliers
  - Analyzed for descriptive statistics
  - Normalized to account for
    - Cost and sizing units
    - Mission or application
    - Technology maturity, and
    - Content so that it is consistent for comparing
  - Normalized to a constant base year dollar to remove the effects of inflation
    - The inflation index used should be documented and explained

Chapter 11: Developing the Point Estimate

- To develop the point estimate there are several activities that a cost estimator must accomplish:
  - Develop the cost model by estimating each WBS element using the best methodology from the data collected,
  - Include all estimating assumptions in the cost model,
  - Express costs in constant year dollars,
  - Time-phase the results by spreading costs in the years they are expected to occur,
  - Sum each of the WBS elements to develop the overall point estimate,
  - Validate the estimate by looking for errors like double counting and omitting costs,
  - Compare the estimate against an independent cost estimate and examine any differences,
  - Perform cross-checks on cost drivers to see if results are similar, and
  - Update the model as more data becomes available or as changes occur
- No one methodology is a best practice in all circumstances.
  - Analogies should be used early in a program's life-cycle, when specific information is limited
  - The Build-up method should only be used when an analyst has detailed information
  - Parametrics may be used throughout the acquisition cycle, provided there is a database of sufficient size, quality, and homogeneity to develop valid Cost Estimating Relationships (CERs)
  - Expert opinion should only be used very early in the life-cycle, and only when there is simply no other way to derive the estimate
  - Extrapolating from actual cost data yields credible results, but such data is not typically available until the start of production

GAO CAG: Chapter 11

- Cost Estimators should do the following before using a CER:
  - Examine the underlying data set to understand what anomalies, if any, are present
  - Check the equations to ensure that the relationships make logical sense
  - Normalize the data properly to avoid questionable results
  - Ensure that CER inputs are within the valid dataset range
  - Check the modeling assumptions to ensure that they are applicable to the new program being estimated
- Learning curve theory should be applied when:
  - A high amount of manual labor is required to produce the item,
  - The production of items is continuous (or adjustments have to be made),
  - Items to be produced require complex processes,
  - Technological change is minimal between production lots,
    - Production rate and breaks in productions should also be considered
  - Contractor business process is under continual improvement
- Estimates based on actual costs are the most defensible and reliable
- Subjective estimates should be avoided, but can be useful as cross-checks

Chapter 12: Software Cost Estimation

- Estimating software development is a difficult and complex task
  - Close to 31 percent of software programs are canceled
  - More than half overrun original estimates by 50 percent, according to a Standish Group International, Inc. study (2000)
- There is an overwhelming sense of optimism about how quickly software can be developed
  - Stems from a lack of understanding of how staffing, schedule, software complexity, and technology all interrelate
  - Optimism about new technology and reuse savings result in unachievable schedules
- This chapter highlights what is unique about software cost estimation, identifies software cost drivers, and supplements the 12 step cost estimating process identified in Chapter 1
- Software costs are comprised of two basic elements
  - The amount, or size, of software to be developed
  - The development effort, or manpower, necessary to accomplish the requirements

Chapter 12: Software Cost Estimation (continued)

- Which method to use for sizing software depends on the software application and what information is available
  - SLOC can be used when
    - Requirements are well-defined,
    - There is a historical database of SLOC counts for similar programs, and
    - There is a standard definition of what constitutes a line of code
  - Function points can be used when
    - Detailed requirements and specifications are available,
    - The software does not contain a lot of algorithmic functions, and
    - There is an experienced and certified function point counter available
  - Object points can be used when
    - Computer-aided software engineering tools are used to develop the software, and
    - Each count is weighted for complexity, summed to a total count, and adjusted for reuse
  - Feature points can be used instead of function points when the software has a high degree of algorithms
- Auto-generated and reused SLOC should be identified separately from new and modified SLOC
  - Because it is necessary to account for differences in pre- and post-implementation activities

Chapter 12: Software Cost Estimation (continued)

