

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

by Carol Cha

October 2009



Outline

- Why is the GAO Cost Assessment Guide important?
- An overview of the Guide
- Intended Benefits of the Guide
- Recent GAO Reports based on criteria in the Guide
- Case Studies Showing how GAO Used the Guide as Audit Criteria
- Invitation to participate in future expert meetings at GAO

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 that can be used across the federal government for the development and management of its program cost estimates

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

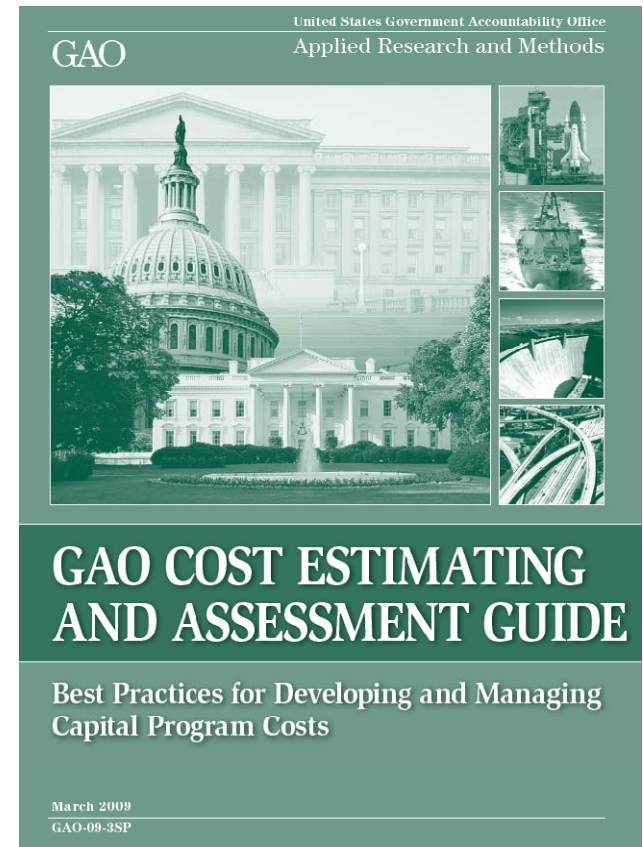
- Original intent was to provide auditors with a standardized approach for analyzing program costs
 - Our research, however, found federal guidelines to be limited on the processes, procedures, and practices for ensuring credible cost estimates
 - We decided to fill the gap and shifted the intent of 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
 - OMB has cited as a key reference document for use by federal agencies in its June 2006 Capital Programming Guide
- The Guide can be downloaded for free at:
 - <http://www.gao.gov/products/GAO-09-3SP>



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

An Overview of the Guide

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

- Chapter 1: Characteristics of credible cost estimates and a reliable process for creating them
- Chapter 2: Why cost estimates are required for government programs and challenges associated with developing credible results
- Chapter 3: Criteria related to cost estimating/Earned Value Management and data reliability
- Chapter 4: Cost Analysis Overview
- Chapter 5: The Cost estimate's Purpose, Scope, and Schedule
- Chapter 6: The Cost Assessment Team
- Chapter 7: Technical Baseline Description
- Chapter 8: Work Breakdown Structure
- Chapter 9: Ground Rules and Assumptions
- Chapter 10: Data

GAO CAG: Table of Contents (cont)

- Chapter 11: Developing the Point Estimate
- Chapter 12: Software Cost Estimation
- Chapter 13: Sensitivity Analysis
- Chapter 14: Cost Risk/Uncertainty
- Chapter 15: Validating the Estimate
- Chapter 16: Documenting the Estimate
- Chapter 17: Presenting the Estimate
- Chapter 18: Managing Cost - Planning
- Chapter 19: Managing Cost - Execution
- Chapter 20: Managing Cost - Updating