- Software cost estimates should include:
  - Software development labor costs for coding/testing, other labor supporting software development (e.g., program management), and non-labor costs like purchasing hardware and licenses
  - Productivity factors for converting software size into labor effort
    - Factors should be based on historical data and calibrated to match the program's size and development environment
  - When converting labor hours into cost, assumptions should be made about
    - How many productive labor hours there are in a day
    - How many workdays there are per year
  - Costs for help desk support, corrective, adaptive, and preventive maintenance should also be estimated as part of the software's life cycle cost
  - Cost estimators should be trained to calibrate parametric tools to match their program
- Estimators should account for additional efforts related to effective COTS integration including developing custom code and glue-code
  - COTS is never free and is often underestimated
- Common software risks impacting cost and schedule include:
  - Underestimating software size, vague requirements, and overestimating reuse and ERP/COTS savings
  - Productivity levels, high level of module integration, high quality (e.g., loss of life impact), amount of new code to be developed and integrated
  - Developer skill, location of development team, unrealistic schedule, new language/process, poor quality control

Chapter 13: Sensitivity Analysis

- Sensitivity analysis is a best practice because all estimates are uncertain
  - Sensitivity analysis identifies which cost elements represent the most risk
  - The amount of risk should be quantified, if possible
- Sensitivity analysis reveals how the cost estimate is affected by changing one assumption at a time, while holding all other variables constant
  - Sometimes, a sensitivity analysis can be done to examine the effect of multiple assumptions changing for a specific scenario
  - The analysis focuses on varying high cost drivers and assumptions
    - Some factors that are often varied include: shorter or longer economic life, requirements changes, quantities, inflation rates, technology heritage savings, labor rates, software size, etc.
  - The sources supporting the assumption or factor ranges should be well documented and reasonable
  - Sensitivity analysis should be done as part of a quantitative risk assessment and not based on arbitrary + / - percentages.
  - Cost sensitive assumptions and factors should be further examined to see whether design changes should be implemented to mitigate risk
- A sensitivity analysis should be used to create a range of best and worst case costs
  - Results should be well documented and presented to management
  - Enables management to make informed decisions

Chapter 13: Sensitivity Analysis (continued)

The following steps should be followed when performing a sensitivity analysis:

1. Identify key cost drivers (i.e., highest cost) and examine what parameters / assumptions drive them
2. Re-estimate the total cost by varying each parameter / assumption between a range (e.g., min / max)
3. Document the results
4. Repeat steps 1-3, recalculating the estimate for each parameter identified as a key cost driver
5. Evaluate all the outcomes to determine which parameters the cost estimate is most sensitive to cost

Sensitivity analysis is useful because it

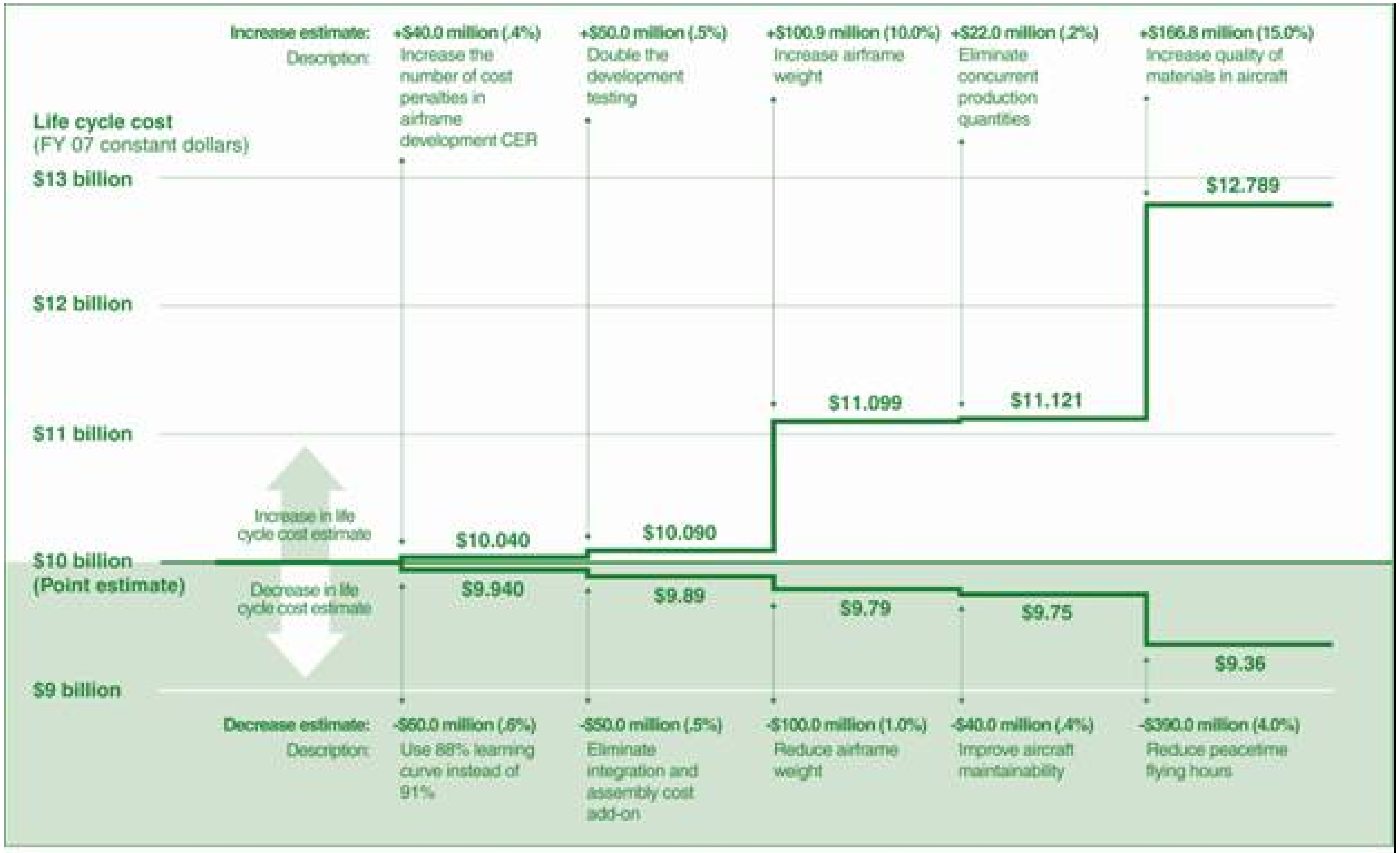
- Aids decision makers in choosing which alternative is the best choice
- Focuses management on what drives program cost the most
- Establishes a method for performing what-if analysis
- Provides a range of possible costs in addition to a point estimate
- Provides a careful assessment of what drives that range (e.g., underlying risks based on supportable data)
- Can help determine what level of risk reserve may be required

Sensitivity analysis cannot provide an overall sense of the uncertainty underlying the point estimate

- It only examines the effect of one variable changing at a time
- A risk / uncertainty that examines multiple changes at the same time is required (discussed in Chapter 14)

A cost risk / uncertainty analysis using a Monte-Carlo simulation should be used in conjunction with a sensitivity analysis to determine the overall variability within a particular point estimate

Chapter 13: Sensitivity Analysis (continued)



Source: GAO.

Chapter 14: Cost Risk/Uncertainty

- Every cost estimate is uncertain due to
  - A lack of knowledge about the future
  - Errors resulting from historical data inconsistencies, assumptions, cost estimating equations, and factors
- Because many parameters can change at once, a risk / uncertainty analysis should be performed
  - Identifies the effect of changing key cost drivers and assumptions all at the same time
  - Considered a best practice for quantifying the risk around point estimate
  - Required by some legislation, such as the Clinger Cohen Act, for assessing and managing the risks of acquiring major information systems
- A point estimate, by itself, is meaningless--Management needs to know
  - The range of all possible costs
  - The level of certainty associated in achieving the point estimate in order to make a wise decision
  - Whether a realistic baseline has been estimated for the program
    - An unrealistic baseline has been the cause of many government programs overrunning cost and not delivering promised functionality on time
    - A realistic baseline is critical to a program successfully achieving its objectives
- As programs mature, the level of confidence increases
  - The point estimate also grows as risks are realized and budget is required to resolve them
- A cumulative probability density function, commonly called and “S”-curve, can be used to
  - Map various cost estimates to probability levels allowing management to know the probability of an overrun
  - Develop defensible contingency reserves