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

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

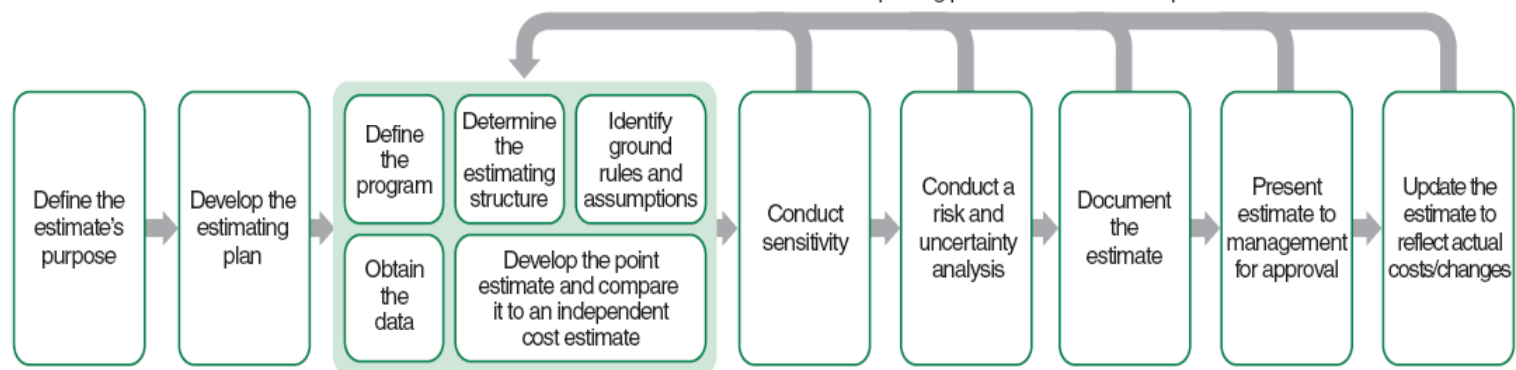
Analysis

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

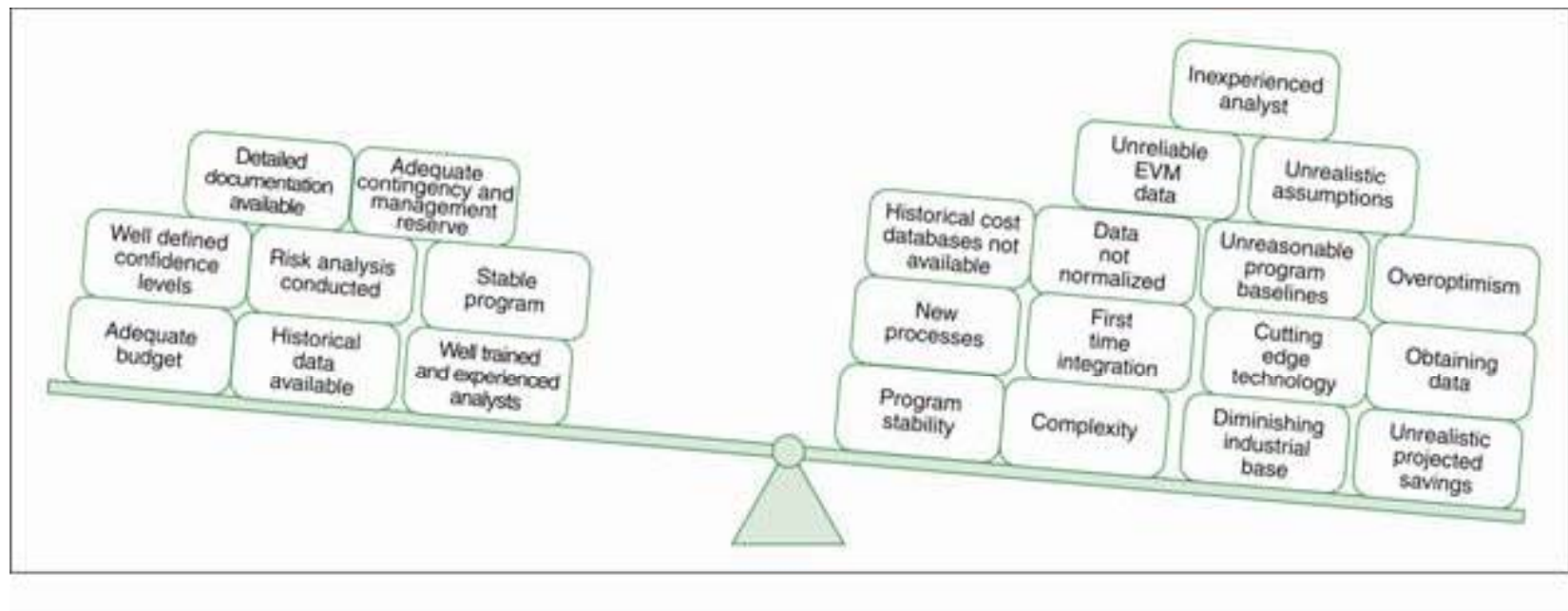
Analysis, presentation, and updating the estimate steps can lead to repeating previous assessment steps