Chapter 14: Cost Risk/Uncertainty (continued)

There are six steps to be followed to develop a justifiable S-curve:

1. Determine the program cost drivers and associated risks
2. Develop probability distributions to model various types of uncertainty (e.g., programmatic, technical, cost estimating, schedule, etc.)
3. Account for correlation between cost elements to properly capture risk
4. Perform the uncertainty analysis using a Monte Carlo simulation model
5. Identify the probability level associated with the point estimate
6. Recommend sufficient contingency reserves to achieve certain levels of

Determining potential sources of program cost uncertainty (Step 1) includes:

- Examining all sources of risk including requirements uncertainty, cost estimating uncertainty, economic or business uncertainty, technology uncertainty, schedule uncertainty, programmatic and software uncertainty
- Examining the level of uncertainty by:
  - Applying a cost growth factor, relying on expert opinion, using a mathematical approach (i.e., statistics)
  - Analyzing Technology Readiness Levels (TRLs) and Software Engineering Institute (SEI) Maturity Models
  - Performing a schedule risk analysis, employing the risk cube method, or applying a risk score

Chapter 14: Cost Risk/Uncertainty (continued)

- The next step involves choosing probability distributions (Step 2):
  - There are many kinds including: normal, lognormal, triangular, uniform, Beta, Weibull, Poisson, and Bernoulli
  - A probability distribution accounts for all possible outcomes
  - Probability distributions should be chosen at the WBS level to best represent each WBS' unique risk
  - The shape of the distribution will be determined by the data that is gathered for each WBS element
    - The potential for experts to bias results by providing too narrow of a range can be mitigated by requesting historical data to back up any claims
- Account for Correlation (Step 3)
  - Correlation between WBS elements will occur since many cost elements are interrelated
    - A change in one element can affect another
    - For example, technical problems can cause other activities to slip increasing both cost and schedule
  - The cost model should be structured with all dependencies intact so that risks flow through the cost model
  - Sometimes risk must be injected into the model to account for risks that affect other items
    - For example, if the wing span increases, this may result in a larger engine being procured than planned
- Perform uncertainty analysis using Monte Carlo simulation (Step 4)
  - During the simulation the cost model is recalculated thousands of times based on random draws from each WBS probability distribution
  - The output illustrates not only what can happen in a given outcome, but how likely each outcome is to occur
  - Risk associated with all outcomes can be quantified allowing management to make informed decisions

Chapter 14: Cost Risk/Uncertainty (continued)

- Identify the probability associated with the point estimate (Step 5):
  - Using information from the S-curve, management can determine
    - The probability associated with achieving the point estimate
    - The range of possible outcomes including the minimum and maximum costs for the program
    - Whether funding is adequate to meet program cost, schedule, and technical objectives
    - The probability associated with various risks occurring
  - Management can develop proactive responses to mitigate risks likely to occur
- Recommend sufficient contingency reserves (Step 6)
  - Using information from step 5, management can determine whether a program's cost, schedule and performance goals can be met
  - Contingency reserves can be recommended to raise the level of confidence in successfully completing the program
    - The difference in cost between the point estimate and the desired level of confidence determines the amount of contingency reserve
    - Risk reserves should be allocated equitably to the riskiest WBS cost elements so that risk funding is available to quickly mitigate problems if they occur
- As a best practice, a risk management process should be used to track risks identified in step 1
  - Involves identifying, analyzing, planning for and implementing risk mitigation, and tracking risks

Chapter 15: Validating the Estimate

- Cost estimates should be validated against these best practice characteristics:
  - They are comprehensive, well-documented, accurate, and credible
  - Cost estimates are considered comprehensive if they
    - Completely define the program and reflect the current schedule
    - Include all possible costs using a logical WBS that accounts for all requirements
    - Ensure that no costs are omitted nor double-counted
    - Explain and document key assumptions that are technically reasonable
  - Cost estimates are well-documented if
    - They can be easily repeated or updated and traced to original sources through auditing
    - Supporting documentation identifies the data sources, justifies all assumptions, and provides a description of each estimating methodology for every WBS cost element
    - Schedule milestones and deliverables are traceable and consistent with the cost estimate documentation
  - Cost estimates are accurate if
    - They are not overly conservative or too optimistic
    - Based on an assessment of most likely costs and adjusted properly for inflation
    - Contain few, if any, mistakes that are minor in nature
    - Are updated when assumptions or requirements change to reflect current status
    - CERs and parametric cost models are validated to ensure they are good predictors of costs
      - Data is current and applicable to the new program,
      - The relationships between technical parameters are logical and statistically significant
      - Results are tested with independent data