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 4: Cost Analysis Overview

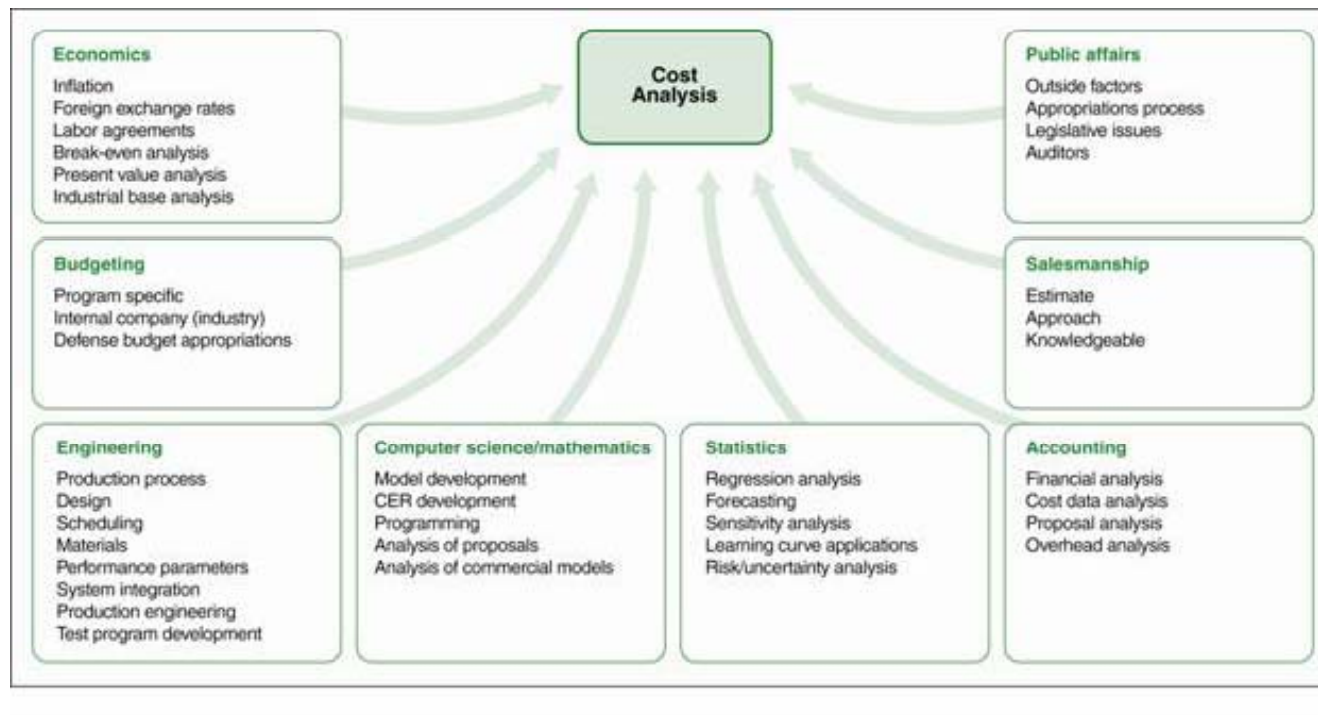
- We review the two main categories of cost estimates
 - Life Cycle Cost Estimates (LCCE) including independent cost estimates (ICE) and total ownership costs (TOC)
 - Business Case Analysis including Analysis of Alternatives (AOA), Cost Effectiveness Analysis (CEA), Economic Analysis (EA), and Cost 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 (GR&A)

- 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 document the rationale, historical data, and risks that may occur if the assumption fails
- Each cost estimate, at a minimum should define the following GR&As:
 - 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
- 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

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
 - Normalized so it is consistent for comparing
 - 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

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) and learning curves
 - 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

Chapter 12: Software Cost Estimation

- Estimating software development is a difficult and complex task
 - Close to 31 percent of software programs are canceled and 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 (expressed in SLOC, Function / Object / Feature Points, Use Cases, etc.)
 - The development effort, or manpower, necessary to accomplish the requirements
 - 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
 - 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

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)



Chapter 14: Cost Risk/Uncertainty

- Every cost estimate is uncertain due to
 - A lack of knowledge about the future
 - Errors resulting from historical data, 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

Chapter 14: Cost Risk/Uncertainty (continued)

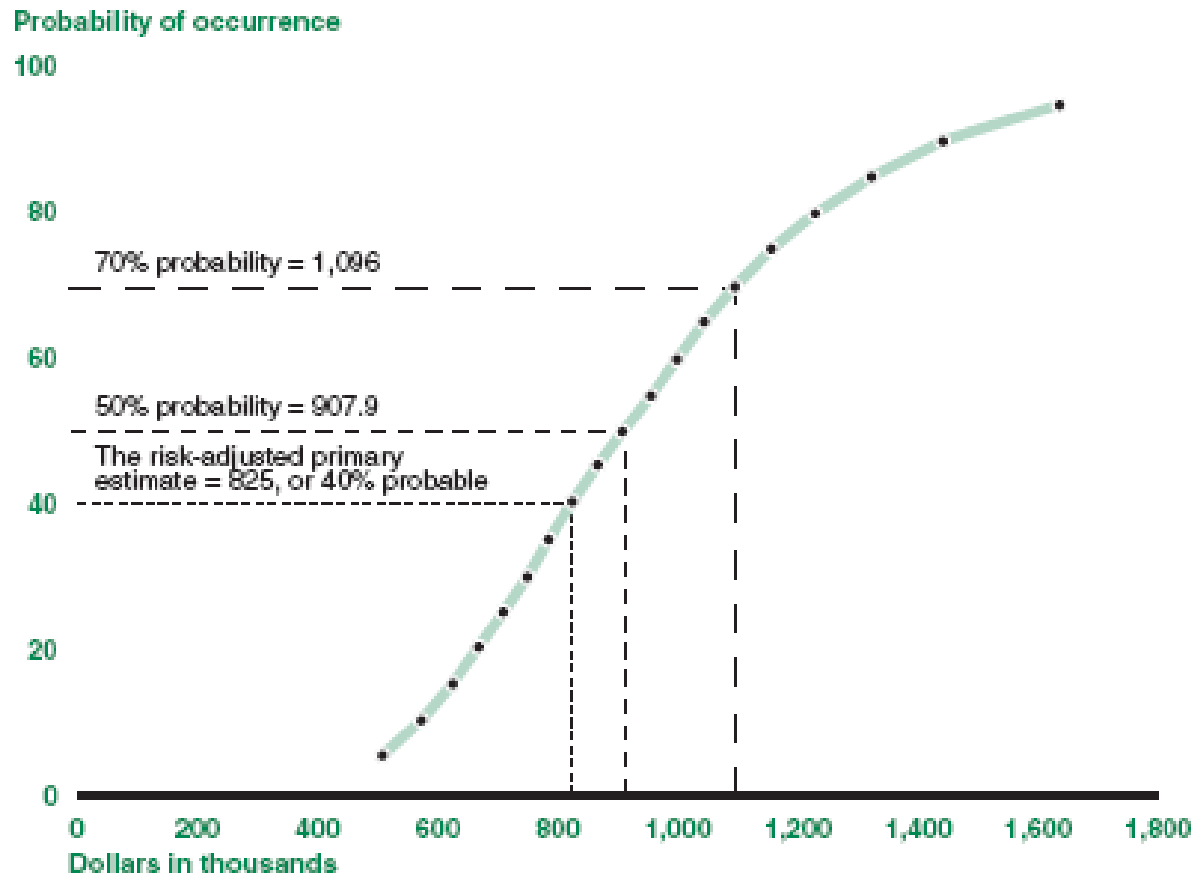
A cumulative probability density function, commonly called an “S”-curve, can be used to

- Map various cost estimates to probability levels allowing management to know the probability of an overrun
- Develop defensible contingency reserves

There are seven 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 confidence, and
7. Allocate, phase, and convert the risk adjusted cost estimate to then year dollars and identify high risk elements for risk mitigation

Chapter 14: Cost Risk/Uncertainty – Example of an S-curve



Chapter 15: Validating the Estimate

- Cost estimates should be validated against these best practice characteristics:
 - They are comprehensive, well-documented, accurate, and credible

Characteristic	Related step
<p>Well documented</p> <ul style="list-style-type: none"> • The estimate is thoroughly documented, including source data and significance, clearly detailed calculations and results, and explanations for choosing a particular method or reference. • Data have been traced back to the source documentation. • A technical baseline description is included. • All steps in developing the estimate are documented, so that a cost analyst unfamiliar with the program can recreate it quickly with the same result. • All data sources for how the data was normalized are documented. • The estimating methodology and rationale used to derive each WBS element's cost are described in detail. 	<ul style="list-style-type: none"> 1. Define the estimate's purpose 3. Define the program 5. Identify ground rules and assumptions 6. Obtain the data 10. Document the estimate 11. Present estimate to management
<p>Comprehensive</p> <ul style="list-style-type: none"> • The estimate's level of detail ensures that cost elements are neither omitted nor double counted. • All cost-influencing ground rules and assumptions are detailed. • The WBS is defined and each element is described in a WBS dictionary; a major automated information system program may have only a cost element structure. 	<ul style="list-style-type: none"> 2. Develop the estimating plan 4. Determine the estimating approach

Chapter 15: Validating the Estimate (continued)