Chapter 15: Validating the Estimate (continued)

- Cost estimates are credible if
  - They clearly identify any limitations because of uncertainty or biases surrounding the data or assumptions
  - Results are similar to cross-checks and an independent cost estimate derived using different methodologies
    - ICEs performed by estimators farthest away from the acquiring program office represent a best practices because they
      - Tend to produce higher and more accurate cost estimates than those performed by staff sharing a common supervisor with the program office
      - Produce more credible estimates than other types of independent estimate reviews which may not be as inclusive as an ICE (e.g., IGCE, ICA, Sufficiency Review, etc.)
  - A sensitivity analysis has been performed to identify cost drivers and the impacts of varying assumptions
  - A risk / uncertainty analysis has been performed to determine the level of risk associated with the point estimate

Chapter 16: Documenting the Estimate

- Thorough documentation is considered a best practice because it
  - Presents a convincing argument for why an estimate is valid
  - Can help answer probing questions from oversight groups
  - Provides a step by step approach so someone unfamiliar with the estimate could update or recreate it
  - Helps with analyzing changes in program costs
  - Contributes toward the collection of data to be used in future estimates
  - Provides for an effective independent review to ensure the estimate is valid and credible
  - Supports reconciling differences with an independent cost estimate
- Good documentation should describe the cost estimating process, data sources, and methodologies used
  - It should include both narrative text and cost tables to describe the basis of the estimate
  - It should follow a standard format including:
    - An executive summary, introduction, cost estimate methodology and data broken out by WBS cost elements,
    - Sensitivity analysis, risk/uncertainty analysis, and management approval, and
    - Updates to reflect actual costs and changes
  - Documentation should make sense, both mathematically and logically
  - The documentation should include a discussion of contingency reserve and how it was derived
- Documentation should not occur at the last minute, but done in parallel with the estimate
- An electronic copy of the cost model and data should always be provided with the cost estimate

Chapter 17: Presenting the Estimate

- All cost estimates must be approved by management before they can be considered valid
- Cost estimators should prepare a briefing for management that
  - Includes enough detail to easily defend the accuracy and quality of the estimate
  - Is simple, clear and concise so that
    - Staff unfamiliar with the program estimate can comprehend the estimate's level of competence
  - Focuses on illustrating the largest cost drivers presented in a logical manner
    - With backup charts for responding to more probing questions
  - Follows a consistent format so management can focus on the cost estimate's content
  - Breaks out the estimate by program phase
- Feedback from the briefing, including management's acceptance of the estimate, should be acted upon and recorded in the cost estimate documentation

Chapter 17: Presenting the Estimate (continued)

- Cost estimate briefings to management should contain the following:
  - A title page, outline, and brief purpose of the estimate
  - An overview of the program's technical foundation and objectives
  - Life cycle cost estimate results shown in time phased constant year dollars
    - Results should be tracked to any previous estimates
  - A discussion of estimating Ground Rules and Assumptions
  - The estimating methodology and process for each WBS cost element
    - Including estimating techniques, data sources, etc.
  - Results of the Sensitivity Analysis and any cost drivers identified
  - Results of the Risk/Uncertainty Analysis
    - Including the resulting confidence interval, S-curve analysis, and bounds and distributions selected
  - Results from comparing the point estimate to an independent cost estimate
    - Including a discussion of any differences and whether the point estimate is reasonable
  - An affordability analysis based on funding profile and contingency reserves
  - Discussion of any other concerns or challenges
  - Conclusions and recommendations
    - Including requesting management to approve the estimate