Characteristic	Related step
<p>Accurate</p> <ul style="list-style-type: none"> • The estimate is unbiased, not overly conservative or overly optimistic, and based on an assessment of most likely costs. • It has few, if any, mathematical mistakes; those it has are minor. • It has been validated for errors like double counting and omitted costs. • Cross-checks have been made on cost drivers to see if results are similar. • The estimate is timely. • It is updated to reflect changes in technical or program assumptions and new phases or milestones. • Estimates are replaced with EVM EAC and the Independent EAC from the integrated EVM system. 	<ul style="list-style-type: none"> 7. Develop the point estimate and compare it to an independent cost estimate 12. Update the estimate to reflect actual costs and changes
<p>Credible</p> <ul style="list-style-type: none"> • Any limitations of the analysis because of uncertainty or biases surrounding data or assumptions are discussed. • Major assumptions are varied and other outcomes recomputed to determine how sensitive outcomes are to changes in the assumptions. • Risk and uncertainty analysis is performed to determine the level of risk associated with the estimate. • An independent cost estimate is developed to determine if other estimating methods produce similar results. 	<ul style="list-style-type: none"> 7. Develop the point estimate and compare it to an independent cost estimate 8. Conduct sensitivity analysis 9. Conduct risk and uncertainty analysis

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 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)
 - The option to conduct a Pre-Award Integrated Baseline Review (IBR), 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 that tie award fee to objective outcomes/milestones that can be corroborated with EVM data
 - Validating the EVM system

Chapter 18: Managing Cost – Planning, 13 steps in the EVM Process

1. Define the scope of effort using a WBS
2. Identify who in the organization will perform the work
3. Schedule the work
4. Estimate the labor and material required to perform the work and authorize the budgets, including management reserve
5. Determine objective measure of earned value
6. Develop the performance measurement baseline
7. Execute the work plan and record all costs
8. Analyze EVM performance data and record variances from the PMB plan
9. Forecast EACs using EVM
10. Conduct an integrated cost-schedule risk analysis
11. Compare EACs from EVM (step 9) with EAC from risk analysis (step 10)
12. Take management action to mitigate risks
13. Update the performance measurement baseline as changes occur

Chapter 18: Managing Cost – Planning, Step 3 Schedule Risk Analysis

Figure 47: Cumulative Distribution of Project Schedule, Including Risk

Date: 12/7/2007 5:35:45 PM

Samples: 5000

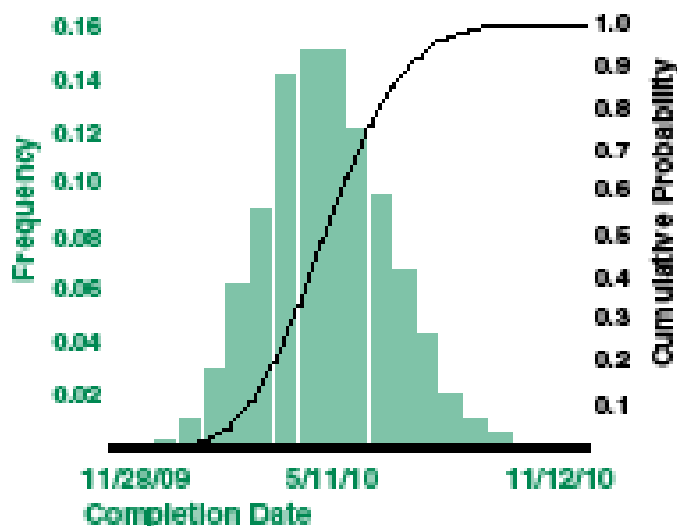
Unique ID: 0

Name: Three Path Project GAO

Completion Std Deviation: 51.79 d

95% Confidence Interval: 1.44 d

Each bar represents 20 d



Completion Probability Table

Prob	Date	Prob	Date
0.05	2/18/10	0.55	5/15/10
0.10	3/6/10	0.60	5/22/10
0.15	3/18/10	0.65	5/29/10
0.20	3/28/10	0.70	6/6/10
0.25	4/5/10	0.75	6/15/10
0.30	4/12/10	0.80	6/24/10
0.35	4/19/10	0.85	7/5/10
0.40	4/25/10	0.90	7/20/10
0.45	5/2/10	0.95	8/8/10
0.50	5/9/10	1.00	11/12/10

GAO

Source: Copyright 2007 Hult and Associates, LLC.

Chapter 18: Managing Cost – Planning (cont'd)

- Benefits of Implementing EVM
 - Provides a **single management control system** that requires work to be broken down to a detailed schedule plan
 - Enhances **insight into program performance** allowing for problems to be detected early on
 - **Reduces cycle time** to deliver a product by imposing discipline and objective measurement
 - Promotes **management by exception** by drawing attention to only the most critical problems
 - **Fosters accountability** by clearly defining what is expected and when
 - Allows for **comparative analysis** against completed projects
 - Provides **objective information** for managing the program and identifying risk

Chapter 18: Managing Cost – Planning Best Practices

- A cost estimate was used to measure performance against the original plan, using EVM.
- EVM and risk management were tightly integrated to ensure better program outcomes.
 - Strong leadership demands EVM be used to manage programs.
 - Stakeholders make it clear that EVM matters and hold staff accountable for results.
 - Management is willing to hear the truth about programs and relies on EVM data to make decisions on how to mitigate risk.
 - Policy outlines clear expectations for EVM as a disciplined management tool and requires pertinent staff to be continuously trained in cost estimating, scheduling, EVM, and risk and uncertainty analysis.

Chapter 18: Managing Cost – Planning Best Practices (cont'd)

- Award Fee and Implementation Areas
 - ✓ A pre-award IBR was performed where provided for to verify the performance measurement baseline's realism and compliance with ANSI guidelines.
 - ✓ Award fee criteria were developed to motivate the contractor to manage its contract with EVM to deliver the best possible product, were tied to specific contract events, and did not predetermine specific EVM measures.
 - ✓ A performance-based-payment contract was considered for fixed-price contracts where technical effort and risk are low.
 - ✓ The EVM system implemented was validated for compliance with the ANSI guidelines by independent and qualified staff and therefore can be considered to provide reliable and valid data from which to manage the program.

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 19: Managing Cost - Execution Best Practices

- An IBR verified that the baseline budget and schedule captured the entire scope of work, risks were understood, and available and planned resources were adequate.
 - ✓ Separate IBRs were conducted at the prime contractor and all major subcontractors.
 - ✓ A performance measurement baseline assessment made a comprehensive and value-added review of control accounts.
 - Before award, or not more than 6 months after, an IBR categorized risks by severity and provided team training.
 - Work definition (including provisions for rework and retesting), schedule integration, resource identification, earned value measures, and baseline validation were matured and reviewed.
 - Interviewers used a template in discussions with control account managers and identified where additional training was needed.
 - An action plan for assigning responsibility for handling risks was developed, and a final program risk rating was based on a summary of all identified risks.
 - Management reserve was set aside that covered identified risks and care was taken to include risks identified during the IBR in the risk management plan.
 - An EVM analyst monitored corrective action requests for closure.
 - A memorandum for the record described the IBR findings.

Chapter 19: Managing Cost - Execution Best Practices (cont'd)

- A contract performance report summarized EVM data.
 - ✓ The data were reviewed monthly to track program progress, risks, and plans.
 - ✓ Management used the data to
 - integrate cost and schedule performance data with technical measures;
 - identify the magnitude and effect of problems causing significant variances;
 - inform higher management of valid and timely program status and project future performance.
 - ✓ Format 1 of the CPR reported data to at least level 3 of the WBS, and format 5 explained variances and the contractor's plans for fixing them.

Chapter 19: Managing Cost - Execution Best Practices (cont'd)

- ❑ Program managers analyzed EVM data monthly and sequentially for variances and EACs.
 - ✓ The EVM data were checked for validity and anomalies.
 - ✓ Performance indexes were analyzed and plotted for trends and variances.
 - ✓ Schedule variances were analyzed against the most recently statused schedule to see if problems were occurring on or near the critical path.
 - ✓ Management reserve allocations in the WBS were examined and compared against risks identified in the cost estimate.
 - ✓ A range of EACs was developed, using a generic index-based formula or relying on probable cost growth factors on remaining work, combined with an integrated cost schedule risk analysis.
 - ✓ An independent date for program completion was determined, using schedule risk analysis that identifies which activities need to be closely monitored.
 - ✓ Senior management used EVM data to answer basic program questions.