Chapter 18: Managing Cost - Planning

- Discusses how the cost estimating effort does not end once a program has been approved
  - Instead, the next steps involve
    - Assigning someone (government and/or contractor) responsibility for developing, producing and implementing the program
    - Converting the cost estimate into a realistic and executable program baseline to manage program cost, schedule, and technical goals

- This chapter also introduces EVM including a discussion of
  - Its background, concept, benefits, and industry standards
  - EVM options based on contract type / cost / duration
  - Scheduling and Planning the Effort
  - Setting up the Performance Measurement Baseline (PMB)
    - Including detailed schedule information and performing a schedule risk assessment in an appendix
  - The option to conduct a Pre-Award Integrated Baseline Review (IBRs)
    - Including pros and cons
  - A-12 Program cancellation due to front loading and lessons learned
  - Management Reserve for mitigating risks

- It also addresses:
  - Setting up effective Award Fee criteria
    - Including tying award fee to objective outcomes/milestones that can be corroborated with EVM data
  - Validating the EVM system

Chapter 19: Managing Cost - Execution

- This chapter discusses:
  - Performing an Integrated Baseline Review to validate the PMB and determine risks
  - Monitoring risks using
    - A formal risk management plan
    - EVM risk “watch list” items derived from the cost risk/uncertainty analysis
  - Performing monthly EVM analysis
    - Discusses terms and concepts (e.g., BCWS, BCWP, ACWP, CV, SV, CPI, SPI, TCPI, etc., format 5 variance analysis, developing EACs, etc.)
  - Projecting future performance
  - Rolling Wave Planning and re-planning remaining work
  - Determining award fees based on objective outcomes/milestones based on actual EVM data

Chapter 20: Managing Cost - Updating

- This chapter addresses:
  - Incorporating authorized changes into the PMB, including Engineering Change Proposals (ECPs)
  - Performing continual EVM surveillance to ensure PMB is realistic and reflects current requirements
  - Implementing Over Target Baselines and Over Target Schedules
  - Program Rebaselining
  - Updating program cost estimate with actual costs
  - Continually reporting updated Estimates at Completion (EACs) to management
    - Best practices require updated EACs, at a minimum, during quarterly program reviews
  - Incorporating lessons learned and document reasons for cost and / or schedule variances

GAO CAG: Appendices

- **APPENDIX I: CASE STUDY BACKGROUND INFORMATION**
- **APPENDIX II: GENERIC DATA COLLECTION INSTRUMENT**
- **APPENDIX IIA: DATA COLLECTION INSTRUMENT DATA REQUEST RATIONALE**
- **APPENDIX III: RELEVANT COST ESTIMATING AND EVM CRITERIA**
- **APPENDIX IV: INFORMATION ON AUDITING AGENCIES**
- **APPENDIX V: LIST OF EXPERTS**
- **APPENDIX VI: SEI CHECKLIST FOR EVALUATING ESTIMATING CAPABILITIES**
- **Appendix VII: DOD STANDARD WBS EXAMPLES**
- **APPENDIX VIII: TECHNOLOGY READINESS LEVELS (TRLs)**
- **APPENDIX IX: LEARNING CURVE ANALYSIS**
- **APPENDIX X: OVERVIEW OF THE FEDERAL BUDGET PROCESS**

Recent GAO Reports Highlighting Cost Estimating Issues

Based on Best Practices outlined in our Guide

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Accountability • Integrity • Reliability

GAO 2007 Reports Highlighting Cost Estimating Issues

GAO-07-404	Russian Nuclear Security
GAO-07-268	GSA Networx Implementation
GAO-07-240R	Chemical Demilitarization
GAO-07-133R	DNDO's Cost Benefit Analysis of Radiation Detection Equipment
GAO-07-581T	DNDO's Decision to Deploy New Radiation Detection Equipment Not Supported by its Cost Benefit Analysis

Invitation to Participate in Further Development of the Guide

- GAO invites interested parties to meet with us and other experts to discuss further development of the Guide during the year long exposure draft period
  - If interested, please e-mail your contact info to:
    - Karen Richey - richeyk@gao.gov
    - Jennifer Echard – echardj@gao.gov
    - Carol Cha – chac@gao.gov