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 the 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:** Auditing Agencies and Their WebSites
- **APPENDIX II:** Case Study Background Information
- **APPENDIX III:** Experts Who Helped Develop This Guide
- **Appendix IV:** The Federal Budget Process
- **Appendix V:** Federal Cost Estimating and EVM Legislation, Regulations, Policies, and Guidance

- **Appendix VI:** Data Collection Instrument
- **Appendix VII:** Data Collection Instrument: Rationale
- **Appendix VIII:** Software Engineering Institute (SEI) Checklist
- **Appendix IX:** Examples of Work Breakdown Structures
- **Appendix X:** Schedule Risk Analysis
- **Appendix XI:** Learning Curve Analysis
- **Appendix XII:** Technology Readiness Levels (TRLs)
- **Appendix XIII:** EVM-Related Award Fee Criteria
- **Appendix XIV:** Integrated Baseline Review Case Study & Other Supplemental Tools
- **Appendix XV:** Common Risks to Consider in Software Cost Estimating
- **Appendix XVI:** GAO Contacts and Acknowledgements
- **References**

*Recent GAO Reports
Highlighting Cost
Estimating Issues*

Based on Best Practices
outlined in our Guide

Recent GAO Reports Highlighting Cost Estimating Issues

GAO-07-96	Space Acquisitions Unrealistic Cost Estimates
GAO-07-133R	DNDO's Cost Benefit Analysis of Radiation Detection Equipment
GAO-07-240R	US Chemical Weapons - Shaw Report
GAO-07-268	GSA's NETWORKX Report
GAO-07-387	Missile Defense 2006 Mandate
GAO-07-581T	DNDO's Decision to Deploy New Radiation Detection Equipment Not Supported by CBA
GAO-07-1139R	Defense Integrated Military Human Resource System
GAO-08-134	U.S. Chemical Weapons Demilitarization
GAO-08-388	Joint Strike Fighter
GAO-08-456T	TSA Secure Flight Testimony
GAO-08-595R	US / Mexico Wastewater Treatment Alternatives
GAO-08-623	Border Security - Cost Implications to Changes in the Visa Waiver Program
GAO-08-554	Census Bureau Lacks Credibility and Accuracy of Its Cost Estimate for the Decennial Census
GAO-08-619	DOD Acquisition Funding
GAO-08-756	FAA EVM Report
GAO-08-822	GCSS-MC ERP Report
GAO-08-939	VA Cost of Underutilized Space
GAO-08-982	DOD's Use of Cost Estimating Tool for Contingency Operations May Not Follow Best Practices
GAO-08-1081	Action Needed to Improve Accountability and Management of DOE's Major Cleanup Project:
GAO-09-50	Timely and Accurate Estimates of Costs Are Needed to Define Optimal Strategic Airlift Mix
GAO-09-406T	Project Management Concerns at the National Nuclear Security Administration
GAO-09-303	Joint Strike Fighter Concerns with Procurement Schedule

GAO Report on the Federal Aviation Administration

**FAA Uses EV Techniques to
Help Manage IT Acquisitions, but
Needs to Clarify Policy and
Strengthen Oversight
(Report # GAO-08-756)**

FAA EVM: Congressional Request

The source of our work – Congressional request made by

- Senate Subcommittee on Aviation Operations, Committee on Commerce, Science, and Transportation
- House Subcommittee on Aviation, Committee on T&I
- House Committee on Science and Technology

We were asked to:

- (1) Assess FAA's policies for implementing EVM on its IT investments.
- (2) Evaluate whether the agency is adequately using these techniques to manage key IT acquisitions.
- (3) Assess the agency's efforts to oversee compliance with its EVM policies.
- (4) Evaluate whether the agency is using earned value data as part of its investment management process.

FAA EVM: GAO Findings

Comprehensiveness of FAA EVM Policy

FAA fully met all but 3 key policy components. In particular, FAA

- requires its programs to establish a standard WBS—but one that is *function-oriented*, rather than *product-oriented*.
- has developed EVM training and requires program managers to complete it—but does not *specify training requirements* for program team members or executives with program oversight responsibilities or *enforce* EVM training.
- requires Joint Resources Council approval of program rebaselines—but does not *define acceptable reasons* for rebaselining or *require programs to identify and address* the underlying root cause.

Policy Component	Assessment of FAA policy
Clear criteria for implementing EVM on all major IT investments	Fully met
Compliance with the ANSI standard	Fully met
Standard structure for defining the work products	Partially met
Integrated baseline review	Fully met
Training requirements	Partially met
Rebaselining criteria	Partially met
System surveillance	Fully met

FAA EVM: GAO Findings

Use of EVM on Key Acquisitions

We selected four programs for case study: Airport Surveillance Radar (ASR-11), En Route Automation Modernization (ERAM), Surveillance and Broadcast Services (SBS), and System Wide Information Management (SWIM)

Program management area	ASR-11	ERAM	SBS	SWIM
Establish a comprehensive EVM system	Partially implemented—with justification	Partially implemented—with justification	Fully implemented	Work in progress
Ensure that the data resulting from the EVM system are reliable	Partially implemented—with justification	Partially implemented	Fully implemented	Not applicable—currently in planning phase through Sept. 2008
Ensure that the program management team is using earned value data for decision-making purposes	Fully implemented	Fully implemented	Fully implemented	Not applicable—currently in planning phase through Sept. 2008

FAA EVM: GAO Findings

Use of EVM on Key Acquisitions

Establishing a comprehensive EVM system

The four programs did not consistently establish comprehensive EVM systems, but were able to justify these shortfalls—and had established workarounds.

- **SBS** demonstrated that it had fully implemented the six practices in this area.
- **ASR-11** is a joint-program with Air Force and the FAA team does not receive any EVM data on the AF contract, so it established a PMB to estimate the work remaining on both the contractor and government portion for the program.
- **ERAM** was initiated before the EVM policy but implemented EVM to govern the contract deliverables, but not the government's portion of the program. Instead, the program estimates government costs.

FAA EVM: GAO Findings

Use of EVM on Key Acquisitions

Ensuring that the data resulting from the EVM system are reliable

The three programs that currently collect or estimate monthly EVM data did not consistently ensure that their EVM data were reliable.

- **SBS** fully implemented the practices for ensuring the reliability of the prime contractor and government performance data.
- **ASR-11** could only partially implement these practices due to limited oversight capabilities in the joint-program arrangement.
- **ERAM** partially implemented the practices. The ERAM team analyzes the contractor's monthly CPRs; however, we found several anomalies in these reports that may undermine reliability (e.g., cases in which the contractor reported that no work was planned or accomplished, yet funds were spent).

FAA EVM: GAO Findings

Use of EVM on Key Acquisitions

Ensuring that the program management is using earned value data

All three programs that currently collect monthly EVM data were able to demonstrate that they use these data to manage their programs.

- **SBS** program manager conducts rigorous reviews with its internal performance management review board to discuss the program's earned value performance and take appropriate actions to reverse negative trends.
- **ASR-11** program manager is using the current cost and schedule variances being accrued on site construction work to make projections on the overall cost to complete this work and to create risk mitigation plans to address the cost and schedule drivers.
- **ERAM** program manager uses the earned value data to identify areas of concern and make recommendations to the contractor on items that should be watched, mitigated, and tracked to closure.

FAA EVM: GAO Findings

Oversight of EVM Policy Compliance

- FAA has taken important steps to oversee compliance with EVM policies:
 - Established the Value Management Office in August 2005
 - Assesses major systems using defined criteria
 - Provides executives with a summary of EVM compliance status of all major programs
- However, the oversight office's assessments are not thorough enough to identify anomalies in contractor data, and its agencywide progress reports can be misleading, in that the agency's evaluation process does not distinguish between systems that collect comprehensive data and those that do not.
- As a result, FAA executives do not always receive an accurate view of the quality of a program's EVM data when making investment decisions on that program.

FAA EVM: GAO Findings

Use of EVM in IT Investment Management

- FAA executives are reviewing EVM data as part of their investment review process. Level of detail in EVM data reporting is dependent on the level of executive review.
 - Executives responsible for a portfolio of projects conduct project reviews on a quarterly basis.
 - FAA's Joint Resource Council receives project data on a monthly basis, is briefed on projects that are breaching cost and schedule variances by more than 10 percent on a quarterly basis, and obtains detailed briefings on projects twice a year.

FAA EVM: Recommendations

Recommended the following seven actions to FAA:

Modify acquisition policies governing EVM to

- require the use of a product-oriented standard WBS.
- enforce existing EVM training requirements and expand these requirements to include senior executives responsible for investment oversight and program staff responsible for program oversight.
- define acceptable reasons for rebaselining and require programs seeking to rebaseline to (1) perform root cause analysis to determine why significant cost and schedule variances occurred and (2) establish mitigation plans to address the root cause.

FAA EVM: Recommendations

- Direct the ERAM program office to work with FAA's Value Mgmt Office to
- determine the root causes for the anomalies found in the contractor's EVM reports.
 - develop a corrective action plan to resolve these problems.

- Direct the Value Mgmt Office to improve its oversight processes by
- including an evaluation of contractors' performance data as part of its program assessment criteria, when FAA has the authority to do so.
 - distinguishing between programs that collect earned value data on fully integrated programs and those that do not in its agencywide progress reports to provide transparency to decision makers.

Invitation to Participate in GAO Expert Meetings

Updates to the Guide

Invitation to Participate in Further Updates to the Guide

- GAO invites interested parties to meet with us and other experts to discuss further updates to the Guide so that it continually reflects best practices
 - If interested, please e-mail your contact info to:
 - Karen Richey - richeyk@gao.gov
 - Jennifer Echard – echardj@gao.gov
 - Carol Cha – chac@gao.gov